Geospace revisited:

a Cluster/MAARBLE/Van Allen Probes Conference

BOOK OF ABSTRACTS

15-20 September 2014

Island of Rhodes, Greece

Book of Abstracts

(alphabetically)

Keynote Talk

James Van Allen and the quest for the discovery of radiation belts: from Mercury to the heliosphere

Stamatios M. Krimigis

Johns Hopkins University Applied Physics Laboratory and Academy of Athens

May 1, 1958 was an exciting time in the Great Hall of the US National Academy of Sciences. An announcement was made that the Earth possessed radiation belts at high altitudes with intensities thousands of times greater than those of galactic cosmic rays (GCR) that were known to penetrate the atmosphere and produce secondaries detectable at ground level. The leading scientist at the time was James A. Van Allen, head of the Physics Department at the University of Iowa, who instrumented Explorer-1 and follow-on satellites with radiation detectors, and the press labeled the doughnut-shaped structures Van Allen Belts. Once the basic properties of what was subsequently named Earths Magnetosphere were established, the quest began to search for Van Allen Belts at other nearby planets, namely Venus and March. Mariner 2 was launched to Venus in 1962, but did not have radiation detectors, although a plasma instrument was used to firmly establish the properties of the solar wind. The Mariner 4 mission to Mars was properly instrumented and expectations were high that radiation belts were likely to be present. No planet-associated increase in radiation was measured, but using scaling arguments with Earth magnetosphere established an upper limit to the ratio of magnetic moments of $M_M/M_E < 0.001$ (Van Allen et al, 1965). Similarly, the Mariner 5 flyby of Venus produced an upper limit of the ratio of magnetic moments < 0.001 (Van Allen et al, 1967), dealing another blow to the expectation that all planetary bodies must possess significant radiation belts. Jupiter, however, came to the rescue with the discovery of Io-controlled decametric radio emissions in 1965, proving that at least that planet must have large intensities of trapped electrons and therefore radiation belts. Flybys of Jupiter by Pioneers 10, 11 in 1973 and 1974, respectively, measured a variety of energetic particles in Jupiter magnetosphere and established the fact that it was rotationally modulated. A flyby of Mercury in 1974 by Mariner 10 established that the planet possessed a magnetic field but the presence of higher energy particles remained controversial until MESSENGER. The two Voyager missions, in addition to making the key discovery that an internal plasma source (Io) was populating Jupiter magnetosphere, and that internal plasma rather than solar wind pressure played a dominant role, measured a variety of plasma waves, identified the Io plasma torus and measured the huge current connecting that satellite to the planet upper atmosphere. The flybys of Saturn revealed that the magnetosphere possessed its own internal plasma source(s) and high-energy radiation belts. The subsequent discoveries of Van Allen belts at Uranus and Neptune by Voyager 2, established beyond any doubt that radiation belts were the rule rather than the exception in planetary environments. Finally, we now know from the Voyagers and through Energetic Neutral Atom images from Cassini and IBEX that an intense energetic particle population surrounds the heliosphere. Thus, the reconnaissance of radiation belts of our solar system was completed, some 55 years after the discovery of the Van Allen Belts.

Invited Talks

Outflow of low–energy ions and the Solar cycle

M. Andre[1], K. Li[2], A.I.E. Eriksson[1], H. Nilsson[3] and S. Haaland[2,4]

[1] Swedish Institute of Space Physics, Uppsala
[2] Max-Planck Institute for Solar System Research, Gottingen
[3] Swedish Institute of Space Physics, Kiruna
[4] University of Bergen, Bergen

Ions with energies less than tens of eV originate from the ionosphere. Positive low-energy ions are complicated to detect onboard sunlit spacecraft at higher altitudes, which often become positively charged to several tens of Volts. We use two Cluster spacecraft and study low-energy ions with a recently developed technique based on the detection of the wake behind a charged spacecraft in a supersonic ion flow. We find that low-energy ions usually dominate the density and the outward flux in the geomagnetic tail lobes, during all parts of the solar cycle. The global outflow is of the order of 10^{26} ions/s and often dominates over the outflow at higher energies. The outflow increases with a factor 2 with increasing solar EUV flux during a solar cycle. The increase is due to increased density of the outflowing population, while the outflow velocity does not vary much. Thus, the outflow is limited by the available density in the ionospheric source, rather than by the energy available in the magnetosphere to increase the velocity.

Transient processes in the magnetotail as revealed by recent multi–point observations

V. Angelopoulos

EPSS/IGPP, UCLA

Recent observations from THEMIS and Cluster show that transport during substorms is episodic and is driven by 1-2 min time scale high-speed flux bundles that churn and heat the plasma sheet ahead of them, while accelerating energetic particles within and around them. Kinetic fronts ahead of such recently reconnected flux bundles host energy conversion sites which, when integrated over flux transport spatial scales, can account for global magnetic energy conversion. The results of such bundles are widespread across the entire near-Earth and mid-tail plasma sheet; heating of the plasma sheet plasma by them is cumulative. On the tailward side of the X-points reconnection fronts are responsible for plasmoid formation and acceleration. On the earthward side they result in elemental substorm current wedges (often termed ”wedglets”). The same transient processes are likely also operational during storms - as recent Van Allen Probes observations suggest. Understanding the interaction between wedgelets with the inner magnetosphere or with the near-Earth plasma sheet, particularly during the substorm recovery phase, is critical for understanding global substorm energy release in the magnetosphere. This reopens the question whether the physics of the energy transfer is best described as a disruption of the cross-tail current that is diverted to the ionosphere at the ion-scale fronts of dipolarizing flux bundles (a leakage of Poynting flux) or by the energy conversion due to the bundle's earthward motion (local heating). I will discuss the exciting possibility to answer these questions with coordinated observations from the upcoming international Heliophysics System Observatory.

ERG satellite project: exploration of the terrestrial inner magnetosphere

K. Asamura[1], T. Takashima[1], Y. Miyoshi[2], K. Shiokawa[2], K. Seki[2], T. Hori[2], Y. Miyashita[2], K. Keika[2], M. Shoji[2], I. Shinohara[1], M. Hirahara[2], N. Higashio[1], H. Matsumoto[1], S. Kasahara[1], T. Mitani[1], Y. Kazama[5], Y. Kasaba[3], A. Matsuoka[1], H. Kojima[4], M. Fujimoto[1], T. Ono[3] and ERG project group

[1] Japan Aerospace Exploration Agancy, Japan
[2] STEL, Nagoya University, Japan
[3] Tohoku Univeristy, Japan
[4] RISH, Kyoto University, Japan
[5] Academia Sinica Isititute of Astronomy and Astropshysics, Taiwan

The ERG (Exploration of energization and Radiation in Geospace) is Japanese satellite which will be launched in 2015 (Japanese fiscal year). ERG will make in-situ plasma / particle measurements in the terrestrial inner magnetosphere. One of scientific targets of ERG is to explore acceleration / loss mechanisms of high-energy electrons (∼MeV energy range) in the outer belt. ERG focuses on energy transfer between plasma particles and waves, which is most probably an important mechanism to provide the significant acceleration of electrons toward ∼MeV. Coordinated observations of ERG with Van Allen Probes, other spacecraft, and ground-based observation network will provide detailed, and also global-scale plasma environment in the inner magnetosphere. The overview of the project and possible collaborations with other geospace satellite missions as well as the ground-based observations will be presented.

Substorm dynamical role in radiation belt particle enhancements

D.N. Baker

Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, CO

Observational and numerical modeling evidence demonstrates that magnetospheric substorms are a global, coherent set of processes within the coupled near-Earth system. The magnetosphere progresses through a specific sequence of energy-loading and stress-developing states until the entire system suddenly reconfigures. Related long-term studies of relativistic electron fluxes in the Earth's magnetosphere have revealed many of their temporal occurrence characteristics and their relationships to solar wind drivers. In order to observe major relativistic electron enhancements, there must typically be a significant interval of southward IMF along with a period of high ($V_{SW} \geq 500$ km/s) solar wind speed. This has led to the view that enhancements in geomagnetic activity (i.e., magnetospheric substorms) are normally a key first step in the acceleration of radiation belt electrons to high energies. A second step is a period of powerful low-frequency waves that is closely related to high values of V_{SW} or higher frequency ("chorus") waves that rapidly heat and accelerate electrons. Hence, substorms provide a "seed" population, while high-speed solar wind drives the acceleration to relativistic energies in this two-step geomagnetic activity scenario. In this talk, we discuss the substorm relationships as they pertain to high-energy electron acceleration and transport. We also discuss various models of electron energization that have recently been advanced. We present remarkable new results from the Van Allen Probes (Radiation Belt Storm Probes) mission that confirm and greatly extend these key ideas.

Resolving global geospace processes: what ENA imaging can and cannot do

P.C. Brandt, M. Sitnov, E.C. Roelof and D.G. Mitchell

The Johns Hopkins University Applied Physics Laboratory, Laurel, MD, USA

The recognized challenge of magnetospheric research is being able to determine the global impacts of micro- and mesoscale phenomena. Examples include the processes that generate and energize the ring current, and how its global plasma pressure distribution impacts the geomagnetic field. Energetic Neutral Atom (ENA) imaging of the terrestrial ring current and plasmasheet have been performed from several missions including Astrid, POLAR, IMAGE, TWINS and Double Star. In this presentation we review the current capabilities of ENA imaging in the ring-current and plasmasheet ion energy ranges (>1 keV). We focus on results from IMAGE and TWINS, discussing techniques of retrieving the large-scacle ion differential intensities. In particular, we demonstrate what can be done using these techniques and discuss their quantitative limitations. Examples include imaging of substorm dynamics of the plasmasheet and its relation to mesoscale phenomena such as bursty bulk flows; retrieval of plasma pressure distributions and its possibility to constrain the magnetic field perturbations of the inner magnetosphere. We conclude the presentation with a summary of future capabilities required to make important and quantitative progress in inner magnetospheric research.

Van Allen Probes observations of wave–particle interactions in the Earth's radiation belts

S.G. Claudepierre[1], J.F. Fennell[1], J.B. Blake[1], T.P. O'Brien[1] and I.R. Mann[2]

[1] The Aerospace Corporation, El Segundo, CA, USA
[2] The University of Alberta, Edmonton, AB, Canada

We present data from the Magnetic Electron Ion Spectrometer (MagEIS) instrument, part of the Energetic Composition and Thermal Plasma (ECT) Suite, onboard the NASA Van Allen Probes spacecraft. MagEIS measures radiation belt electrons in the ∼40-4000 keV energy range and protons in the ∼60-1000 keV energy range, with high resolution in both energy and pitch-angle. We present a summary of our findings from the prime mission (2 years), with a focus on the large number of wave-particle interaction events we have observed. In particular, MagEIS frequently observes drift-resonance between magnetospheric ultra-low frequency (ULF) waves and energetic electrons and protons, and a number of interesting ULF wave characteristics can be deduced from the particle measurements alone. We also present observations of quasiperiodic increases, or bursts, of 10's of keV electron fluxes in conjunction with chorus wave bursts, often observed following a plasma injections.

The ring current: Cluster results

I. Dandouras

Institut de Recherche en Astrophysique et Planétologie, Université de Toulouse / CNRS, Toulouse, France

The inner magnetosphere electric currents configuration and mapping is one of the key elements for understanding current loop closure inside the entire magnetosphere. The ring current is toroidal-shaped and flows in the near-Earth region, where the magnetic field is dipole-like. This current system is driven by the pressure gradients, and it is formed by the drift of the charged particles that are injected from the magnetotail towards the Earth during the magnetospheric storms and substorms. A method for directly computing current is the multi-spacecraft curlometer technique, which is based on Maxwell-Ampere law application. This requires the use of four point simultaneous magnetic field measurements. The FGM experiment on board the four Cluster spacecraft allows for the first time an instantaneous calculation of the magnetic field gradients and thus a measurement of the local current density. This technique requires however a careful analysis concerning all the factors that can affect the accuracy of the current density calculation. The CIS experiment, on board these spacecraft, provides the ion distribution functions of the current carriers within its energy range. Earlier and more recent results, based on Cluster data acquired during passes in the ring current region at different perigee altitudes, will be reviewed in the light of recent progress on the accuracy of the method.

Links between the plasmapause and the radiation belts boundaries as observed by the instruments CIS, RAPID and WHISPER onboard Cluster

F. Darrouzet[1], V. Pierrard[1], S. Benck[2], G. Lointier[3], J. Cabrera[2], K. Borremans[1], N. Ganushkina[4] and J. De Keyser[1]

[1] Belgian Institute for Space Aeronomy (IASB-BIRA), Brussels, Belgium
[2] Center for Space Radiations (CSR), Louvain-la-Neuve, Belgium
[3] Laboratoire de Physique et Chimie de l'Environnement et de l'Espace (LPC2E), Orléans, France
[4] Finnish Meteorological Institute (FMI), Helsinki, Finland

In a recently published work, we studied the relations between the position of the plasmapause and the position of the radiation belt boundaries. The Cluster mission offers the exceptional opportunity to analyze those different regions of the inner magnetosphere with identical sensors on multiple spacecraft. We compare the positions of the radiation belt edges deduced from CIS observations (electrons with energy larger than 2 MeV) with the positions of the plasmapause derived from WHISPER data (electron plasma frequency). In addition, we compare those results with the boundary positions determined from RAPID observations (electrons with energy between 244.1 and 406.5 keV).
The period of 1 April 2007 to 31 March 2009 has been chosen for the analysis because at that time Cluster's perigee was located at lower radial distances than during the earlier part of the mission (as close as $2\,R_E$, deep inside the plasmasphere and the radiation belts). This time period corresponds to a long solar activity minimum.
Differences are observed between the radiation belt boundary positions obtained from the two different instruments: The radiation belt positions are related to the energy bands. The plasmapause position is more variable than the radiation belt boundary positions, especially during small geomagnetic activity enhancements. A correspondence is observed between the plasmapause position determined by WHISPER and the outer edge of the outer radiation belt of energetic electrons (> 2 MeV) observed by CIS. There may be an apparent contradiction with previous studies that indicated a correlation between the inner edge of the outer radiation belt and the plasmapause. Radiation belt losses through plasmaspheric waves, however, occur on a longer time scale and are longitudinally averaged because of energetic particle drift motion, so the radiation belt boundaries should not necessarily reflect the instantaneous plasmapause position at one particular local time. Moreover, during higher geomagnetic activity time periods, the plasmapause is located closer to the inner boundary of the outer radiation belt.
We have pursued the analysis of radiation belt boundary positions during time periods with higher geomagnetic activity, showing different characteristics. We present also some first conclusions from a comparison of those data with a global plasmasphere model and a radiation belt model.

Multi–scale analysis of dayside reconnection and future Swarm–Cluster coordination

M.W. Dunlop

Space Science Institute, School of Astronautics, Beihang University, 100191, Beijing, China
RAL, Chilton, Oxfordshire, OX11 0QX, UK

The use of multi-scale (lustered spacecraft data is explored in two separate scenarios: to probe the distribution and small scale structure of dayside reconnection signatures and to show the capability of Swarm-Cluster coordination for probing the response of the ring current, field aligned currents and cusp currents. Recent investigations suggest predominantly component driven X-line regions on the dayside magnetopause, independent of guide field conditions and extending across a wide range of preferred, and often multiple, locations. We show simultaneous sampling, by four Cluster spacecraft in close formation, of the plasma signatures at a high-latitude reconnection site, where the spacecraft locations are known relative to the magnetic X-line geometry, determined unambiguously from the four spacecraft data. Clear evidence is obtained, both of expected structure surrounding a finite length X-line (from ion data) and of the repeatedly sampled central, small scale diffusion region (from electron data) and associated null magnetic field. Simultaneous monitoring of the local magnetosheath behaviour at lower latitudes by a fifth spacecraft suggests that sequential or multiple reconnection sites may be formed. We also refer to distributed multi-scale data from Cluster, Double Star and Themis, to comment on the occurrence of magnetic reconnection along the dayside merging line. The second theme concerns one of the four primary science objectives of Swarm is to investigate the external electric currents flowing in the magnetosphere and ionosphere. The ring current (RC) and connecting R2 field aligned currents (FAC) are a dominant influence on the geomagnetic field at low Earth orbit (LEO) and these are sampled in situ by the four Cluster spacecraft every perigee pass. Coordination of the configuration of the three Swarm spacecraft with the constellation of the four Cluster spacecraft has been planned through joint operations; providing a set of distributed, multi-point measurements covering this region. A particularly close coordination of all spacecraft is expected during the beginning of the Swarm operations. We show preliminary study of the morphology and influence of the ring current from the in-situ RC and associated FACs determined directly from the 4-spacecraft Cluster perigee observations. We report here preliminary results of joint science targets, including coordinated cusp encounters; the comparative significance of the connecting R2 FACs, and the use and application of new analysis techniques derived from the calculation of curl B and magnetic gradients to compare estimates of the current distributions

Highlights from Cluster, first 3D mission

C.P. Escoubet[1], A. Masson[1], H. Laakso[1], M.G.G.T. Taylor[1], J. Volpp[2], D. Sieg[2], M. Hapgood[3] and M.L. Goldstein[4]

[1] ESA/ESTEC, The Netherlands
[2] ESA/ESOC, Darmstadt, Germany
[3] RAL Space/STFC, Harwell Oxford, UK
[4] GSFC/NASA, USA

The Cluster mission has been operated successfully for 14 years. As the first science mission comprising four identical spacecraft, Cluster has faced many challenges during its lifetime: its long selection process together with SOHO, the failure of the first Ariane V launch, its fast rebuilt, and the launch on two Soyuz rockets in 2000. The separation of the Cluster spacecraft was changed more than 30 times from a few kilometers up to 36000 km to address the various scientific objectives in key regions of Earth's geospace environment: solar wind and bow shock, magnetopause, polar cusps, magnetotail, plasmasphere and auroral zone. The smallest distance achieved between two Cluster spacecraft was 4 km in the inner magnetosphere, about 50 times smaller than planned at the beginning of the mission. We will present science highlights obtained such as Kelvin-Helmholtz rollup waves at the magnetopause, energetic particles in the cusp, electron scale structures at the bow shock, tiny current sheets in the solar wind, motion of dipolarisations in the magnetotail, surface waves in the plasmasheet, auroral acceleration temporal evolution and localisation of plasmaspheric waves with one spacecraft tilted at 45^o. We will also present the distribution of data through the Cluster Science Data System (CSDS), and the Cluster Science Archive. Those systems were implemented to provide, for the first time for a plasma physics mission, a permanent and public archive of all the high resolution data from all instruments.

Energetic electron acceleration by unsteady magnetic reconnection

H.S. Fu[1,2], Yu.V. Khotyaintsev[2], A. Vaivads[2], A. Retino[3], M. Andre[2] and J.B. Cao[1]

[1]Space Science Institute, School of Astronautics, Beihang University, Beijing, China
[2]Swedish Institute of Space Physics, Uppsala, Sweden
[3] Laboratoire de Physique des Plasmas, École Polytechnique, Universite Pierre et Marie Curie, Palaiseau, France

The mechanism that produces energetic electrons during magnetic reconnection is poorly understood. This is a fundamental process responsible for stellar flares, substorms, and disruptions in fusion experiments. Observations in the solar chromosphere and the Earth‘s magnetosphere indicate significant electron acceleration during reconnection, whereas in the solar wind, energetic electrons are absent. Here we show that energetic electron acceleration is caused by unsteady reconnection. In the Earth‘s magnetosphere and the solar chromosphere, reconnection is unsteady, so energetic electrons are produced; in the solar wind, reconnection is steady, so energetic electrons are absent. The acceleration mechanism is quasi-adiabatic: betatron and Fermi acceleration in outflow jets are two processes contributing to electron energization during unsteady reconnection. The localized betatron acceleration in the outflow is responsible for at least half of the energy gain for the peak observed fluxes.

Simulating the Earth's radiation belts with continuous losses to the magnetopause

S.A. Glauert, R.B. Horne and N.P. Meredith

British Antarctic Survey, Cambridge, UK

The relativistic electron flux in the Earth's radiation belts is highly dynamic and has been observed to change by orders of magnitude within a few hours. As these energetic electrons can damage satellites it is important to understand the processes driving these changes and, ultimately, to develop forecasts of the energetic electron population. One approach to modelling these processes uses three dimensional diffusion models based on a Fokker-Planck equation. Using recently published chorus diffusion coefficients for $1.5 \leq L^* \leq 10$, we present results from the BAS Radiation Belt Model with a new boundary condition where the phase-space density is zero at the outer L^* boundary, simulating losses to the magnetopause. Our simulations suggest that the outer radiation belt can be formed by local acceleration of electrons from the low energy boundary without the need for a source of electrons at the outer L^* boundary. Comparisons between the model and data are shown; flux drop-outs events are reproduced in the model by the increased outward radial diffusion that occurs during storms. Including the inward movement of the magnetopause in the model has little additional effect on the results. The location of the low energy boundary is shown to be important for accurate modelling of observations.

The research leading to these results received funding from the European Union Seventh Framework Programme under grant agreements no. 284520 (MAARBLE) and 262468 (SPACECAST).

What happens to flow bursts as they propagate towards the Earth?

M. Hamrin[1], T. Pitkänen[1], T. Karlsson[2], H. Nilsson[3] and P. Norqvist[1]

[1] Department of Physics, Umeå University, Umeå, Sweden
[2] KTH, School of Electrical Engineering, Stockholm, Sweden
[3] Swedish Institute of Space Physics, Kiruna, Sweden

Bursty bulk flows (BBFs) are expected to be generated through reconnection at a magnetic neutral line. The occurrence rate of BBFs decreases closer to the Earth. This decrease is believed to be caused by a general flow braking and diversion of the plasma flows in the near-Earth plasma sheet around -10R_E. However, what happens to the BBFs during their propagation from the neutral line towards the Earth is still an open question. Are they continuously decelerated along their way, or is the main deceleration concentrated to the near-Earth plasma sheet where the plasma flows meet the more dipolar geomagnetic field? By using data observed by Cluster in the magnetotail plasma sheet, we find indications of a plasma deceleration in the region $-20R_E < X < -15R_E$. This is considerably tailward of the inner boundary of the plasma sheet ($\sim 10R_E$) where the flow braking is expected to be substantial. The deceleration can be measured through the power density, $\mathbf{E} \cdot \mathbf{J}$, where $\mathbf{E}$ and $\mathbf{J}$ are the electric field and the current density, respectively. The exact amount of deceleration is difficult to determine, but it is likely that it is often rather weak. We propose a braking mechanism where compressed magnetic flux tubes in so called dipolarization fronts (DFs) can constitute a local obstacle to the earthward propagating flow bursts, hereby decelerating the incoming flow bursts.

Effects of EMIC waves and the magnetopause on the radiation belts

R.B. Horne, S.A. Glauert, N.P. Meredith and T. Kersten

British Antarctic Survey, Madingley Road, Cambridge UK

The relativistic electron flux in the radiation belts can vary by up to five orders of magnitude. To understand the variability we must understand how geomagnetic activity affects at least five main processes: the low energy source particle population, acceleration by plasma waves, losses by plasma waves, losses to the outer magnetic field boundary, and radial diffusion across the magnetic field. Here we describe some recent modelling using the BAS radiation belt model that addresses the magnetopause boundary and losses due to EMIC waves. We present a model for EMIC waves based on the analysis of CRRES data. Results from the BAS model that show that these waves can cause significant electron loss for energies of 2 -6 MeV and higher and result in a pancake distribution at high energies. We include a model of the magnetopause and show how losses to the magnetopause occur during periods of high solar wind pressure and southward IMF Bz. We discuss these results in terms of flux drop-out events, and the need to consider the flux at the low energy boundary in more detail.

The research leading to these results received funding from the European Union Seventh Framework Programme under grant agreements no. 284520 (MAARBLE) and 262468 (SPACECAST).

The dynamic magnetosphere: Cluster and ground–based observations

S. Imber, M. Lester and S.E. Milan

Department of Physics and Astronomy, University of Leicester, Leicester, LE1 7RH, UK

The Cluster mission has provided us with a wealth of novel and exciting new results on fundamental physical phenomena in space plasmas, such as reconnection, shocks etc. In addition there has been a wide variety of work which has used data from collaborating sources, notably ground-based observations, which have provided such results on the dynamics of the solar wind magnetosphere ionosphere interaction. In this paper we provide an overview of some of this work focussing on recent work which has resulted in the availability of a wide range of ground based and space based data sets in the Cluster Archive. The European Cluster Assimilation technology (ECLAT) programme also provides results from an MHD model. Results that will be discussed include long time series development of the ionospheric convection pattern as well as comparison of boundaries determined by Cluster with radar and auroral boundaries.

Plasma wave measurements in Earth's magnetosphere by Juno, Van Allen probes and Cluster

W.S. Kurth[1], G.B. Hospodarsky[1], S.J. Bolton[2], D.A. Gurnett[1], O. Santolik[3,4], C.A. Kletzing[1], R.M. Thorne[5] and J.S. Pickett[1]

[1] University of Iowa, Iowa City, IA 52242, USA
[2] Southwest Research Institute, San Antonio, TX, USA
[3] Inst. of Atmospheric Physics, ASCR, Prague, Czech Republic
[4] Charles University, Prague, Czech Republic
[5] University of California, Los Angeles, CA, USA

On October 9, 2013, Juno flew within about 550 km of Earth in the process of executing a gravity assist on its way to its eventual arrival at Jupiter in July 2016. Since this was the only magnetospheric plasma regime Juno will sample prior to arrival at Jupiter, the flyby presented both engineering and scientific opportunities. One of the scientific opportunities was to make observations in the inner magnetosphere at the same time as the twin Van Allen Probes and Cluster. During the Juno flyby, which was on the dusk side at closest approach, the Van Allen Probes' apoapsis was also in the dusk sector. The Cluster orbits favored comparisons on the nightside after Juno's closest approach. Juno traversed both the inner and outer belts, albeit at higher latitudes than the low-inclination Van Allen Probes. The Cluster spacecraft are also in a rather high inclination orbit compared to the Van Allen Probes. The Waves instrument on Juno utilizes a single electric dipole antenna and a single search coil sensor for measurements of the electric and magnetic components of plasma waves, consequently it provides wave spectra and brief bursts of waveforms. The Waves instrument on Van Allen Probes, on the other hand, makes triaxial electric and magnetic measurements of plasma waves, hence, can determine the propagation characteristics of waves such as the wave-normal angle, Poynting flux, and polarization characteristics of the waves. The Wideband Instruments on Cluster were configured to capture single axis (electric or magnetic) waveforms at selected times designed to coincide with Juno and Van Allen Probes burst observations. Juno entered a safe mode shortly after closest approach to Earth, hence, the Juno observations are limited primarily to the inbound portion of the trajectory and limits comparisons with observations on the Cluster spacecraft, which were in the pre-noon sector at the time. We compare observations of whistler-mode emissions and electron cyclotron harmonic emissions in and near the radiation belts from the vantage points of these spacecraft. While none of the spacecraft were co-located or even on common flux tubes during the Juno flyby, Juno and the Van Allen Probes did sample similar L-shells on the inbound leg, albeit at significantly different local times. Relatively weak chorus and plasmaspheric hiss were commonly observed.

Altered solar wind–magnetosphere interaction at low Mach numbers

B. Lavraud

IRAP/CNRS/Universite de Toulouse

Fundamental alterations of the solar wind magnetosphere interaction occur during low Mach number solar wind. We show that such low Mach number solar wind conditions are often characteristic of coronal mass ejections (CME), and magnetic clouds in particular. We illustrate the pivotal role of the magnetosheath. This comes from the fact that low Mach number solar wind leads to the formation of a low thermal beta magnetosheath downstream of the bow shock. This property influences magnetic forces and currents, in particular, and in turn alters magnetosheath magnetosphere coupling. The implications of this unusual regime of interaction have generally been overlooked. Potentially affected phenomena include: (1) asymmetric magnetosheath flows (with substantial enhancements); (2) asymmetric magnetopause and magnetotail shapes; (3) changes in the development of the Kelvin-Helmholtz instability and giant spiral auroral features; (4) variations in the controlling factors of dayside magnetic reconnection; (5) cross polar cap potential saturation and Alfven wings; and (6) global sawtooth oscillations. In this presentation we will briefly describe these phenomena, primarily by use of global magneto-hydrodynamic simulations, and discuss the mechanisms that rule such an altered interaction. We emphasize the fact that all these effects tend to occur simultaneously so as to render the solar wind magnetosphere interaction drastically different from the more typical high Mach number case. In addition to the more extensively studied inner magnetosphere and magnetotail processes, these effects may have important implications during CME-driven storms at Earth, as well as at other astronomical bodies such as Mercury.

Dynamics of relativistic electrons during non–storm times

X. Li[1], Q. Schiller[1], L. Blum[1] and A. Jaynes[2]

[1] Laboratory for Atmospheric and Space Physics and Dept. of Aerospace Engineering Sciences of University of Colorado at Boulder, USA

[2] Laboratory for Atmospheric and Space Physics of University of Colorado at Boulder, USA

It is well known that the radiation belt electrons have the largest variations during magnetic storms. Not much attention has been paid to the dynamics of relativistic electrons during non-storm times. However, some quantitative analysis for both enhancement and decay of the relativistic electrons can be performed better during less active times. Here we will present recent results based on conjunctive measurements from the Relativistic Electron and Proton Telescope integrated little experiment (REPTile) onboard the Colorado Student Space Weather Experiment (CSSWE), a 3U CubeSat (10cm x 10cm x 30cm), and other larger missions, such as Van Allen Probes and BARREL. CSSWE, which has been designed, built, tested, and operated by a team of students at the University of Colorado with close mentorship from professionals, was launched into a low-Earth, 480km x 780km, and highly inclined (65 deg) orbit on 13 September 2012. REPTile measures differential fluxes of 0.58 to >3.8 MeV electrons and 9-40 MeV protons and is still operational.

Findings from the Van Allen probes mission and the path forward to future understanding regarding Earth's radiation belts and inner magnetosphere

B.H. Mauk[1], N.J. Fox[1], R.L. Kessel[2], D.G. Sibeck[3] and S.G. Kanekal[3]

[1] The Johns Hopkins University APL, Laurel, Maryland USA
[2] NASA Headquarters, Washington DC, USA
[3] NASA Goddard Space Flight Center, Greenbelt, Maryland USA

As the Van Allen Probes mission approaches the end of its prime mission (31 October 2014) we here review and assess the outstanding findings and science understandings achieved by the mission. At the same time we look forward to the continued operation of the Probes on the basis of the new understandings that can be achieved. Among other advantages expected during a proposed continuing operation phase, new science understandings will be achieved by: 1) taking advantage of orbit evolutions that allow us to focus more on radial transport, 2) taking advantage of a second precession of the spacecraft lines-of-apogee around the Earth during the solar Corotating-Interaction-Region-rich declining phase of the solar cycle, 3) taking advantage of improved risk postures to obtain much higher rates of data return, and 4) coordinating with anticipated new assets, particularly the Japanese ERG mission and the MMS mission, We review here both the past and the anticipated future, and solicit advice from the broad scientific community as to the best approaches for maximizing the future impact of the Probes.

The role of O^+ in the near–earth magnetotail dynamics

C.G. Mouikis, L.M. Kistler, Y. Liu, S. Wang and J. Liao

Space Science Center, University of New Hampshire, USA

The magnetospheric plasma is a multi-species plasma and it is known that during geomagnetically active times, O^+ ions of ionospheric origin can contribute significantly to, if not dominate, the density and pressure both in the magnetotail and in the inner magnetosphere/magnetopause. Magnetic reconnection is a key process that impacts thin current sheet dynamics and is fundamentally responsible for driving magnetospheric dynamics and as such it has been studied extensively both theoretically and observationally as a two species plasma (H^+ and e^-). However, the reconnection process in the Earth magnetosphere should be approached as a three-species plasma problem introducing an additional larger scale length. We use data from the CODIF instrument on Cluster to study the impact of the ionospheric O^+ on the reconnection process in the Earth's magnetotail, as well as the global tail dynamics.

Hot and cold ion outflow, from the ionosphere to the plasma sheet and back

H. Nilsson

Swedish Institute of Space Physics, Kiruna, Sweden

Recent progress in our understanding of ion outflow in the magnetosphere of earth has led us to revise our picture of heating and acceleration of ionospheric origin ions in the magnetosphere. We have to simultaneously explain very efficient heating of ions in some regions, and remarkably little heating in other regions. For outflowing ions the strongest heating is seen for oxygen ions in the cusp and mantle. In the tail lobes there appears to be very little heating, and a cold population, typically not observable with ion spectrometers, dominates both density and total flux. This cold ion population appears to consist primarily of protons. Judging from models of flight trajectories, most of these cold ions should end up in the plasma sheet rather than escape through the far tail. Understanding how these cold ions are affected by, and affect the plasma sheet is the next step in understanding the role this cold plasma plays in geospace dynamics. There appear to be a sufficient outflow of cold protons to supply the entire plasma sheet population if the cold population is heated to plasma sheet energies. There are some indications that at times part of the plasma population of the plasma sheet can remain at energies below the detection threshold of most ion spectrometers. This would affect our estimates of the total return flow in the plasma sheet, as well as our estimates of and understanding of the global circulation feeding ions from the tail to the inner magnetosphere. We discuss whether there is evidence in the Cluster data for such a cold component in the plasma sheet. We also discuss the oxygen motion in the polar cap, lobes and in the plasma sheet, and relate this to proton motion. We show how the average oxygen earthward drift in the plasma sheet is somewhat slower than the proton drift and that oxygen motion is generally not affected by bursty bulk flows as seen in proton data.

Magnetospheric mass and energy transfer: Vlasiator and GUMICS-4 simulation results

M. Palmroth[1], C.R. Anekallu[2], H. Hietala[3], T.V. Laitinen[1], Y. Kempf[1,4], S. Hoilijoki[1,4], S. von Alfthan[1], U. Ganse[4] and R. Vainio[5]

[1] Finnish Meteorological Institute, Helsinki, Finland
[2] Mullard Space Science Laboratory, London, UK
[3] Imperial College, London, UK
[4] University of Helsinki, Helsinki, Finland
[5] University of Turku, Turku, Finland

We investigate the solar wind - magnetosheath - magnetopause plasma and energy transfer using Cluster spacecraft observations and two global simulations. In the first part of the presentation, we use a newly developed global kinetic simulation Vlasiator to investigate foreshock and magnetosheath plasma properties. Vlasiator models the evolution of the proton distribution function using the Vlasov equation in self consistent electromagnetic fields determined by electrons modeled with magnetohydrodynamic (MHD) equations. This approach allows Vlasiator to address multi-component plasmas beyond the MHD approach, featuring distribution functions with unprecedented quality and including kinetic effects such as foreshock ULF waves, cavities, hot flow anomalies and the like. In recent simulations, Vlasiator was used to simulate the foreshock, bow shock and magnetosheath regions in the ecliptic plane under radial and Parker spiral type interplanetary magnetic field (IMF) conditions. We investigate the properties of the 3-dimensional proton distribution functions within the foreshock, including transfer through the bow shock as well as the backstreaming reflected populations taking part in the formation of the global foreshock ULF wave field. Within the magnetosheath, we investigate the modulation of the transferred population. Since Vlasiator is currently still semi-global in the ordinary space, at this point we introduce the second global simulation used in the presentation; a global 3-dimensional MHD simulation GUMICS-4, which is used to characterize the global magnetopause energy and plasma transfer under several IMF and solar wind conditions. We find that in GUMICS-4, energy transfer agrees with the Cluster observations spatially and is about 30% lower in magnitude, while plasma transfer is majorly controlled by the magnetopause reconnection process while also solar wind dynamic pressure has a role in modulating magnetopause plasma transfer. The largest plasma inflow occurs during northward IMF and lobe reconnection, while for southward IMF plasma is accelerated outwards from the closed field region.

Connecting upstream transient phenomena and their effects on geospace: the major Solar eruptions of 7 March 2012

S. Patsourakos and the Hellenic National Space Weather Research Network

University of Ioannina, Department of Physics, Section Astrogeophysics, Greece

During the interval of 7-10 March 2012, Earth's space environment experienced a barrage of space weather phenomena. Early during 7 March 2012, the biggest proton event of 2012 took place with particle showers observed at 1 AU as well past Earth's orbit close to Mars, while on 8 March 2012, an interplanetary shock and coronal mass ejection (CME) arrived at 1 AU. Several months afterwards, radio waves generated by these activities were detected in-situ by Voyager 1. This sequence triggered one of the most intense geomagnetic storms of cycle 24, with a minimum Dst of $\approx$ -150 nT. The solar source of these activities was a pair of homologous, eruptive X-class flares associated with two ultra-fast CMEs. The two eruptions originated from NOAA active region 11429 during the early hours of 7 March 2012 and within an hour from each other.

Using satellite data from a flotilla of solar, heliospheric and magnetospheric missions and monitors, we perform a synergistic Sun-to-Earth study of various observational aspects of the event sequences. We present a framework that starting from solar and near-Sun estimates of the magnetic and dynamic content and properties of the Earth-directed CME assess in advance their values as well as the subsequent geomagnetic response expected, once the associated interplanetary CME reaches 1 AU. In addition, we discuss why the particular eruptions were so geoeffective from the solar, IP and geospace standpoint.

This research has been co-financed by the European Union (European Social Fund ESF) and Greek national funds through the Operational Program "Education and Lifelong Learning" of the National Strategic Reference Framework (NSRF) - Research Funding Program: Thales. Investing in knowledge society through the European Social Fund.

Auroral kilometric radiation generation in the neighbourhood of a double layer

R. Pottelette[1], M. Berthomier[1] and J. Pickett[2]

[1] LPP-CNRS/INSU, 4 avenue de Neptune, 94107 Saint-Maur des Fosses, France
[2] Department of Physics and Astronomy, The Universitry of Iowa, Iowa city, USA

Remote observation of Auroral Kilometric Radiation (AKR) is a useful tool for detecting the dynamic of the auroral acceleration region. Being a direct consequence of the parallel acceleration processes, the radiation contains fundamental information on their characteristic spatial and temporal scales. The satellite measurements indicate that the AKR frequency spectrum mostly consists of fine spectral features, which are extremely narrow in bandwidth and drift in frequency up and down. These observations provide ample reason for asking whether the presence of nonlinear phase space holes structures generated near Double Layers could contribute to the production of the observed spectral features. In this case, the fine structured AKR features would result from the motion of phase space holes through space, with the frequency drift mapping the variation of the electron gyrofrequency along the magnetic flux tubes to which they are confined.

We use high-time resolution measurements from the FAST and CLUSTER spacecraft in the AKR source region. We emphasize that the recorded frequency structures are the ones which are expected to occur on the low- and high-potential sides of an accelerating Double Layer. Electron holes producing steep parallel and perpendicular velocity gradients on the electron velocity distribution function appear as crucial elements in the generation of the fine AKR spectral structures. However, both ion and electron hole dynamics seem to play a major role in the generation of the subtle, fine structures moving across the radiation spectrum. These observational results inspire investigation of such radiating processes through numerical simulations because they could be relevant to other astrophysical radio sources.

Radiation belts and ring current – the energetic geospace

G.D. Reeves[1], H.E. Spence[2], B.A. Larsen[1], C.A. Kletzing[3] and D.G. Mitchell[4]

[1] Los Alamos National Lab., Los Alamos NM, USA
[1] University of New Hampshire, Durham NM, USA
[3] University of Iowa, Iowa City IA, USA
[4] Johns Hopkins Applied Physics Lab., Laurel MD, USA

The Van Allen Probes mission (RBSP) was launched just over two years ago with the goal of understanding the complex, coupled dynamics of the energetic geospace system. The mission science objectives focus on the processes that control acceleration, transport, and loss of particles in the radiation belts but also focus on the dynamic plasma and energetic particle populations in the plasmasphere, and plasma sheet, and ring current that determine the overall, coupled systems response.

Now, the Van Allen Probes has completed it 2-year prime mission - in which the orbit apogee precessed through all local times - and the satellites have begun their second swing through the night side of the inner magnetosphere. During that time the Van Allen Probes have developed the most complete statistical picture to date, of the energetic geospace environment including plasma conditions, the composition of plasmas and energetic particles in the inner magnetosphere, the distribution of chorus and other waves, the dynamics of the ring current, and the spatial-temporal-energetic structure of the radiation belts.

At the same time, we have been able to analyze individual energetic geospace events in unprecedented detail. We have discovered the dominant role of wave-particle acceleration in the energization of the radiation belts but, at the same time, how no single process ever accounts for the remarkable variation from event-to-event that makes no two alike. Recent studies have been able to use observed plasma and wave conditions to quantitatively test competing theories. They have been able to identify the unique contributions of individual processes to the collective response.

Along with unprecedented new detail in the observations available to our field, new models of energetic geospace events (as well as providing greatly improved accuracy) have dramatically improved our physical understanding of the system. In many cases the role of competing processes of acceleration, transport, and loss can only be disentangled through simultaneous modeling and analysis. Revolutionary improvements are possible, in part because models can be driven by event-specific wave, particle, and boundary conditions. These new, event-specific models vastly reduce the number of free parameters in the system moving our understanding closer to the ultimate mission goal of predictability.

Flow bursts intrusion into the inner magnetosphere and some its consequences

V.A. Sergeev[1], V. Angelopoulos[2], J. Birn[3] and R. Nakamura[1]

[1] St.Petersburg State University, St.Petersburg, Russia
[2] University of California, Los Angeles, USA
[3] Space Science Institute, Boulder, USA
[4] Space Res. Institute, Austrian Acad. Sci., Graz, Austria

We discuss recent advances in studies of inner-magnetospheric effects of the plasma sheet flow bursts (FBs, or BBFs). Due to occasional radial constellation of multiple spacecraft in the inner magnetosphere and, especially, due to regular coverage of its periphery by THEMIS spacecraft, we are now able to identify the plasma sheet flow bursts as the origin of energetic particle injections into the inner magnetosphere and understand some important consequences of their inward penetration. After identifying the FB entropy as the parameter which controls the penetration, we now may predict the penetration distance of individual flow burst and understand how significantly its deep access (to GEO orbit and more inner shells) depends on the stretching of the nightside configuration. Recent observations and simulations identified a considerable plasma pressure increase in front of the flow burst, demonstrated its long relaxation time scale and close relationship to the Substorm Current Wedge (SCW) current system. We now better understand the complicated geometry of the SCW, which particularly includes the region-2-type field aligned currents (in addition to traditional region-1-type ones) and is responsible for the magnetic field dipolarization pattern. The FB intrusion have some other important effects (e.g. bring accelerated plasma into the RC and radiation belt, provide conditions for generating energetic e-precipitation, etc) which are briefly discussed together with remaining unclear issues.

Ground–based optical and ULF/ELF/VLF wave measurements at subauroral latitudes prepared for the ERG project

K. Shiokawa[1], C.W. Jun[1], C. Martinez[1], N. Sunagawa[1], Y. Miyoshi[1], T. Nagatsuma[2], M. Ishii[2], M. Ozaki[3], M. Connors[4], I. Schofield[4], P.T. Jayachandran[5], I. Poddelsky[6], B. Shevtsov[6] and D. Baishev[7]

[1] Solar-Terrestrial Environment Laboratory (STEL), Nagoya University, Japan
[2] National Institute of Information and Communications Technology (NICT), Japan
[3] Kanazawa University, Japan
[4] Athabasca University, Canada
[5] University of New Brunswick, Canada
[6] Institute of Cosmophysical Research and Radio Wave Propagation (IKIR), Russia
[7] Yu.G.Shafer Institute of Cosmophysical Research and Aeronomy (IKFIA), Russia

We develop (1) all-sky aurora/airglow imagers with cooled-CCD detectors, (2) 64-Hz sampling induction magnetometers, and (3) 20-100 kHz sampling loop antennas, which monitor aurora/airglow and ULF/ELF/VLF wave activities at subauroral latitudes. These instruments were used to investigate wave propagation and particle acceleration/loss processes occurring in the inner magnetosphere in collaboration with the Energization and Radiation in Geospace (ERG) satellite project. As shown in Tables 1 and 2, these instruments have been in automatic operation at Athabasca in Canada and Paratunka and Magadan in Far-eastern Russia, and will be installed at Fredericton in Canada and at Zhigansk in Siberian Russia. These longitudinal chain stations at subauroral latitudes give a great opportunity to monitor particle dynamics and ULF/ELF/VLF waves in the inner magnetosphere on a global scale. In this presentation we report several initial results on waves and auroras observed by these instruments to show their measurement capability at subauroral latitudes.

Table 1. Station location, dipole magnetic latitudes (MLAT), and L-value

station name	latitude	longitude	MLAT	L-value
Fredericton, Canada (FRD)	46.4°N	292.6°E	55.9°	3.2
Athabasca, Canada (ATH)	54.7°N	246.7°E	61.7°	4.4
Paratunka, Russia (PTK)	53.0°N	158.2°E	45.8°	2.1
Magadan, Russia (MGD)	60.1°N	150.7°E	51.9°	2.6
Zhigansk, Russia (ZGN)	66.8°N	123.4°E	57.2°	3.4

Table 2. Instruments and start month of routine measurements

station	instruments	start time
FRD	loop antenna/induction magnetometer	Summer 2014
ATH	all-sky camera/induction magnetometer	September 2005
ATH	loop antenna	September 2012
PTK	all-sky camera/induction magnetometer	August 2007
MGD	all-sky camera/induction magnetometer	November 2008
ZGN	induction magnetometer	Summer 2014
ZGN	all-sky camera/loop antenna	Summer 2015

Ultra–relativistic electrons in the Van Allen radiation belts

Y.Y. Shprits[1,2], A. Drozdov[1], D. Subbotin[1], A. Kellerman[1], K.G. Orlova[1], D. Baker[3] and M. Usanova[3]

[1] EPSS, UCLA, USA
[2] Skoltech and EAPS, MIT, USA
[3] LASP, USA

The Van Allen radiation belts consist of energetic electrons and ions at energies above 100 keV trapped by the Earths magnetic field. These very energetic particles may be harmful to satellite electronics and humans in space. Observations together with predictive and data assimilative modeling showed that energetic electrons can be accelerated to relativistic energies by taking energy from ULF and VLF plasma waves during resonant wave-particles interactions. Recent observations by NASAs Van Allen Probes showed an event where three radiation zones were observed at ultra-relativistic energies. The additional middle, and unusually narrow, belt persisted for approximately 4 weeks. Detailed observations from the Van Allen Probes mission and Versatile Electron Radiation Belt (VERB) code modelling demonstrates that different physical processes can dominate acceleration and loss of particles at ultra-relativistic energies, which explains the unusual spacial and temporal structures in the radiation belts.

Reanalysis based on the VERB diffusion code

Y.Y. Shprits, A. Kellerman and A. Drozdov

UCLA, USA

We present the results of the long term reanalysis obtained using the VERB diffusion code and multiple satellites for the CRRES and Van Allen Probes area. We discuss automated estimation of model and data errors, filtration and smoothing, as well as objective determination of the model bias. We demonstrate the results of the reanalysis can provide much better specification of the space environment than measurements alone.

Modeling ultra–relativistic radiation belt electron dynamics during two magnetic storms observed by the Van Allen probes

R.M. Thorne[1], W. Li[1,2], B. Ni[1,2], Q. Ma[1], J. Bortnik[1]
and the EMFISIS and RBSP–ECT Science Teams on the Van Allen Probes

[1] Department of Atmospheric and Oceanic Sciences, University of California, Los Angeles, CA, USA
[2] Department of Space Physics, School of Electronic Information, Wuhan University, Wuhan, Hubei, China

Two magnetic storms on October 9, 2012, and March 17, 2013 led to a rapid enhancement of ultra-relativistic electrons in the outer radiation belt as observed by the REPT instrument on the Van Allen Probes. During both storms strong local peaks in phase space density (PSD), indicative of a local acceleration process, developed near 4 RE in the low-density region outside the storm-time plasmapause. The period of electron enhancement was associated with a strong intensification of whistler-mode chorus emissions observed by the EMFISIS wave instrument on the Van Allen Probes. To simulate the electron dynamics associated with resonant interactions with chorus, we develop a novel model for the global distribution of chorus wave amplitudes using 30-100 keV electron data from the POES satellites. The global wave model, which is consistent with the limited local observations by EMFISIS, is used to derive global rates of electron pitch-angle and energy scattering during the storms, and thus quantitatively evaluate the temporal 2D (pitch-angle and energy) evolution of electron phase space density. Our modeling demonstrates that local acceleration by chorus emissions can account for the observed relativistic electron flux increase near the peaks in PSD and also for the evolving pitch-angle distributions. At locations away from the PSD peaks additional processes such as radial diffusion and other loss processes need to be included, but this will require 3D or 4D modeling. While acceleration to $\sim$MeV energies occurs during many magnetic storms, local acceleration to ultra-relativistic energies ($>$5 MeV) seems to require special conditions. These include: 1. A prolonged period of enhanced convection, which injects plasma sheet electrons into the inner magnetosphere leading to an enhanced seed electron population, lower total plasma density, accompanied by the excitation of intense whistler mode chorus in the low density region outside the plasmasphere; 2. An inflated magnetosphere associated with low solar wind pressure to minimize loss to the magnetopause boundary.

Dawn–dusk asymmetries in the coupled Solar wind–magnetosphere–ionosphere system

A.P. Walsh[1], S. Haaland[2,3], C. Forsyth[4], A.M. Keesee[5], J. Kissinger[6], K. Li[2], A. Runov[7], J. Soucek[8], B.M. Walsh[6,11], S. Wing[9] and M.G.G.T. Taylor[10]

[1] Science and Robotic Exploration Directorate, European Space Agency, ESAC, Villanueva de la Cañada, Madrid, Spain
[2] Max-Planck-Institute for Solar System Research, Göttingen, Germany
[3] Birkeland Institute for Space Science, University of Bergen, Bergen, Norway
[4] UCL Department of Space and Climate Physics, Mullard Space Science Laboratory, Holmbury St. Mary, Surrey, UK
[5] West Virginia University, Morgantown, West Virginia, USA
[6] NASA Goddard Space Flight Center, Greenbelt, Maryland, USA
[7] Department of Earth and Space Sciences, UCLA, Los Angeles, California, USA
[8] Institute of Atmospheric Physics, Czech Academy of Sciences, Prague, Czech Republic
[9] Johns Hopkins University Applied Physics Laboratory, Maryland, USA
[10] Science and Robotic Exploration Directorate, European Space Agency, ESTEC, Noordwijk ZH, Netherlands
[11] Space Sciences Laboratory, University of California, Berkeley, USA

Dawn–dusk asymmetries are ubiquitous features of the coupled solar-wind–magnetosphere–ionosphere system. During the last decades, increasing availability of satellite and ground-based measurements has made it possible to study these phenomena in more detail. Numerous publications have documented the existence of persistent asymmetries in processes, properties and topology of plasma structures in various regions of geospace. In this paper, we present a review of our present knowledge of some of the most pronounced dawn–dusk asymmetries. We focus on four key aspects: (1) the role of external influences such as the solar wind and its interaction with the Earth's magnetosphere; (2) properties of the magnetosphere itself; (3) the role of the ionosphere and (4) feedback and coupling between regions. We have also identified potential inconsistencies and gaps in our understanding of dawn–dusk asymmetries in the Earth's magnetosphere and ionosphere.

Contributed Oral Presentations

A study of the spacecraft potential of Cluster while in active control

M. Andriopoulou, R. Nakamura and K. Torkar

Space Research Institute, Austrian Academy of Sciences

Ion emitters, as part of the Active Spacecraft Potential Control (ASPOC) instruments onboard the Cluster spacecraft, have been operational in at least one of the four spacecraft from the beginning of the mission till March 2005. Their operation ensures that the floating potential of the spacecraft, which is determined by the equilibrium of the acting currents (mainly the photoelectron current due to their emission at the spacecraft surface, the current of the ambient electrons and the ion beam current from ASPOC in low-density plasma regions), is reduced, allowing the measurements of cold electrons that would otherwise be masked by photoelectrons to be resolved and also enabling higher accuracy in the electric field measurements.

In this work, we focus on reconstructing the uncontrolled spacecraft potential using controlled spacecraft potential measurements at different magnetospheric regions and time intervals. Such reconstructions can allow electron density estimations obtained from spacecraft potential measurements also under the controlled potential (ASPOC-on) condition.

This work has been performed as preparation for the upcoming Multiscale Magnetospheric Mission (MMS) mission.

ULF wave observations in the topside ionosphere by the Swarm mission

G. Balasis[1], I.A. Daglis[2,1], C. Papadimitriou[1,2], M. Georgiou[1,2] and R. Haagmans[3]

[1] IAASARS, National Observatory of Athens, Athens, Greece
[2] Department of Physics, University of Athens, Athens, Greece
[3] ESTEC, European Space Agency, Noordwijk, Netherlands

Recently developed automated methods for deriving the characteristics of ultra low frequency (ULF) waves (Balasis et al., 2012, 2013) can be effectively applied to the Swarm datasets in order to retrieve, on an operational basis, new information about the near-Earth electromagnetic environment. Processing Swarm measurements with these methods will help to elucidate the processes influencing the generation and propagation of ULF waves, which in turn play a crucial role in magnetospheric dynamics. Moreover, a useful platform based on a combination of wavelet transforms and artificial neural networks has been developed to monitor the wave evolution from the Earth magnetosphere (using Cluster observations) through the topside ionosphere (with Swarm measurements) down to the surface (using ground-based magnetometer arrays recordings). Here we present the first ULF wave observations by Swarm, obtained by applying our analysis tools to the first nine months of the mission Absolute Scalar Magnetometer (ASM) and Vector Field Magnetometer (VFM) data.

System science approach to the magnetospheric physics

M.A. Balikhin, R.J. Boynton and S.A. Billings

ACSE, University of Sheffield, Sheffield, United Kingdom

There are many dynamical systems in nature that are so complex that their mathematical models can not be deduced from first physical principles at the present level of our knowledge. Obvious examples are organic cells and human brains. The system approach has been developed to understand such complex objects. The system approach employs advanced experimental data analysis methodologies to identify patterns in the overall system behaviour, that provide information regarding the linear and nonlinear processes involved in the dynamics of that system. This, in combination with the knowledge deduced from the first principles, provides the opportunity to find mathematical relationships that govern the evolution of a particular physical system. The presentation aims to explain how exploitation of the cutting edge data analysis techniques of system science can assist in the understanding and modelling of magnetospheric processes.

On the fine structure of dipolarization fronts

M.A. Balikhin[1], A. Runov[2], S.N. Walker[1], I. Dandouras[3,4] and A. Fazakerley[5]

[1]ACSE, University of Sheffield, Sheffield, United Kingdom.
[2]IGPP, UCLA, California, USA
[3]UPS-OMP, IRAP, Toulouse, France
[4]CNRS, IRAP, 9 Av. Colonel Roche, Toulouse, France
[4]MSSL, UCL, London, UK

Measurements from the closely spaced Cluster spacecraft are used to study the structure of the magnetic and electric fields within the magnetic ramp of dipolarisation fronts (DF) observed close to the neutral sheet and the midnight meridian ($Y_{GSM} < 3\,\mathrm{R}_E$). The spacecraft separation was small enough ($<$ 300 km) to treat the magnetic ramp of the DF front as a planar structure as indicated from variance analysis. The finite value of the magnetic field along the minimum variance direction for the events studied indicates that the dipolarisation front structure was distinct from a tangential discontinuity. In addition to the main increase of the magnetic field in the maximum variance component, strong oscillations were observed in the intermediate component. The presence of this oscillatory structure results in an expansion of the region in which a change of magnetic pressure occurs, the size of which is typically an ion Larmor radius or greater. This widening is important in maintaining the pressure balance at the edge of the DF. This phenomenon resembles observations of intense current sheets in the magnetotail and also laboratory experiments of current sheet formation, in which a similar widening of the ramp region has been observed. In this paper we argue against the idea that an electron temperature anisotropy, resulting in electron curvature currents, can explain the formation of the oscillatory structures observed at DFs. These oscillations can be explained as eigen mode waves of the plasma that propagate away from the disturbance (DF) that is moving at subsonic speeds. Oscillations observed within the magnetic ramp indicate field align currents that are expected to be associated with DF.

Relativistic 3D test particle simulations of radiation belt electrons and protons during geomagnetic storms

K. Borremans, J. Lemaire and V. Pierrard

Belgian Institute for Space Aeronomy, Ringlaan-3-Avenue Circulaire, B-1180 Brussels, Belgium

Observations show that during the main phase of a geomagnetic storm an electron dropout occurs in the outer radiation belt. We conduct relativistic 3D test particle simulations, while keeping an eye on the guiding center approximation, the adiabatic invariants, and the mirror points. We launch electrons and protons at different locations and with different pitch angles, simulate Dst events, and analyse the resulting trajectories of the particles. The simulations show that during the main phase of a geomagnetic storm an energetic electron decelerates, and is radially transported outwards until magnetopause shadowing will remove it from the inner magnetosphere. During the recovery phase the reverse happens, an electron accelerates and drifts radially inwards.

Recent progress in understanding the origin of plasmaspheric hiss

J. Bortnik[1], W. Li[1], L. Chen[2], R.M. Thorne[1], V. Angelopoulos[3], C. Kletzing[4], W.S. Kurth[4] and G.B. Hospodarsky[4]

[1] Department of Atmospheric and Oceanic Sciences, University of California, Los Angeles, CA, USA
[2] Department of Physics, University of Texas at Dallas, Richardson, TX 75080, USA
[3] Department of Earth and Space Sciences, University of California, Los Angeles, CA, USA
[4] Department of Physics and Astronomy, University of Iowa, Iowa City, Iowa, USA.

Plasmaspheric hiss is a wideband, incoherent, whistler-mode plasma wave that is found predominantly in inner magnetospheric high-density plasma regions such as the plasmasphere or plasmaspheric drainage plume. The origin of plasmaspheric hiss has been a topic of intense study and controversy ever since its discovery in the late 1960. A recent set of modeling studies has shown that a different plasma wave, namely whistler-mode chorus, could be responsible for creating plasmaspheric hiss by propagating from its source region in the equatorial plasmatrough, and into the plasmasphere.

In this talk, we review some of the early observations made on the THEMIS spacecraft that have shown excellent consistency with model predictions. We also discuss more recent observations made with the Van Allen Probes that reveal a number of curious features: a low frequency component of plasmaspheric hiss that cannot be accounted for by the chorus-hiss mechanism but must be generated *in-situ* by particle injections, as well as a case of plasmaspheric hiss correlated to chorus waves at very high L-shells, almost at the magnetopause.

These observations underscore the importance of coordinated, multi-spacecraft observations, and will provide an overview of our rapidly evolving understanding of plasmaspheric hiss and its complex generation processes.

EnKF–Salammbo data assimilation tool: progress in the framework of the MAARBLE EU–project

S. Bourdarie[1], V. Maget[1], D. Lazaro[1] and I. Sandberg[2,3]

[1] ONERA–The French Aerospace Lab, 2. A. E. Belin 31055 Toulouse, France
[2] IAASARS, Athens, Greece
[2] Department of Physics, University of Athens, Athens, Greece

In the framework of the EU-FP7 MAARBLE project, the Salammbo code and an ensemble Kalman filter is being used to reproduce the electron radiation belt dynamics during storms:
(1) The ONERA data assimilation tool has been improved to ingest count rates instead of flux when the instrument response function is available. As an example, the ESA/SREM radiation monitor has complex response functions (proton and electron events are mixed, and for a given specie the instrument responds to a broad range of energies with different efficiencies) which makes very challenging to get fluxes out of count rates.
(2) Realistic distribution of probable radiation diffusion coefficients have been introduced for various magnetic activities.
(3) Realistic distribution of probable boundary conditions at L*=8 have been implemented for various magnetic activities.
In the present talk, an overview of the progress made on the data assimilation tool in the framework of the MAARBLE EU-project will be given. Validation with third-part data will be shown during magnetic storms. A discussion on the state of the art of radiation belt data assimilation tool will be made to conclude on prospects.

MAARBLE has received fundings from the European Community's Seventh Framework Programme (FP7-SPACE-.2010-1, SP1 Cooperation, Collaborative project) under grant agreement n284520. This paper reflects only the authors' views and the European Union is not liable for any use that may be made of the information contained therein.

Particle–in–cell simulations of whistler–particle interactions: an assessment of the quasi–linear paradigm

E. Camporeale

Center for Mathematics and Computer Science (CWI), Amsterdam, Netherlands

Whistler wave chorus are believed to play a crucial role in the radiation belt dynamics, possibly being crucially responsible for the loss and acceleration of energetic electrons. For this reason, the mechanisms related to the formation and propagation of whistlers in the radiation belt have been intensively investigated during the last decade. It is now generally acknowledged, via observational and simulation studies, that the whistler waves generated close to the magnetic equator through linear temperature anisotropy instabilities undergo an amplitude amplification that is essentially regulated by nonlinear mechanisms.

In this work we focus on the wave-particle interactions between resonant electrons and whistler chorus by employing two-dimensional fully-kinetic, relativistic, Particle-in-Cell (PIC) simulations in a dipole magnetic field. The particles pitch-angle/energy scattering is commonly described through a diffusive process, that results from the quasi-linear approximation of the kinetic theory, and that is based on a certain number of assumptions. We analyze and discuss the pitch-angle/energy scattering of energetic particles observed in the self-consistent PIC simulations. The PIC results are compared with the more commonly used test-particle simulation results. Finally, we comment on the general applicability of the quasi-linear diffusion paradigm.

Initial results from the CRRES/MICS empirical model of ion plasma in the inner magnetosphere

S.G. Claudepierre, J.L. Roeder, M.W. Chen, C.L. Lemon and T.B. Guild

The Aerospace Corporation, El Segundo, CA, USA

We present initial results from a recently developed empirical model of low energy ion plasma (∼1-300 keV/e) in the inner magnetosphere. This model is constructed from data taken by the Magnetospheric Ion Composition Spectrometer (MICS) on-board the Combined Release and Radiation Effects Satellite (CRRES). The model has been constructed in a similar fashion to the Roeder et al., [2005] CAMMICE/MICS model, which used NASA Polar satellite data. The orbital differences between CRRES (GTO) and Polar (highly-inclined polar orbit) result in each spacecraft sampling different portions of the ion pitch-angle distributions. Such models can be used to estimate the average flux for major ion species (e.g. H^+, He^+, He^{++}, O^+) along any orbit in the inner magnetosphere. To construct this new model, CRRES/MICS ion fluxes were computed and sorted into bins of magnetic coordinates L, MLT, MLAT, equatorial pitch-angle and activity indices. Preliminary comparisons are made between the CAMMICE/MICS and CRRES/MICS models, highlighting the strengths and limitations of both. We find that, on average, the H^+ flux from the CRRES and CAMMICE models is comparable, while the O^+ flux is considerably higher in the CRRES model. We also fit kappa functions to the H^+ distribution functions from the CAMMICE model and investigate the dependence of the kappa parameter on L and MLT.

Major results of the MAARBLE FP7–Space project

I.A. Daglis[1,2], I.R. Mann[3], S. Bourdarie[4], Y. Khotyaintsev[5], O. Santolik[6,7], R.B. Horne[8] and D.L. Turner[9]

[1] Department of Physics, University of Athens, Athens, Greece
[2] IAASARS, National Observatory of Athens, Athens, Greece
[3] Department of Physics, University of Alberta, Edmonton, AB T6G 2R3, Canada
[4] ONERA, The French Aerospace Lab, 2. Av. E. Belin 31055 Toulouse, France
[5] Swedish Institute of Space Physics, Uppsala, Sweden
[6] Faculty of Mathematics and Physics, Charles University, Prague, Czech Republic
[7] Institute of Atmospheric Physics, Prague, Czech Republic
[8] British Antarctic Survey, Natural Environment Research Council, Cambridge, England
[9] UCLA, Los Angeles, CA, USA.

We present major results of the MAARBLE (Monitoring, Analyzing and Assessing Radiation Belt Loss and Energization) project. MAARBLE has been implemented by a consortium of seven institutions (five European, one Canadian and one US) with support from the European Community's Seventh Framework Programme. The MAARBLE project has employed multi–spacecraft monitoring of the geospace environment, complemented by ground-based monitoring, in order to analyze and assess the physical mechanisms leading to radiation belt particle energization and loss. Particular attention has been paid to the role of ULF/VLF waves. Within MAARBLE we have created a database containing properties of ULF and VLF waves, based on measurements from the Cluster, THEMIS and CHAMP missions and from the CARISMA and IMAGE ground magnetometer networks. The database is now available to the scientific community through the Cluster Science Archive as auxiliary content. Based on the wave database, a statistical model of the wave activity dependent on the level of geomagnetic activity, solar wind forcing, and magnetospheric region is being developed. Multi-spacecraft particle measurements have been incorporated into data assimilation tools, leading to a more accurate estimate of the state of the radiation belts. The synergy of wave and particle observations is in the core of MAARBLE research studies of radiation belt dynamics. Results and conclusions from these studies will also be presented in this talk.

The MAARBLE (Monitoring, Analyzing and Assessing Radiation Belt Energization and Loss) collaborative research project has received funding from the European Unions Seventh Framework Programme (FP7–SPACE–2011–1) under grant agreement no. 284520.

Long–term analysis of cosmic ray background seen by the RAPID electron detector on Cluster

P.W. Daly

Max Planck Institute for Solar System Research, Göttingen, Germany

Since the beginning of Cluster operations in 2001, the RAPID/IES electron detectors (39–400 keV) have consistently measured a very low background rate of $\sim<1$ count/sec. At the highest time resolution of 4 sec, during times when no obvious events are occurring, the detectors mainly register 0 counts with occasional single, and rarely double counts. However, when averaged over an interval of at least 1 min, a fairly constant rate is determined, subject to variations due to Poisson statistics.

In this work, we analyse 13 years of background data to find its spectral and temporal variations, if any. First, the counts are averaged over 60 min, each interval containing $\sim$900 individual 4-sec "samples"; next, a statistical analysis is performed to test if the resulting distribution is consistent with a Poisson distribution with a single mean value. Finally, for each orbit ($\sim$54 hr) the lowest background value is taken. This is repeated for each of the 9 detectors, 6 energy channels, and 4 spacecraft.

The results show that the background appears in all energy channels, is omnidirectional, and displays a time variation with an 11-year cycle. Similar backgrounds have been observed on Cassini at Saturn, which were attributed to galactic cosmic rays modulated by the solar cycle. It is therefore likely that RAPID too is subject to this cosmic ray "contamination", since very high energy particles can actually be registered within its lower energy range.

Modelling CLUSTER observations of cold ionospheric plasma outflow in polar cap arcs

J. De Keyser[1], R. Maggiolo[1], L. Maes[1] and I. Dandouras[2]

[1] Space Physics Division, Belgian Institute for Space Aeronomy, Brussels, Belgium
[2] University of Toulouse, Institut de Recherche en Astrophysique et Planetologie, Toulouse, France

One source for cold plasma in the magnetosphere are polar cap arcs. Earlier statistical studies based on CLUSTER data have suggested that small scale polar cap arcs can be regarded as quasi-electrostatic structures bounded by tangential discontinuity interfaces. The CLUSTER signatures of such arcs include a bipolar perpendicular electric field signature and the observation of an upward accelerated beam of ionospheric ions with an ionospheric O^+/H^+ ratio inside the structure. The region inside the polar cap arc corresponds to an upward current. The outflowing ions have been accelerated electrostatically below the spacecraft. Narrow return current regions are found on either side of the structure, with narrow beams of electrostatically accelerated upgoing electrons. We use a model that describes the particles, the currents, and the electric and magnetic field configuration in polar cap arcs. The model takes the magnetospheric electrostatic potential difference between the structure and its environment as a boundary condition. It self-consistently computes the detailed bipolar electric potential variation across the structure and explains the strong localized electric fields at the interfaces that confine the structure. Current continuity determines the electric currents in the circuit and allows to compute the ionospheric electric potential and the parallel potential difference. This parallel potential difference controls the energy of the accelerated ions and electrons, which are subsequently included in the magnetospheric structure to obtain a self-consistent solution.

Use of the IMAGE ground magnetometer network ULF wave observations to derive radial diffusion coefficients in the radiation belts

S. Dimitrakoudis[1], G. Balasis[1], C. Papadimitriou[1,2], A. Anastasiadis[1] and I.A. Daglis[2]

[1] National Observatory of Athens
[2] University of Athens

Approximately half of all operational satellites are in orbits that pass through the radiation belts, where they are susceptible to internal and surface charging by energetic electrons. In the interest of risk assessment, it is important to develop reliable models of electron acceleration and propagation in these radiation belts. Although there is as yet no universally accepted dominant mechanism for those effects, a prominent one that has been under consideration since 1965 is adiabatic radial diffusion, generated by fluctuations of ultra-low-frequency (ULF) waves. In situ measurements of those wavespower spectral densities would require a large number of satellites operating in different orbits, which is currently prohibitively expensive. As a more practical alternative, measurements from ground-based magnetometers can be continuously taken and then mapped to their equivalent L-shells in the equatorial plane. Here we have used 11 years of dayside ground magnetometer measurements from ten IMAGE stations to derive the electric field diffusion coefficient from L=3.34 to 6.46 and, tentatively, up to L=13.6. A previous study by Ozeke et al. (2012), using CARISMA and SAMNET measurements in the same way, had found that the magnetic field diffusion coefficient is negligible compared to the electric one, thus justifying our focus on the latter. We have processed the measurements with four binning methods, as functions of Kp, Dst, solar wind speed and solar wind pressure. Upper and lower quartiles were calculated for all initial values and derived diffusion coefficients, and their mean ratios were found to be lowest when binning with solar wind pressure. This may have implications on future radiation belt modeling, where the choice of geomagnetic indices used in binning can affect the accuracy of simulations and forecasts. Our expansion of calculations to very high L-values shows that a linear fit to the lower L-value data can be safely extrapolated up to L=13.6 under calm geomagnetic conditions, but not during storms.

This research has been co-nanced by the European Union (European Social Fund - ESF) and Greek national funds through the Operational Program "Education and Lifelong Learning" of the National Strategic Reference Framework (NSRF) - Research Funding Program: Thales. Investing in knowledge society through the European Social Fund.

Numerical modelling of ULF waves in a magnetospheric waveguide

T. Elsden and A.N. Wright

Department of Mathematics and Statistics, University of St Andrews, St Andrews, Fife, Scotland, KY16 9SS

We model ultra low frequency (ULF) waves in the magnetosphere numerically assuming an ideal, low-β, inhomogeneous plasma waveguide. The waveguide is based on the hydromagnetic box model implemented by, for example, [*Kivelson & Southwood*, 1986]. We investigate driving the magnetopause boundary with a pressure perturbation, in order to simulate solar wind dynamic pressure fluctuations disturbing the magnetopause. The model is applied to two observations from [*L. B. N. Clausen, T. K. Yeoman, R. Behlke, and E.A. Lucek*, 2008] and [*Michael Hartinger, Vassilis Angelopoulos, Mark B. Moldwin, Yukitoshi Nishimura, Drew L.Turner, Karl-Heinz Glassmeier, Margaret G. Kivelson, Jürgen Matzka, and Claudia Stolle*, 2012] . The former discusses a large scale Pc4 pulsation observed by Cluster believed to couple to a field line resonance (FLR), the latter a Pc5 global mode observed by THEMIS. Our model is able to reproduce similar wave signatures to those in the data and despite its simplicity, can shed light on the nature of propagating waveguide modes.

Van Allen probes, NOAA, and ground observations of an intense Pc 1 wave event extending 12 hours in MLT

M.J. Engebretson[1], J.L. Posch[1], J.R. Wygant[2], C.A. Kletzing[3], M.R. Lessard[4], R.B. Horne[5], G.D. Reeves[6], A.Y. Ukhorskiy[7], J.F. Fennell[8], K. Oksavik[9] and T. Raita[10]

[1] Augsburg College, Minneapolis, MN
[2] University of Minnesota, Minneapolis, MN
[3] University of Iowa, Iowa City, IA
[4] University of New Hampshire, Durham, NH
[5] British Antarctic Survey, Cambridge, UK
[6] Los Alamos National Laboratory, Los Alamos, NM
[7] Applied Physics Laboratory, Johns Hopkins University, Laurel, MD
[8] Aerospace Corporation, El Segundo, CA
[9] Birkeland Centre for Space Science, University of Bergen, Bergen, Norway
[10] Sodankylä Geophysical Observatory, University of Oulu, Sodankylä, Finland

On February 23, 2014 a Pc 1 wave event extending 8 hours in UT and 12 hours in MLT was observed at Halley, Antarctica and Ivalo, Finland in the dawn sector, and by both Van Allen Probes spacecraft from late morning through local noon. The wave activity was stimulated by a gradual 4-hour rise and subsequent sharp increases in solar wind pressure. Intense hydrogen band right-hand-polarized Pc 1 wave activity (up to 25 nT p-p) with very similar time variations appeared for over 4 hours at both Van Allen Probes, located ∼8 and ∼9 hours east of Halley. Waves appeared when these spacecraft were outside the plasmapause, with densities ∼5-20 cm^{-3}. Ten passes of NOAA-POES and METOP satellites near the northern hemisphere footpoint of the Van Allen Probes (over Siberia) show the presence of 30-80 keV subauroral proton precipitation. This is the longest-duration and most intense Pc1 event we have yet observed with the Van Allen Probes. The combination of its duration, intensity, and large local time extent (from before 02 to nearly 14 hours MLT) suggests that it might have a significant effect on the ring current, and possibly even electrons in the outer radiation belt.

Inner radiation zone and slot region electron fluxes: Van Allen probes ECT/MagEIS data

J.F. Fennell[1], S.G. Claudepierre[1], P. O'Brien[1], J.B. Blake[1], J.H. Clemmons[1], H. Spence[2], G. Reeves[3] and J.L. Roeder[1]

[1] Space Science Application Laboratory, The Aerospace Corp, El Segundo, California, USA
[2] Institute for the Study of Earth, Oceans, and Space, University of New Hampshire, Durham, New Hampshire, USA
[3] Space and Atmospheric Sciences Group, Los Alamos National Laboratory, Los Alamos, New Mexico, USA

The electron content of the inner radiation zone and slot region is seldom studied because of lack of good access and the serious background conditions there. The backgrounds created by the high-energy protons that exist in the inner radiation zone and extending into the lower parts of the slot region make it difficult to obtain good measurements of the electron fluxes. In addition, the backgrounds from penetrating bremsstrahlung x-rays produced by energetic electrons striking the spacecraft can cause difficulty for electron flux measurements of the central and outer edge of the slot region. The Van Allen Probes traverse the slot and inner zone regions twice an orbit near the magnetic equator. The MagEIS electron sensors on the Probes were designed to meet this challenge and provide clean electron measurements over a wide range of energies (0.03 to 4 MeV). New techniques have been used to remove the backgrounds and provide clean measurements in these regions. We find that deep in the inner zone the electron fluxes at energies above 800 keV are very low or non-existent while there are significant fluxes of electrons at lower energies, down to the MagEIS limit of 30 keV. The slot region fluxes have been similarly dominated by such lower energy electron fluxes thus far during the Van Allen Probes mission. The techniques used and the new electron flux results will be described and discussed in detail.

Long term response of energetic electrons in the inner magnetosphere

J.F. Fennell

Space Science Application Laboratory, The Aerospace Corp, El Segundo, California, USA

We use HEO observations, taken since 1998, to examine the inner magnetospheres energetic electron response to both geomagnetic storms and extended quieting periods of solar cycles 23 and 24. We follow the penetration and enhancements of the electrons as a function of L value using HEO3 (and in some parts, HEO1) observations. HEO3 measures electrons of >130, >230, >450, >630, >1500 and >3000 keV and makes four traversals of the L=2–7 R_e region each day. HEO1 measures electrons >130, >230, >1500, >4000, >6500, and >8500 keV down to L=4 every day and down to L=2.5 during some intervals. We find that moderate activity often caused enhancements in the <300 keV electron "seed" populations down to L=3.0 which are not accompanied by enhancements in relativistic electron fluxes for L<5, indicating that the presence of the "seed" populations is not sufficient to lead to post storm enhanced relativistic fluxes. These observations clearly show the long quiet period of the last solar minimum and differences between the maxima for solar cycles 23 and 24.

Interaction of magnetic clouds with the terrestrial bow shock and implications on their geoeffectivity

D. Fontaine, L. Turc and P. Savoini

LPP-CNRS, Palaiseau, France

Magnetic clouds are known as very geoeffective solar events. Statistics show that the orientation of their magnetic field and the state of preceding or following solar winds contribute to their impact on the terrestrial magnetosphere, but that other factors should also play a role. We investigate here the role of the terrestrial bow shock. Before reaching the terrestrial magnetosphere, magnetic clouds first interact with the terrestrial bow shock which contributes to slow down the solar wind, and the interaction with the magnetosphere is finally performed by this downstream decelerated plasma. Cluster observations in the magnetosheath and at bow shock crossings reveal different features of the magnetic field direction of magnetic clouds downstream of a bow shock: it can remain similar, rotate or be strongly modified relative to the upstream magnetic field. We discuss the origin of these different behaviours and their consequences for the magnetic clouds' geoeffectivity.

How plasma sheet temperature varies with upstream solar wind conditions and affects substorm intensity

C. Forsyth[1], C.E.J. Watt[2], I.J. Rae[1], A.N. Fazakerley[1], P. Boakes[3] and R. Nakamura[3]

[1] UCL Mullard Space Science Laboratory, Dorking, Surrey, UK
[2] University of Reading, Reading, UK
[3] Institut für Weltraumforschung, Graz, Austria

In the canonical model of the magnetospheric substorm, energy is extracted from the solar wind and being stored as magnetic energy in the magnetotail lobes through dayside reconnection. An increase in the flaring angle of the magnetosphere increases the proportion of the solar wind ram pressure transmitted into the magnetosphere and thus the pressure in the plasma sheet. In this study, we show that increase in plasma sheet pressure associated with increased solar wind driving results in an increase in plasma sheet temperature, rather than density, as one would expect from the thermodynamics of a gas adiabatic medium. Furthermore, we show that there is a weak link between the temperature of the plasma sheet just prior to onset and the magnitude of the minimum SML in the subsequent substorm. We do this statistically, making use of 9 years of Cluster tail data and the ECLAT region analysis to provide over 19 million data points. These results show an additional energy pathway for solar wind energy input into the magnetosphere that may have a significant impact on the substorm cycle.

Filed–aligned current and electric field observed near the dipolarization front

S.Y. Fu[1], W.J. Sun[2] and G.K. Parks[2]

[1] Peking University, Beijing,China
[2] Space Sciences Laboratory, UC Berkeley, USA

Dipolarization front is often observed in front of a high speed flow and supposed to be formed by the interaction between the flow plasma and the background plasma. Here we report the research results of the current densities associated with dipolarization fronts (DFs) in the geomagnetic tail and electric field associated with DFs using Cluster observations. It is found that region 1 current sense flowing inside the DFs and region 2 sense just in front of DF (in the Bz dips). Applying multi-spacecraft technique, we evaluate each term in the generalized Ohm law. Case study reveals that in the plasma flow frame there are electric fields directed normal to the DF in the magnetic dip region ahead of the DF as well as in the DF layer, but in opposite directions. Case and statistical studies show that Hall electric field become important in both regions; the contribution of electron pressure gradient term to the electric field is negligible. We conclude that the ions decouple from the magnetic field in the DF layer and dip region, whereas electrons are still rozen-in

Dependence of radiation belt electron enhancements on the Earthward propagation of Pc5 waves during magnetic storms

M. Georgiou[1,2], I.A. Daglis[2,1], E. Zesta[3], G. Balasis[1], I.R. Mann[4], Ch. Katsavrias[1,2] and K. Tsinganos[2,1]

[1] IAASARS, National Observatory of Athens, Penteli, 15236, Greece
[2] Department of Physics, University of Athens, Panepistimioupoli Zografou, 15784, Greece
[3] Goddard Space Flight Center, National Aeronautics and Space Administration, Greenbelt, MD 20771, USA
[4] Department of Physics, University of Alberta, Edmonton, AB T6G 2R3, Canada

Low-energy electrons are accelerated to relativistic energies through different mechanisms, transporting them across their drift shells to the outer radiation belt. Of acceleration mechanisms, radial diffusion describes the result of ultra low frequency (ULF) magnetic field variations resonantly interacting with radiation belt electrons. In this study, we analyzed the response of relativistic electrons in the outer radiation belt to 39 intense and moderate magnetic storms which occurred between 2001 and 2004. The relativistic electron population appeared enhanced in observations from the low-altitude SAMPEX satellite and the geosynchronous GOES satellites following 27 of the magnetic storms. We then compared relativistic electrons observations with concurrent wave power enhancements at ULF frequencies detected by the IMAGE and CARISMA ground magnetometer arrays as well as other networks collaborating in SuperMAG. During the course of the magnetic storms characterized by increased relativistic electron fluxes in the recovery phase as compared to the pre-storm values, Pc5 wave power enhancement were observed nearly simultaneously at different magnetic latitudes. More intense magnetic storms were accompanied by greater ULF wave power enhancements tending to be more pronounced at magnetic stations located at lower L-shells. Furthermore, the inward shift of peak and inner boundary of the outer electron radiation belt followed the Pc5 wave activity penetrating to L-shells as low as 4. On the other hand, 12 magnetic storms characterized by losses of electrons were related with relatively low Pc5 wave activity. These observations provide support for the hypothesis that enhanced Pc5 ULF wave activity distinguishes magnetic storms resulting in increased relativistic electron fluxes in the outer radiation belts from those that do not. Particularly, Pc5 wave activity extending deep in the magnetosphere is common among magnetic storms with enhanced fluxes of relativistic electrons.

This work has received support from the European Unions Seventh Framework Programme (FP7-SPACE-2011-1) under grant agreement no. 284520 for the MAARBLE (Monitoring, Analysing and Assessing Radiation Belt Energization and Loss) collaborative research project.

Two–scale nature of electron solitary waves at the dayside magnetopause

D.B. Graham, Yu.V. Khotyaintsev, A. Vaivads and M. André

Swedish Institute of Space Physics, Uppsala, Sweden

Electron solitary waves (ESWs) are observed at Earth's magnetopause with two distinct timescales, differing by an order of magnitude. These ESWs are associated with asymmetric reconnection between the cold dense magnetosheath plasma and the hot tenuous magnetospheric plasma. The two timescales are shown to be due to electron holes of comparable lengths $\sim 6\,\lambda_D$ propagating at distinct speeds. The slow ESWs have speeds of $v \sim 100\,\mathrm{km\,s^{-1}}$, while the fast ESWs have $v \sim 1000\,\mathrm{km\,s^{-1}}$. The ESWs are associated with unstable electron distributions near the reconnection separatrices. The mechanisms responsible for ESW generation and implications for asymmetric reconnection at the magnetopause are discussed.

Experimental analysis of dispersion relations of EMIC triggered emissions

B. Grison[1], O. Santolik[1,2] and N. Cornilleau–Wehrlin[3,4]

[1] Institute of Atmospheric Physics AS CR, Czech Republic
[2] Charles University, Czech Republic
[3] LPP CNRS, France
[4] Observatoire de Meudon, France

The wavenumber k is a key parameter to understand the physics of the interactions between the electromagnetic waves and the ionized particles in space plasmas. Search-coil magnetometers and electric antennas measure time series of both magnetic and electric field fluctuations, respectively. Using three orthogonal magnetic components and two electric antennas, it is possible to estimate n/Z where n is the refractive index and Z the transfer function of the interface between the plasma and the electric antennas. Assuming $Z = 1$ for ULF waves we can thus obtain the wavenumber.

Large EMIC triggered emissions have recently been observed close to the plasmapause nightsisde in the inner magnetosphere region [Pickett et al., 2010]. The frequency-time dispersion and the high level of coherence are the most typical observed properties of EMIC triggered emissions. Considering the large frequency extent of these emissions, we reconstruct their dispersion relation based on estimations of the refractive index. We compare our results with the theoretical relation dispersion in the cold plasma approximation. Discrepancies are discussed in terms of theoretical approximations and uncertainties of our technique.

The research leading to these results has received funding from the European Community Seventh Framework Programme (FP7PACE010) under grant agreement n. 284520 (MAARBLE).

Vlasov simulation of the trapping and loss of auroral electrons

H. Gunell[1], L. Andersson[2], J. De Keyser[1] and I. Mann[3,4]

[1] Belgian Institute for Space Aeronomy, Avenue Circulaire 3, B-1180 Brussels, Belgium
[2] University of Colorado, Laboratory for Atmospheric and Space Physics, Boulder, Colorado 80309, USA
[3] Eiscat Scientific Association, P. O. Box 812, SE-981 28 Kiruna, Sweden
[4] Department of Physics, Umeå University, SE-901 87 Umeå, Sweden

In the auroral acceleration region, electric fields that are parallel to the magnetic fields contribute to the acceleration of the electrons that cause the auroral emissions. Therefore, these parallel electric fields form an integral part of the auroral current circuit. The parallel electric fields can be supported by the magnetic mirror field, by electric double layers, or both.

We have performed Vlasov simulations of the plasma on a magnetic field line from the equatorial magnetosphere to the auroral ionosphere. In the upward current region, we found that about two thirds of the total voltage is concentrated in a stationary double layer at an altitude of about one earth radius (*Gunell, et al.*, Ann. Geophys., **31**, 1227–1240, 2013).

We present numerical experiments where the total voltage between the ionosphere and the equatorial magnetosphere is changed during the course of the simulation. We start from a state where the total acceleration voltage is 3 kV and there is a double layer approximately 5000 km above the ionospheric end of the system. When the voltage is increased, low energy electrons are trapped between the double layer and the magnetic mirror in a previously unoccupied part of velocity space. When the voltage subsequently is decreased these trapped electrons are lost. If the voltage first is decreased and then increased back to its initial value, the newly trapped electrons remain trapped. An implication of the difference between the two cases is that the electron pitch angle distribution, at Cluster altitudes, carries information about the recent history of the acceleration voltage. In both cases, most of the change in voltage, ΔV, is assumed by the double layer, in agreement with a recent study of Cluster data that could confine most of ΔV to altitudes below the spacecraft (*Forsyth et al.*, JGR, **117**, A12203, 2012). Hysteresis effects are seen in the double layer position.

This work was supported by the Belgian Science Policy Office through the Solar-Terrestrial Centre of Excellence and by PRODEX/Cluster contract 13127/98/NL/VJ(IC)-PEA 90316.

Characteristics of the flank magnetopause: Cluster results

S. Haaland[1,2], J. Reistad[2], P. Tenfjord[2], L. Maes[3], J. De Keyser[3], R. Maggiolo[3], C. Anekallu[4] and N. Dorville[5]

[1] Max-Planck-Institute, Göttingen, Germany
[2] Birkeland Center for Space Science, University of Bergen, Norway
[3] Belgian Institute of Space Science, Brussels, Belgium
[4] University College London, Mullard Space Science Laboratory, Holmbury St. Mary, United Kingdom
[5] Laboratoire de Physique des Plasmas, École Polytechnique, Universite Pierre et Marie Curie, Palaiseau, France

The terrestrial magnetopause - a thin current sheet forming the boundary between the geomagnetic field on one side and the and the shocked solar wind on the other side - is often well defined on the dayside but more variable and difficult to characterize at the flanks. We have used a large number of Cluster measurements to calculate macroscopic features such as thickness, location, motion and orientation of the low latitude flank magnetopause. The results show that the flank magnetopause is significantly thicker than the dayside magnetopause and also possesses a pronounced and persistent dawn-dusk asymmetry. Thicknesses vary from 150 - 5000 km, with an average thickness of around 1800 km on dawn and 1500 km on dusk. Current densities are on average higher on dusk, suggesting that the total current at dawn and dusk are similar. For a number of crossings we were also able to derive detailed current density profiles from multi-spacecraft observations. The profiles show that the magnetopause often consist of several adjacent current sheets, often with different current directions.

Relativistic (MeV) electron acceleration at geosynchronous orbit during High-Intensity Long-Duration Continuous AE Activity (HILDCAA) events

R. Hajra[1], B.T. Tsurutani[2] and E. Echer[1]

[1] Instituto Nacional de Pesquisas Espaciais, Sao Jose dos Campos, SP, Brazil
[2] Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA

Relativistic (MeV) electrons at geosynchronous orbit during solar cycle 23 are well-correlated with the intervals of High-Intensity, Long-Duration, Continuous AE Activity (HILDCAA) events. The response of the energetic electrons to HILDCAAs is found to vary with solar cycle phase. The initial electron fluxes are lower for events occurring during the ascending and solar maximum (AMAX) phases than for events occurring during the descending and solar minimum (DMIN) phases. The flux increases for the DMIN-phase events are $> 50\%$ larger than for the AMAX-phase events. It is concluded that electrons are accelerated to relativistic energies most often and most efficiently during the DMIN-phases of the solar cycle. We propose two possible solar UV-related mechanisms to explain this solar cycle effect. Enhanced $E > 0.6$ MeV electron fluxes at geosynchronous orbit are first detected ~ 1 day after the statistical onset of HILDCAAs, $E > 2.0$ MeV electrons after ~ 1.5 days, and $E > 4.0$ MeV electrons after ~ 2.5 days. As expected from the above, for short-duration ($D \leq 3$ days) HILDCAA events, there are no $E > 4.0$ MeV electron enhancements. For longer-duration ($D > 3$ days) HILDCAAs, the $E > 0.6$ MeV and $E > 2.0$ MeV fluxes appear to reach saturation values of $\sim 3\text{-}4\times10^5$ and $5\text{-}6\times10^3$ cm^{-2} s^{-1} sr^{-1} respectively. The above results are consistent with the general concepts of theoretical models of relativistic electron acceleration (and losses). Relativistic electrons are bootstrapped from high energy electrons: the $E > 0.6$ MeV electrons are accelerated from HILDCAA-injected $E \sim 100$ keV electrons, the $E > 2.0$ MeV electrons from the $E > 0.6$ MeV electron population, and consequently the $E > 4.0$ MeV electrons are accelerated from the $E > 2.0$ MeV population, etc. Relativistic electron acceleration and decay timescales will be provided for wave-particle investigators to attempt to match their models to empirically derived values.

Dual–spacecraft reconstruction of a three–dimensional magnetic flux rope at the Earth's magnetopause

H. Hasegawa[1], B.U.Ö. Sonnerup[2], S. Eriksson[3], T.K.M. Nakamura[4] and H. Kawano[5]

[1] Institute of Space and Astronautical Science, JAXA
[2] Thayer School of Engineering, Dartmouth College
[3] Laboratory for Atmospheric and Space Physics, University of Colorado
[4] X-Computational Physics Division, Los Alamos National Laboratory
[5] International Center for Space Weather Science and Education, Kyushu University

We present first results of a data analysis method, developed by Sonnerup and Hasegawa (2011), for reconstructing three-dimensional (3-D), magnetohydrostatic structures from data taken as two closely spaced satellites traverse the structures. The method is applied to a flux transfer event (FTE), which was encountered on 27 June 2007 by at least three (TH-C, TH-D, and TH-E) of the five THEMIS probes and was situated between two oppositely directed reconnection jets near the subsolar magnetopause under a southward interplanetary magnetic field condition. The recovered 3-D field indicates that a magnetic flux rope with a diameter of $\sim$3000 km was embedded in the magnetopause. The FTE flux rope obviously had a significantly 3-D structure, because the 3-D field reconstructed from the data from TH-C and TH-D (separated by $\sim$390 km) better predicts magnetic field variations actually measured along the TH-E path than does the 2-D Grad-Shafranov reconstruction using the data from TH-C (which was closer to TH-E than TH-D and was at $\sim$1000 km from TH-E). Such a 3-D nature suggests that reconnected field lines from the two reconnection sites are entangled in a complicated way through their interaction with each other. The generation process of the observed 3-D flux rope is discussed on the basis of the reconstruction results and pitch-angle distribution of electrons observed in and around the FTE.

The transition from asymmetric to symmetric collisionless magnetic reconnection

M. Hesse[1], N. Aunai[2] and M. Kuznetsova[1]

[1] NASA GSFC, Greenbelt, MD USA
[2] IRAP, Toulouse, France

Magnetic reconnection at the Earths magnetopause facilitates the transfer of mass, energy, and momentum from the solar wind into the Earths magnetosphere. Owing to the variability of the solar wind plasma and magnetic field, the reconnection process typically involves different conditions on both inflow sides, but occasionally more symmetric conditions are encountered as well. Based on prior research we now know that the structure of the reconnection diffusion region depends substantially on the symmetry (or lack thereof) of the inflowing plasmas and magnetic fields. It is therefore of considerable interest to investigate the transition of one scenario to the other - in particular for the purpose of understanding the role of plasma mixing, heating, and of features such as pressure nongyrotropies. This presentation will focus on recent theory and modeling results pertaining to these topics, and it will illuminate the means by which these kinetic processes play a role in determining the reconnection rate.

Confronting the AP9/AE9 radiation belt models with spacecraft data and other models

D. Heynderickx[1], P.R. Truscott[2], H. Evans[3] and E.J. Daly[3]

[1]DH Consultancy BVBA, Leuven, Belgium
[2]Kallisto Consultancy Limited, Farnborough, United Kingdom
[3]ESA/ESTEC, Noordwijk, The Netherlands

Usage of the AP9/AE9 model (now commonly referred to as IRENE) in radiation analysis applications has revealed significant differences with results obtained with older radiation belt models for some orbit types. Consequently, an ESA sponsored activity was started to validate the new model results against other radiation belt models and in situ datasets. In addition, the optimal implementation of the new models in existing ESA software packages and tools was investigated.

A thorough evaluation of the new models has been performed under ESA Contract No. 4000108483/13/NL/AK. On the one hand, data from the AZUR/EI-88, SAMPEX/PET, CRRES/MEA, Giove-B/SREM and Integral/IREM were directly compared to model runs (Ax-9 MAX/MIN, UP-8/MAX, PSB97, Ax-9 mean and confidence levels) over the dataset ephemeris. These datasets, with the exception of CRRES/MEA, were not used in the construction of the IRENE models and cover a variety of orbit types. On the other hand, SPENVIS runs were performed using the various models for a series of orbit types (LEO, MEO, GTO, HEO, GEO). The model spectra were compared, and used as inputs for the SPENVIS radiation effects models (TID, TNID, damage equivalent electron fluences).

Birth and evolution of magnetosheath mirror modes as seen by the global hybrid–Vlasov simulation Vlasiator

S. Hoilijoki[1,2], B. Walsh[3], Y. Kempf[1,2], S. von Alfthan[1], O. Hannuksela[1,2] and M. Palmroth[1]

[1] Finnish Meteorological Institute, Helsinki, Finland
[2] University of Helsinki, Helsinki, Finland
[3] Space Sciences Laboratory, University of California, Berkeley, California, USA

We use use a new global hybrid-Vlasov simulation code, Vlasiator, to study mirror modes and global dawn-dusk asymmetries in the Earth's magnetosheath. Vlasiator solves ions in 6-dimensional phase space using Vlasov equation and electrons as massless charge-neutralizing fluid using magnetohydrodynamic equations. We run Vlasiator in 5-dimensional setups, where two dimensions are employed in the ordinary space in the equatorial plane, while the velocity space is fully 3-dimensional. We perform three simulations, each with slightly different solar wind parameters with cone angles 45° , 30° and 0°. We investigate the mirror mode development and propagation in the magnetosheath and their dependence on the IMF cone angle. Additionally, we look at how the ion velocity distributions evolve and interact with the mirror modes along the streamlines in the magnetosheath. Finally, we compare our simulations results with observational data from the THEMIS spacecraft.

The AE9/AP9 next generation radiation specification models: challenges

S.L. Huston[1], T.P. Orien[2] and W.R. Johnston[3]

[1] AER, Inc.
[2] The Aerospace Corporation
[3] Air Force Research Laboratory, Space Vehicles Directorate

The AE9/AP9 model has now been released to the global scientific and satellite design communities. However, many challenges remain after version 1.0. We discuss several of these challenges: incorporating new data, solar cycle variation in the Monte Carlo model, the sample solar cycle, extending the internal magnetic field model far into the future, merging trapped with solar particle models, international collaboration. For each challenge, we put it into context and describe our strategies for progress.

A tailward–moving current–sheet–normal magnetic field front followed by an earthward–moving dipolarization front

K.J. Hwang[1,2], M.L. Goldstein[2], T.E. Moore[2], B.M. Walsh[2], D.G. Baishev[3], B.M. Shevtsov[4], K. Yumoto[5,6] and A.V. Moiseyev[6]

[1] The Goddard Planetary Heliophysics Institute, University of Maryland, Baltimore County, Baltimore, Maryland 21250, USA

[2] NASA Goddard Space Flight Center, Greenbelt, Maryland 20771, USA

[3] Yu.G. Shafer Institute of Cosmophysical Research and Aeronomy (IKFIA), Siberian Branch of the Russian Academy of Sciences, Yakutsk, Russia

[4] Institute of Cosmophysical Researches and Radio Wave Propagation (IKIR), Far East Branch of Russian Academy of Sciences, Paratunka, Russia

[5] International Center for Space Weather Science and Education, Kyushu University, Fukuoka, Japan

[6] Department of Earth and Planetary Sciences, Kyushu University, Fukuoka, Japan

A case study is presented using measurements from Cluster spacecraft and ground-based magnetometers that shows a substorm onset propagating from the inner to outer plasma sheet. On October 3, 2005, Cluster, traversing an ion-scale current sheet at the near-Earth plasma sheet, detected a sudden enhancement of B_z, which was immediately followed by a series of flux-rope structures. Both the local B_z enhancement and flux ropes propagated tailward. Approximately 5 minutes later, another B_z enhancement, followed by a large density decrease, was observed propagating rapidly earthward. Between the two B_z enhancements, a significant removal of magnetic flux occurred, possibly resulting from the tailward-moving B_z enhancement and flux ropes. In our scenario, this flux removal caused the magnetotail to be globally stretched so that the thinnest sheet formed tailward of Cluster. The thinned current sheet facilitated magnetic reconnection that quickly evolved from plasma sheet to lobe and generated the later earthward-moving dipolarization front (DF) followed by a reduction in density and entropy. Ground magnetograms located near the meridian of Cluster magnetic foot points show that a magnetic two-step bay was enhanced in two steps. The first positive bay was associated with the first B_z enhancement, indicating that the substorm-onset signatures propagated from the inner to the outer plasma sheet, consistent with the Cluster observation. The more intense bay features associated with the later DF are consistent with the earthward motion of the front. The event suggests that current-disruption signatures that originated in the near-Earth current sheet propagated tailward, triggering or facilitating mid-tail reconnection, thereby preconditioning the magnetosphere for the second, stronger, substorm enhancement.

Geospace science with Cubesats: present and future

T.M. Jorgensen

National Science Foundation, USA

When the US National Science Foundation (NSF) began exploring the use of cubesats to conduct space weather research in 2007 few people believed the miniature satellites would prove to be a useful scientific tool. However, during the last five years, the NSF cubesat program has seen the highly successful implementation of creative and innovative missions that carry out important science experiments. This program builds on recent engineering and system developments of CubeSat technology that have established the technical feasibility of tiny spacecraft missions that can be launched as secondary payloads at very low cost and rapid time scales as they pose virtually no risk to the launch vehicle or its primary payload. This makes space measurements achievable within the scope of the traditional NSF grants programs and greatly enhances the participation of the larger university community in space activities. Currently, the program supports 10 projects and has 6 missions operating in space. The assortment of scientific investigations being pursued and proposed spans all across solar, space physics, space weather, and atmospheric research. Already, several projects in the program have delivered first-of-their-kind observations and findings that have formed the basis for high profile engineering and science publications. Inarguably, the results from the program have now established beyond doubt the scientific value of cubesats and have proven them as a viable option for space missions that should be taken seriously. Based on examples and lessons learned from current projects the presentation will document and explore the prolific scientific promise of CubeSat missions for Geospace research.

Observational properties of foreshock cavitons

P. Kajdič[1], X.Blanco–Cano[2], N. Omidi[3] and B. Lavraud[4,5]

[1] ESTEC/ESA, Noordwijk, Netherlands
[2] Instituto de Geofísica, UNAM, Mexico
[3] Solana Scientific Inc., Solana Beach, California, USA
[4] IRAP, Université de Toulouse, Toulouse, France
[5] CNRS, Toulouse, France

The region upstream of the quasi-parallel section of the Earth's bow shock, known as the foreshock, is populated by suprathermal particles and ultra-low frequency (ULF) waves with periods of several tens of seconds. There are two types of ULF waves in the Earth's bow-shock: compressive waves propagate obliquely with respect to the interplanetary magnetic field (IMF), while the transverse waves travel almost parallel to it. The interaction of these two types of ULF waves can result in the formation of magnetic structures known as foreshock cavitons. The existence of these strucures was first predicted by global hybrid simulations. Main features of the foreshock cavitons are simultaneous and correlated drops of IMF intensity and plasma density at their centers. In their rims however, the two quantities rise above the average surrounding values. Foreshock cavitons are not easily found in the data since they are always surrounded by highly perturbed foreshock plasma and magnetic perturbations. However, recent analysis of the Cluster data suggests that cavitons can be observed with frequency of ∼2 per day. It has been shown in recent years that foreshock cavitons are carried Earthwards by the solar wind. Their interaction with the bow-shock, causes another phenomenon - spontaneous hot flow anomalies. Their signatures downstream of the bow-shock (magnetosheath/magnetopause/magnetosphere) have not yet been studied in a systematic manner.

Here we present recent results regarding foreshock cavitons - interplanetary conditions under which the cavitons form, how do they propagate, what are their statistical properties and what happens to the cavitons at the Earth's bow shock.

Ring current development in the strongly compressed magnetosphere

V.V. Kalegaev and N.A. Vlasova

D.V. Skobeltsyn Institute of Nuclear Physics, V.V. Lomonosov Moscow State University, Moscow 119991, Russia

The ring current development during magnetic storms 21-22.01.2005 and 14-15.12.2006 was studied on the basis of satellite data and theoretical modeling. It was shown that large-scale magnetospheric convection as well as substorm-related injections can not provide the observed magnetic depression at the Earth surface during 21-22.01.2005. Comparative analysis of magnetospheric particle fluxes (30-80 keV protons in the near-equatorial region and in the region of isotropic precipitations) measured by low-altitude polar sun-synchronous NOAA satellites (POES 15, 16, 17) shows that the proton fluxes as well as isotropic boundary and maximum precipitation locations were approximately the same during maximum of two storms under consideration. It was shown that ring current development during 21-22.01.2005 magnetic storm was provided by prolonged extremely strong solar wind dynamical impact. Extreme pressure pulse during SSC caused intensive trapped particle radial motion to the lover L-shells and subsequent ring current enhancement similar to that taking place due to particle injection from the tail. Ring current development during 14-15.12.2006 was mostly due to IMF southward turning. Magnetospheric compression during SSC was not too strong to create storm-time ring current.

Impact of interplanetary coronal mass ejections on radiation belt dynamics

Ch. Katsavrias[1,2], I.A. Daglis[2,1], M. Georgiou[1,2], D.L. Turner[3], I. Sandberg[1,2], G. Balasis[1] and C. Papadimitriou[1,2]

[1] IAASARS, National Observatory of Athens, Penteli, Greece
[2] Department of Physics, University of Athens, Athens, Greece
[3] University of California, Los Angeles, California 90095-1567, USA

We study the response of the outer electron radiation belt to the impact of different ICMEs (Interplanetary Coronal Mass Ejections), which trigger – or not – geospace magnetic storms. To this end, we analyse direct observations of the equatorial electron phase space density (PSD) using differential flux data from the Solid State Telescope (SST) of THEMIS (A, D and E), the Magnetospheric Electron Detectors (MagED) of GOES 13 and 15, the Radiation Environment Monitor (REM) of INTEGRAL, the Adaptive Particle Imaging Detectors (RAPID) of the 4 Cluster spacecraft, the MagEIS instruments of the RBSP A and B and the EPIC Radiation Monitor of XMM spacecraft. The data provide us with a broad range of energies and local time measurements. We also use wave measurements from CARISMA, THEMIS and IMAGE ground magnetometer arrays, as well as in situ wave data from THEMIS, Cluster, RBSP and GOES in search of ULF, whistler-mode chorus and EMIC waves. This work has received support from the European Union's Seventh Framework Programme (FP7-SPACE-2011-1) under grant agreement no. 284520 for the MAARBLE (Monitoring, Analysing and Assessing Radiation Belt Energization and Loss) collaborative research project.

Losses in the radiation belts caused by EMIC waves

T. Kersten, R.B. Horne, N.P. Meredith and S.A. Glauert

British Antarctic Survey, Madingley Road, CB3 0ET, Cambridge, UK

Electromagnetic Ion Cyclotron (EMIC) waves are electromagnetic waves at frequencies below the local proton cyclotron frequency. EMIC waves can cause electron loss in the radiation belts, if their frequency is Doppler shifted to the electron cyclotron frequency by the relative motion of the waves and electrons along the field line. This enables the EMIC waves to resonate with high energy electrons at energies greater than about 500keV and thereby causing losses due to pitch angle scattering into the loss cone. To determine how effective EMIC waves are in causing losses, we calculate bounce averaged pitch angle diffusion rates for a nominal model based on our analysis of data from the fluxgate magnetometer on the CRRES satellite, which sampled EMIC waves in the equatorial region from about L=4.0 up to about L=7.0 for latitudes up to 30. The diffusion rates are calculated for 5 levels of kp between 12-18 MLT. We find that EMIC waves can diffuse electrons into the loss cone very effectively at energies greater than about 2MeV for pitch angles up to about 60. To determine the overall effect of the waves on the particles we include the diffusion rates due to EMIC waves in the BAS radiation belt model together with lower and upper band chorus waves. Using the model we show that EMIC waves cause a significant reduction in the electron flux for high energies for a range of L-shells from L=4.0 - 7.0 but only for pitch angles lower than 60.

The research leading to these results received funding from the European Union Seventh Framework Programme under grant agreements no. 284520 (MAARBLE) and 262468 (SPACECAST).

Acceleration and transport to the ring current during a small storm

L.M. Kistler[1], C.G. Mouikis[1], A. Menz[1], H.E. Spence[1], D.J. Mitchell[2], M. Gkioulidou[2], R.M. Skoug[3], H.O. Funsten[3], B.A. Larsen[3], J.F. Fennell[4], J.B. Blake[4] and J.L. Roeder[4]

[1] Space Science Center, University of New Hampshire, Durham, NH
[2] Applied Physics Laboratory, Laurel, MD
[3] Los Alamos National Labs, Los Alamos, NM
[4] The Aerospace Corporation, El Segundo, CA

We use data from CODIF on CLUSTER and HOPE, RBSPICE, and MagEIS on the Van Allen Probes to study the acceleration and transport of ions from the plasma sheet into the ring current. During the main phase of a small geomagnetic storm on Aug 4-6, 2013, the Cluster spacecraft were moving inbound in the midnight central plasma sheet, while the two Van Allen Probes were located with their apogees on the duskside. Thus we can use the Cluster spacecraft to monitor composition changes in the plasma sheet, while the Van Allen Probes measure the ions that reach the inner magnetosphere. A significant increase in 1-40 keV O^+ was observed at the Cluster location during the storm main phase. By comparing the phase space density (PSD) vs. magnetic moment of O^+ and H^+ at the Cluster and the Van Allen Probes locations, we will examine if the composition changes observed at Cluster are consistent with the population observed at the Van Allen Probes at a later time, and determine if the inward transport is adiabatic.

Recent results from the Electric and Magnetic Field Instrument Suite and Integrated Science (EMFISIS) on the Van Allen probes

C.A. Kletzing

Department of Physics & Astronomy, The University of Iowa, Iowa City, IA, 52242, USA

The physics of the creation, loss, and transport of radiation belt particles is intimately connected to the electric and magnetic fields which mediate these processes. A large range of field and particle interactions are involved in this physics which are well-measured by the twin Van Allen Probes spacecraft launched in 2012. An overview of recent results from the mission focusing on waves and wave-particle interactions measured by the Electric and Magnetic Field Instrument Suite and Integrated Science (EMFISIS) investigation is presented. We show examples of automated density determination and plasmapause identification as derived from the upper hybrid resonance; low frequency ULF pulsations; EMIC waves with electrostatic harmonics and their occurrence statistics; and whistler mode waves including upper and lower band chorus as well as plasmaspheric hiss and its relation to energetic particles.

Long–lived whistler waves in the free solar wind: Cluster observations

C. Lacombe[1], O. Alexandrova[1], L. Matteini[2] O. Santolík[3], N. Cornilleau–Wehrlin[1,4], A. Mangeney[1], Y. De Conchy[1] and M. Maksimovic[1]

[1] LESIA, Observatoire de Paris, 5 place Jules Janssen, F-92190 Meudon, France
[2] Imperial College, London, SW7 2AZ, UK
[3] Institute of Atmospheric Physics ASCR, Prague, Czech Republic
[4] LPP, CNRS-Ecole Polytechnique-UPMC, Route de Saclay, F-91128 Palaiseau, France

The nature of the magnetic field fluctuations in the free solar wind between the ion and electron scales is still under debate. Using the Cluster/STAFF instrument, we make a survey of the power spectral density and of the polarization of these fluctuations at frequencies $f \in [1, 400]$ Hz, during five years (2001–2005) when Cluster was in the solar wind, not magnetically connected to the Earth's bow-shock. In $\sim 10\%$ of the selected data, we observe narrow-band, right-handed, circularly polarized fluctuations, with wave vectors quasi-parallel to the mean magnetic field, superimposed on the spectrum of the permanent background turbulence. We interpret these coherent fluctuations as whistler mode waves. The life time of such waves varies between a few seconds and several hours. Here we analyze long-lived whistler waves, i.e. with a life time longer than five minutes. We find several conditions for the appearance of such waves: (1) a low level of the background turbulence; (2) a low ion thermal pressure; (3) a slow solar wind speed; (4) an electron heat flux $Q_e > 4\mu\mathrm{W/m}^2$; (5) an electron mean free path larger than 0.5 AU, *i.e.*, a low collisional frequency; (6) a change in the magnetic field direction. When the level of the background turbulence is high, we cannot affirm that whistler waves do not exist: they can be just masked by the turbulence. The six above conditions for the presence of parallel whistlers in the free solar wind are necessary but are not sufficient: even when the permanent turbulence is not intense, when the electron collision frequency is small, and when the heat flux is large, whistler mode waves are not always observed. We show that the electron heat flux instability can be a source of the whistler waves when $\beta_{e\|} \geq 3$. The presence of such waves shows that the whistler heat flux instability contributes to the regulation of the solar wind heat flux, at least for $\beta_{e\|} \geq 3$, in the slow wind, at 1 AU.

Average spatial distributions of oxygen charge states in the magnetosphere, as observed by POLAR

S.A. Livi[1,2] and R.C. Allen[2,1]

[1] Southwest Research Institute
[2] University of Texas at San Antonio

Geomagnetically trapped Oxygen, of solar and ionospheric origin, have previously been observed in the Earth's magnetosphere. Early observations from AMPTE/CCE have studied these distributions within a limited spatial range of L-shells for all magnetic local times (MLT). This study expands on these early results using observations from the POLAR spacecraft. These distributions show O^{6+}, from the solar wind, charge exchanging into O^{5+}, O^{4+}, and O^{3+} as the ion populations drift to lower L-shells. Meanwhile, ionospheric O^{+} and O^{2+} are primarily seen at low L-shells and may also play a role in the O^{3+} populations. We investigate the L-shell, MLT, Kp, Bz, and AE dependencies of these oxygen charge state within the Earth's magnetosphere.

Spectral shapes of whistler–mode chorus emissions

E. Macusova[1], O. Santolik[1,2], J.S. Pickett[3], D.A. Gurnett[3] and N. Cornilleau–Wehrlin[4,5]

[1] Institute of Atmospheric Physics, ASCR, Prague, Czech Republic
[2] Faculty of Mathematics and Physics, Charles University, Prague, Czech Republic
[3] University of Iowa, Iowa City, USA
[4] LPPP/CNRS - Ecole Polytechnique, Palaiseau, France
[5] LESIA/Observatoire de Paris, Meudon, France

The whistler-mode chorus waves usually consist of two frequency bands separated by a gap at one half of the electron cyclotron frequency. These two bands are composed of individual wave packets that exhibit different spectral shapes, as rising tones, falling tones, hooks, broadband lines, noisy patterns, shapeless hiss, and their different combinations. We have processed more than 11 years of high resolution measurements provided by the Wideband (WBD) instrument onboard four Cluster spacecraft in our study. We identify all time intervals containing chorus emissions with the discrete structure and divided them into groups of different spectral shapes. We then identify propagation and polarization properties for these groups of spectral shapes using the multicomponent measurements of the STAFF-SA instrument onboard four Cluster spacecraft. We also determine the distribution of individual groups of chorus spectral shapes in the Earth's magnetosphere and the effect of the different geomagnetic conditions on their occurrence.
This work receives EU support through the FP7-Space grant agreement no 284520 for the MAARBLE collaborative research project.

The 1, 2, 3 of the Van Allen radiation belts: impacts of dynamics driven by observed ULF wave power

I.R. Mann[1], L.G. Ozeke[1], K.R. Murphy[2], S. Claudepierre[3], D. Turner[4], I.J. Rae[5], D.K. Milling[1], A. Kale[1], J. Fennell[3] and D.N. Baker[6]

[1] Department of Physics, University of Alberta, Edmonton, Alberta. Canada.
[2] Goddard Space Flight Center, Greenbelt, Maryland, USA.
[3] The Aerospace Corporation, Los Angeles, CA, USA.
[4] UCLA, Los Angeles, CA, USA.
[5] Mullard Space Science Laboratory, University College, London, U.K.
[6] Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, CO, USA.

We review the impacts of a properly characterised time-series of ULF wave power on the dynamics of ultra-relativistic electrons in the Van Allen belts. We compare results derived from observed wave power with those from statistical characterisations based on geomagnetic indices such as Kp through the course of the main and recovery phases of storm-time Van Allen radiation belt dynamics. We find using the observed ULF wave power presents a remarkable explanation for the overall dynamics of the belts in terms of the impacts of inward and outward radial diffusion in association with plasmasheet sources and magnetopause shadowing. At ultra-relativistic energies the resulting dynamics demonstrate a remarkable simplicity which is controlled by the ULF wave power. ULF wave power can explain all of the morphologies of the Van Allen belts at ultra-relativistic energies in the form of either one, two or three belts. Overall, our results reveal that ULF waves truly provide an explanation for the 1,2,3 of ultra-relativistic radiation belt dynamics. This work has received support from the European Unions Seventh Framework Programme (FP7-SPACE-2011-1) under grant agreement no. 284520 for the MAARBLE (Monitoring, Analysing and Assessing Radiation Belt Energization and Loss) collaborative research project.

Cluster multi–point studies of the auroral acceleration region

G.T. Marklund

Space and Plasma Physics, School of Electrical Engineering, Royal Institute of Technology, Stockholm, Sweden

Multi-probing of the auroral acceleration region (AAR) has enabled a number of open issues on the AAR to be addressed and revealed. Cluster data from crossings of Inverted-V aurora enabled the altitude and latitude distribution of the acceleration potential to be reconstructed in detail, showing it to be stable on a five min time scale. How quasi-static and Alfvénic acceleration contribute to produce aurora is addressed by two event studies, one focused on polar cap boundary aurora, the other on multiple arcs within and adjacent to a surge. Cluster data from surge-horn crossings have revealed detailed acceleration features and new results on the FAC closure at various MLT sectors. The density distribution within the auroral cavity, addressed in two recent studies, show exponential density decreases, relative to the ambient densities, from the middle to the top of the AAR, and cavities which are not confined by, but extending well above the AAR. Finally, statistical high-latitude electric field and plasma density distributions are presented based on 10 years of Cluster data collected between 2 and 4 R_E altitudes. Intense electric fields appear in two regions, centered on the nightside, separated by a gap at 2.8 R_E. The upper altitude fields are interpreted to be Alfvénic and the lower altitude fields quasi-static, related to the AAR. The local electric field minimum in the gap indicates a partial closure of the potentials in the lower region, with similarities to model results of reflected Alfvén waves and earlier reported observations.

Statistical analysis of VLF/ELF emissions at subauroral latitudes in Athabasca, Canada

Martinez C.[1], K. Shiokawa[1], Y. Miyoshi[1], M. Ozaki[2], I. Schofield[3] and M. Connors[3]

[1] Solar-Terrestrial Envirnoment Laboratory (STEL), Nagoya University, Japan
[2] Kanazawa University, Japan
[3] Athabasca University, Canada

Since September 25, 2012, a high-sampling rate (100 kHz) loop antenna located in Athabasca (ATH), Canada (54.7°N, 246.7°E, L=4) has allowed us to continuously monitor VLF/ELF emissions such as chorus waves at subauroral latitudes. In this study, we have made a one-year statistical analysis of these emissions from November 2012 to October 2013.
Using 10 minutes and 24 hours spectra we chose distinct emissions with clearly defined features with a minimum intensity of $2\text{x}10^{-5}$ pT^2/Hz, noting their starting time, duration, frequency range, and their spectral characteristics. We found that there is a maximum occurrence rate in the morning sector, around 07 MLT, and a minimum in the night sector, from 18 to 02 MLT, which agrees with satellite measurements. However we found a much lower occurrence rate on the ground station compared to that detected by satellites on the geomagnetic equator, suggesting that propagation processes are generally not allowing the waves to reach the ground. Additionally, we calculated occurrence rates as a function of the seasons, geomagnetic activity (AE and Dst) and geomagnetic parameters (e.g. solar wind pressure, speed, and IMF) and found no significant seasonal or geomagnetic dependence on the occurrence of VLF/ELF emissions detected on the ground.
We also calculated the variation of central frequency and frequency bandwidth of these emissions with AE and Dst indices. Using the variation of the cyclotron frequency at the equator plane for the field line of ATH estimated from the Tsyganenko model (T01), we found that the central frequency of the detected emissions followed the estimated frequency variation in the post-midnight and morning sectors. However, around 15MLT there is an unexpected dip observed in all curves, followed by a rise of the frequency after ∼18 MLT. We believe this last rise in frequency could be explained by particle injection during substorms.

Global model of low frequency chorus ($f_{LHR} < f < 0.1f_{ce}$) from multiple satellite observations

N.P. Meredith[1], R.B. Horne[1], W. Li[2], R.M. Thorne[2] and A. Sicard-Piet[3]

[1] British Antarctic Survey, Natural Environment Research Council, Cambridge, England
[2] Department of Atmospheric and Oceanic Sciences, University of California, Los Angeles, USA
[3] Office National d'Etudes et Recherches Aérospatiales, Toulouse, France

Whistler mode chorus is an important magnetospheric emission, playing a dual role in the acceleration and loss of relativistic electrons in the Earth's outer radiation belt. Chorus is typically generated in the equatorial region in the frequency range 0.1-0.8f_{ce}, where f_{ce} is the local electron gyrofrequency. However, as the waves propagate to higher latitudes, significant wave power can occur at frequencies below $0.1f_{ce}$. Since this wave power is largely omitted in current radiation belt models we construct a global model of low frequency chorus, $f_{LHR} < f < 0.1f_{ce}$, using data from six satellites. We find that low frequency chorus is strongest, with an average intensity of 200 pT^2, in the pre-noon sector during active conditions at mid latitudes ($20^o < |\lambda_m| < 50^o$) from $4 < L^* < 8$. Such mid-latitude, low frequency chorus wave power will contribute to the acceleration and loss of relativistic electrons and should be taken into account in radiation belt models.

The research leading to these results received funding from the European Union Seventh Framework Programme under grant agreements no. 284520 (MAARBLE) and 262468 (SPACECAST).

First results of simulations of "multi-band structures" in spacecraft observations of inner magnetosphere plasma electrons and ions

K. Mohan, A.N. Fazakerley and C.J. Owen

Mullard Space Science Laboratory, UCL Dept. of Space and Climate Physics, Holmbury St.Mary, Surrey, UK

Several authors have reported inner magnetosphere observations of proton distributions confined to narrow energy bands in the range 1 - 25 keV *(Smith and Hoffman, 1974)*. These structures have been described as "nose structures", with reference to their appearance in energy-time spectrograms and are also known as "bands" if they occur for extended periods of time. Multi-nose structures have been observed if 2 or more noses appear at the same time *(Vallat et al., 2007)*. Gaps between "noses" (or "bands") have been explained in terms of the competing corotation, convection and magnetic gradient drifts. Charge exchange losses in slow drift paths for steady state scenarios and the role of substorm injections has also been considered *(Li et al., 2000; Ebihara et al., 2004)*. The electron populations are not expected to exhibit multiple bands as the drifts are not in opposition. We analyse observations of electron and ion "multi-band structures" seen in Double-Star TC1 PEACE and HIA data mainly recorded in the equatorial plane of the inner magnetosphere ($L \leq 15$). We use a simple particle drift model to try and illustrate whether drifts alone could cause these multi-bands structures in the cases of both ions and electrons (charge exchange or substorms are not yet considered). We present the first results of the simulation and compare them to the results of statistical surveys previously conducted on the DoubleStar TC1 PEACE and HIA data, where ion and electron multi-bands were observed during low K_p. We use the simulation to explore possible explanations.

Solar wind magnetosphere coupling during a long sequence of BBF preceding substorm onset.

L. Palin[1], C. Jacquey[2], H. Opgenoorth[1], J.A. Sauvaud[2], M. Connors[3] and R. Nakamura[4]

[1] Swedish Institute of Space Physics, Uppsala, Sweden.
[2] Institut de Recherche en Astrphysique et Planetologie, CNRS/UPS, Toulouse, France.
[3] Centre for Science, Athabasca University, Athabasca, Canada.
[4] Space Research Institute, Austrian Academy of Sciences, Graz, Austria.

We use an 8 hour long period observations obtained on 31 March 2009 by the 5 THEMIS probes in a regrouped configuration while they were located in the tail at 8-15 Re over the Canadian ground-based network. It was thus possible to follow the sequential occurrence of 8 dipolarisation fronts associated with flow burst at THEMIS, together with their ionospheric counterparts. These were either auroral brightenings and/or localised onsets of upward field-aligned currents, as seen from the local counter-clockwise rotation of ground-based magnetic field measurements (ionospheric Hall current loops). When THEMIS moved out of the central tail portion (and also left the Canadian sector) there were two more auroral brightenings and finally a substorm onset. These BBF occur under relatively quiet solar wind conditions, but are nevertheless coupled to relevant solar wind drivers in an unambiguous way. We believe that this sequence can lead to a better understanding of the substorm and pseudobreakup mechanisms.

A statistical study of low frequency ULF waves as measured by space-borne and ground-based magnetometers

C. Papadimitriou[1,2], G. Balasis[1] and I.A. Daglis[2,1]

[1] Institute for Astronomy, Astrophysics, Space Applications and Remote Sensing, National Observatory of Athens, Athens, Greece

[2] Department of Physics, University of Athens, Athens, Greece

The focus of this work is the statistical study of Ultra Low Frequency (ULF) waves as observed by the CHAMP satellite and the IMAGE ground magnetometer array, both of them being European initiatives in the realm of geospace physics. The CHAMP (Challenging Minisatellite Payload) was a German LEO (Low Earth Orbit) satellite, which flew for more than 10 years (from July 2000 to September 2010) on a polar orbit of initial altitude of 454 km, providing among others high-quality measurements of the Earth magnetic field. The IMAGE (International Monitor for Auroral Geomagnetic Effects) array consists of 31 magnetometer stations in northern Europe.

In the framework of the MAARBLE project, we have developed a set of tools, based on the wavelet transform, that enable us to detect ULF wave activity by both space-borne and ground-based magnetometers. The application of these tools, on data from the CHAMP satellite mission and from selected stations of the IMAGE ground magnetometer array, have enabled us to create a database of power density spectra, for the entire first decade of the new millennium, spanning years from 2001 to 2010. Our focus here is on the lowest bands of the ULF waves, with frequencies lower than 100 mHz and down to a few mHz.

The creation of such a database with the inclusion of additional data, has enabled us to derive valuable statistics for many important physical properties relating to the spatio-temporal location of these waves, the wave power and frequency, as well as other parameters and can be used as a starting point in the launch of further investigations on the correlation of low-frequency ULF waves with solar wind conditions, magnetospheric indices, electron density data, ring current decay and radiation belt enhancements. The database will be further enriched by the analysis of measurements from the recent ESA Swarm mission (launched 22 November 2013).

This work has received support from the European Unions Seventh Framework Programme (FP7-SPACE-2011-1) under grant agreement no. 284520 for the MAARBLE (Monitoring, Analysing and Assessing Radiation Belt Energization and Loss) collaborative research project.

A modified hot flow anomaly model produced by IMF current sheet interacting with Earth's bow shock

G.K. Parks[1], Z.W. Yang[2], Y. Liu[2], E. Lee[3], S.Y. Fu[4], J.B. Cao[5], N. Lin[1], I. Dandouras[6], H. Rème[6], P. Canu[7] and M.L. Goldstein[8]

[1] Space Sciences Laboratory, UC Berkeley
[2] Space Weather, NSSC, Beijing, China
[3] Kyung Hee University, Suwon, Korea
[4] Peking University, Beijing, China
[5] Beihang University, Beijing, China
[6] IRAP, Toulouse, France
[7] Ecole Polytechnique, Paris, France
[8] NASA, GSFC, Greenbelt, MD

Observations, theories and PIC simulations have shown that understanding the physics of collisionless shocks requires that one include the dynamics of nonlinear structures observed in the upstream region. The current model that explains the nonlinear structure of Hot Flow Anomalies (HFAs) upstream of Earths bow shock requires that the interplanetary magnetic field current sheet interact with the bow shock. The solar wind electric field is directed inward toward the current sheet, and that channels the reflected solar wind into the current sheet, causing the edges to steepen nonlinearly as the structure expands. The result resembles HFAs. The reflected solar wind, interacting with the oncoming solar wind, can also excite a counter streaming instability. As the heated plasma expands, its edges steepen nonlinearly. Both of these models have been tested with past observations of HFAs. However, recent Cluster measurements show new features that require modification of these models. This talk will suggest what modifications are needed for the model to be consistent with the Cluster observations and PIC simulations.

Flux variations in the Van Allen belts observed by the energetic particle telescope

V. Pierrard[1,2], K. Borremans[1], G. Lopez Rosson[1] and S. Benck[2]

[1] Belgian Institute for Space Aeronomy
[2] Université Catholique de Louvain, Center for Space Radiations

The Energetic Particle Telescope (EPT) is a new compact and modular ionizing particle spectrometer that was launched on 7 May 2013 in a LEO polar orbit at an altitude of 820 km onboard the ESA satellite PROBA-V. First results show electron, proton and helium ion fluxes in the South Atlantic Anomaly and at high latitudes in the polar horns. High electron flux variations are observed in the outer belt during geomagnetic storms. Proton and ion fluxes are observed to be injected during Solar Energetic Particles events.
The observations are compared with those of other spacecraft, especially those of the Van Allen Probes during the same period of time. Data are also compared with those of previous spacecraft with similar orbits, like SAC-C and DEMETER, used to develop an empirical model at LEO. The dynamics of the electron radiation belts during geomagnetic quiet and disturbed periods is analyzed. During geomagnetic storms determined by a drop in the Dst index, the electron differential fluxes in the outer belt vary several orders of magnitude.

ULF waves as a driver of relativistic electrons: pro and con

V.A. Pilipenko[1], O.V. Kozyreva[2] and M.J. Engebretson[3]

[1] Space Research Institute, Moscow
[2] Institute of Physics of the Earth, Moscow
[3] Augsburg College, Minneapolis, MN

ULF waves have been suggested as a possible intermediary transferring energy from high-speed streams of the solar wind to magnetospheric electrons. Evidently, ULF waves are not the only means of accelerating relativistic electrons, but nonetheless they are an essential element of the electron energization process. Among observational facts regarding to the interrelationships between ULF wave activity and electron dynamics, we discuss the following pro and con factors related to ULF energization mechanisms:

- The correlation of electron fluxes at the geostationary orbit and the ULF wave index, characterizing the level of magnetic fluctuations in the Pc5 band;

- The difference between the mechanisms of common Pc5 pulsations and global Pc5 waves during strong magnetic storms driven by high-speed solar wind streams;

- The correspondence between the azimuthal phase velocities of toroidal and poloidal Pc5 waves and electron magnetic drift;

- The correspondence between latitudinal structures of Pc5 waves and electron radiation belt.

Consideration of these facts does not allow one to unambiguously resolve the issues concerning the role of ULF waves in magnetospheric electron energization.

Azimuthal velocity shear within an earthward fast flow – further evidence for magnetotail untwisting?

T. Pitkänen[1], M. Hamrin[1], P. Norqvist[1], T. Karlsson[2], H. Nilsson[3], A. Kullen[2], S.M. Imber[4] and S.E. Milan[4]

[1] Department of Physics, Umeå University, Umeå, Sweden
[2] Space and Plasma Physics, School of Electrical Engineering, Royal Institute of Technology, Stockholm, Sweden
[3] Swedish Institute of Space Physics, Kiruna, Sweden
[4] Department of Physics and Astronomy, University of Leicester, UK

Theoretical considerations, observations as well as simulations propose that nonzero IMF B_y conditions lead to a twisted magnetotail configuration. The plasma sheet is rotated around its axis and tail magnetic field lines are bent or twisted from the north-south symmetry: A B_y component collinear to the IMF B_y is superimposed on the tail magnetic field. According to the so called untwisting hypothesis, twisting has been suggested to have an effect on the azimuthal direction of convective fast flows in the nightside geospace due to untwisting of the twisted tail field lines. Some observations support this hypothesis, which also predicts azimuthally opposite flows on the opposite sides of the neutral sheet in a limited tail region for a fast flow event. In this presentation, we report multispacecraft observations of an azimuthal flow shear around the neutral sheet associated with an earthward fast flow detected by Cluster on 5 September 2001. The observations show a flow shear velocity pattern, i.e. a $V_{\perp y}$ sign change, at the neutral sheet ($B_x \sim 0$) within a fast flow during the neutral sheet flapping motion across the satellite locations. The tail B_y and the flow shear are in the direction what would be expected in the concurrent IMF B_y -induced tail twisting and subsequent untwisting, respectively. The ionospheric SuperDARN convection maps support the satellite observations suggesting that the azimuthal component of the magnetospheric flows is enforced by magnetic field untwisting. The observations are also supported by the T96 model (magnetotail twisting) giving further support to the tail untwisting hypothesis.

Plasma wave modes observed by Cluster and their possible role in radiation belt dynamics

D. Pokhotelov and I.J. Rae

Mullard Space Science Laboratory, University College London, Dorking, Surrey, RH5 6NT, UK

Various types of plasma waves have profound effects on acceleration and scattering of radiation belt particles. For the purposes of radiation belt modelling it is necessary to know statistical spatial distributions of plasma wave parameters over the broad range of frequencies from ULF to VLF. We analyse four years of plasma wave observations in the Earth's outer radiation belt obtained by the STAFF-SA experiment on board Cluster spacecraft. Statistical distributions of spectral density of different plasma wave modes observed in ELF-VLF range (chorus, plasmaspheric hiss, magnetosonic waves) are presented as a function of magnetospheric coordinates and geomagnetic activity levels. We will also present the preliminary analysis of plasma emissions observed during the recent Cluster inner magnetosphere campaign, whereby the Cluster orbits were optimized for extended equatorial inner magnetospheric measurements up to the geostationary orbit. We show the comparison between the STAFF-SA on-board spectrum analyser and other wave instruments to emphasize the fine structure of plasma emissions that is often missing in statistical distributions used to drive radiation belt models.

Effect of solar wind speed and IMF fluctuations on activity indices

T.I. Pulkkinen[1], A. Dimmock[1], R. Naderpour[1], A. Osmane[1] and K. Nykyri[2]

[1] Department of Radio Science and Engineering, Aalto University, Espoo, Finland
[2] Embry Riddle Aeronautical University, Daytona Beach, FL, USA

The solar wind electric field is known to drive magnetospheric activity via reconnection at the magnetopause. A variety of coupling functions describe the coupling efficiency between driving solar wind parameters (components of the magnetic field, solar wind speed and density) and the ionospheric response (AE-indices, Dst index), but in all cases the scatter in the resulting correlations is large. We note that all commonly used coupling functions underestimate the effect of the solar wind speed as a driver and neglect the effect of solar wind fluctuations. We quantify the effect of the solar wind speed by examining the plasma and magnetic driver components separately and examine the effects of fluctuations especially in the ULF range to the magnetospheric and ionospheric response using the OMNI data set at 1-min resolution. We demonstrate using statistical analysis of the Themis observations that the solar wind speed effect arises from processes at the bow shock crossing from the solar wind to the magnetosheath. We further use MHD simulations to show that the solar wind fluctuations enhance energy and plasma transfer from the magnetosheath to the magnetosphere. We show how the fluctuations, which are transmitted from the solar wind to the magnetosheath and to the magnetosphere yield higher activity also in the ionosphere.

Interaction of flux transfer events and Kelvin–Helmholtz waves at Earth's magnetopause

J. Raeder, S. Kavosi and K. Germaschewski

Physics Department and Space Science Center, University of New Hampshire, Durham, NH 03824, USA

Kelvin-Helmholtz (KH) waves and Flux Transfer Events (FTEs) are usually considered distinct phenomena occurring at Earth's magnetopause. However, a recent survey of THEMIS data near the flank magnetopause turned up cases that seemed to have characteristics of both KH waves and FTEs. One event in particular, on January 2, 2011, showed highly periodic magnetopause motion, but at a longer period than commonly observed for KH waves, yet with SW/IMF conditions that are typically conducive for KH waves. The magnetic field was characterized by short bipolar pulses in the magnetopause normal direction, which would be typical for FTEs. We found several cases of this kind. OpenGGCM simulations reproduced these structures and show that the FTEs originate on the dayside magnetopause. However, as they travel along the magnetopause, they appear to trigger KH waves that grow to very large (several RE) amplitude. At other times, FTEs and KH waves seemed to be interspersed, such that a few KW waves occurred between successive FTEs. We will discuss details of these waves and consequences for the transport of solar wind plasma into the magnetotail.

Geant4 modelling of RAPID/IES detector on Cluster

M.V. Rashev, E.A. Kronberg and P.W. Daly

Max Planck Institute for Solar System Research, Göttingen, Germany

The IES detector is modelled in Geant4 software in order to check detector sensitivity to high energy electrons and protons. Such sensitivity can result in higher electron counts than it should normally be.

Geant4 software allows us to build a detailed geometric model of our detector and subject it to a complex energy distribution of incident radiation. The current detector model contains all major features if IES: shielding, entrance foil, three detectors, detector substrate and support plates. Incident electron/proton beam is varied between 30 keV and 1 GeV. Energy distribution of incident particles is taken from the AE8 and AP8 models.

These calculations are aimed to complement data analysis (especially in the radiation belts) when the results are ambiguous.

Bounce and drift invariants from the rice convection model–equilibrium versus empirical magnetic models: a test of storm–time electron observations by the Van Allen probes

J.L. Roeder, C.L. Lemon, M.W. Chen, J.F. Fennell, S.G. Claudepierre, T. Mulligan, J.B. Blake and J.H. Clemmons

Space Sciences Department, The Aerospace Corporation, Los Angeles, California, USA

Relativistic radiation belt electrons during geomagnetic storms are often analyzed using phase space density (PSD) radial profiles using the three adiabatic invariants of particle motion in the magnetosphere as coordinates. The first invariant, M, is a local quantity and is easily measured. But the other two invariants, K and L*, are more global and must be computed by spatial integrations of geomagnetic field models. Empirical models such as Tsganenko-Sitnov are commonly used, but they include substantial uncertainty especially during geomagnetic storms. Checks of the model magnetic field against spacecraft magnetometer observations show significant deviations in both magnitude and direction. The effects of these uncertainties on K and L*, and the electron PSD analysis are not well known. Recent ring current simulations have improved reproduction of stormtime magnetic field measurements. In particular, the self-consistent Rice Convection Model-Equilibrium (RCM-E) has been shown to match magnetometer observations for several storm events. We have developed methods to compute K and L* from the model field produced by the RCM-E simulations. We use these quantities for a PSD analysis of the electrons during the storm on June 1, 2013 and contrast it with results using empirical magnetic field models. This event had a main phase of 8-hour duration and a minimum Dst of 18 nT. The energetic electrons in the energy range from 30 keV to 4 MeV were measured by the Magnetic Electron and Ion Spectrometers onboard the Van Allen Probes. These measurements display the classic profile with a pronounced drop in flux during the main phase and a slow rise in flux during the recovery phase. We discuss the implications of the PSD analysis on our ability to diagnose accurately the radiation belts for the effects of radial, pitch angle and energy diffusion by interactions with waves.

Cross calibration of NOAA GOES/EPS detectors using NASA IMP8/GME corrected proton flux measurements

I. Sandberg[1,4], P. Jiggens[2], D. Heynderickx[3] and I.A. Daglis[4,1]

[1] Institute of Accelerating Systems and Applications, National and Kapodistrian University of Athens, Greece

[2] European Research and Technology Centre, Noordwijk, The Netherlands.

[3] DH Consultancy, 3000 Leuven, Belgium

[4] Department of Physics, National and Kapodistrian University of Athens, Greece

Solar proton flux measurements on–board Geostationary Operational Environmental Satellites (GOES) are of great importance as they cover several solar cycles, increasingly contributing to the development of long–term solar proton models and to operational purposes such as now–casting and forecasting of space weather. A novel approach for the cross–calibration of GOES solar proton detectors is presented, using as reference the energetic solar proton flux measurements of NASA IMP–8 Goddard Medium Energy Experiment (GME). In order to increase as much as possible the quality of the cross–calibration results, we also have developed and present a method to reduce the spurious behavior in part of the IMP8/GME measurements, which is attributed to a failure of the Low Energy Detector. The derived effective energy values of GOES detectors lead to a significant reduction of the uncertainties in solar proton spectra and can be used to refine existing scientific results, available models and data products based on measurements over the past three decades. It is also shown, that for some cases the measurements of GOES high–energy channel correspond to energies much smaller than the nominal ones. The methods presented are generic and may be used for calibration processes of other datasets as well. The numerical calibration applied to the IMP8/GME Low Energy Detector enables the determination of improved spectra for one of the most widely used instruments for the evaluation of Solar Energetic Particle (SEP) events. The resulting datasets and processing procedures will be integrated into the ESA SEPEM platform for SEP modeling, where data are accessible to the community. This work has been funded through ESA Contract No. 4000108377/13/NL/AK.

Investigation of fine structure of chorus wave packets using multicomponent data from Van Allen Probes and multipoint measurements from Cluster spacefleet

O. Santolík[1,2], W.S. Kurth[3], G.B. Hospodarsky[3], J.S. Pickett[3] and C.A. Kletzing[3]

[1] Institute of Atmospheric Physics ASCR, Prague, Czech Republic
[2] Faculty of Mathematics and Physics, Charles University, Prague, Czech Republic
[3] Department of Physics and Astronomy, University of Iowa, Iowa City, Iowa, USA

Full vector measurements of the electric field and magnetic field waveforms of whistler mode chorus waves are being collected by the Van Allen Probes Electric and Magnetic Field Instrument Suite and Integrated Science's Waves instrument. These multicomponent waveforms, exceptionally reaching amplitudes up to a few nT, show a fine structure of chorus wave packets which was previously discovered by the measurements of the Cluster spacecraft. We investigate the instantaneous polarization and propagation properties of fine structure of chorus and we show that the polarization and wave vector direction usually varies within individual chorus wave packets. We complete these results with measurements of the Cluster spacefleet during the close separation periods where comparison of waveforms between neighboring spacecraft allows us to investigate propagation characteristics of the chorus wave packets and evolution of their amplitudes.

This work receives EU support through the FP7-Space grant agreement no 284520 for the MAARBLE collaborative research project.

Calculating ULF Wave Power vs. L and time: multi–spacecraft analysis using the Van Allen Probes, THEMIS and GOES

T.E. Sarris[1,2] and X. Li[2]

[1] Dept. of Electrical Engineering, Democritus University of Thrace, Xanthi, Greece
[2] Laboratory for Atmospheric and Space Physics, Univ. of Colorado, Boulder, Colorado

Ultra-Low frequency pulsations are critical in radial diffusion processes of energetic particles, and the Power Spectral Density of these fluctuations are an integral part of the radial diffusion coefficients and of assimilative models of the radiation belts. However the L-shell (approximately radial) dependence of ULF wave power has not been characterized in great detail in these simulations. Using simultaneous measurements from two GOES geosynchronous satellites, three of the THEMIS spacecraft constellation and the two Van Allen probes, we calculate the PSDs of ULF pulsations at different L-shells. By performing curve fits through these measurement points, we are able to derive functions of the L-dependence of ULF wave power at different frequencies. Through this analysis it is shown that, during a storm, ULF wave power is not enhanced uniformly throughout the magnetosphere, but instead is mostly enhanced in the outer L-shells, close to the magnetopause, and to a lesser extent in the inner magnetosphere, closer to the plasmapause. These results can have significant implications in better defining the regions where radial diffusion can be effective vs. the regions where it cannot account for the observed changes in the phase space density of energetic particles.

Temporal and spatial scales of a high–flux–electron disturbance in the cusp region: Cluster observations

J.K. Shi[1], Z.Y. Zhang[1], K. Torkar[2], M. Dunlop[3], A. Fazakerley[4], Z.W. Cheng[1] and Z.X. Liu[1]

[1] State Key Laboratory of Space Weather, National Space Science Center, CAS, Beijing, China
[2] Space Research Institute, Austrian Academy of Sciences, Graz, Austria
[3] Space Science and Technology Department, Rutherford Appleton Laboratory, Didcot, UK
[4] Mullard Space Science Laboratory, University College London, London, UK

Using the Cluster multi-spacecraft observations, we analyze a long duration field aligned high flux electron disturbance in the cusp region on 30 September 2001. All four Cluster spacecraft observed the same disturbance in which both the upward and downward electrons are observed and the electron flux was one order of magnitude higher than usual in the cusp. The temporal scale of the field aligned electron disturbance was at least 36 minutes. The spatial scale was about 540 km in the direction along the orbit and at least 1800 km in local time extent in the mid-altitude cusp region. It was the longest duration and the largest spatial scale of any field aligned electron disturbance observed in the polar region up to date, and it shows a advantage of the Cluster multi observation. Both upward and downward electrons are the main contributors to the field aligned currents in the electron disturbance. During this electron disturbance, the solar wind dynamic pressure increased and the IMF kept being southward. It is likely that the field aligned high flux electron disturbance with its long temporal and large spatial scales was caused by high dynamic pressure of the solar wind during a permanently southward IMF. This enables us to learn more about electron disturbances in the cusp and is important to understand the physical mechanism, especially for the solar wind-magnetosphere-ionosphere coupling.

Ground network observations for the ERG project

K. Shiokawa[1], R. Fujii[1], K. Hashimoto[2], K. Hosokawa[3], M. Ishii[4], A. Kadokura[5], H. Kawano[6], T. Kikuchi[1], K. Kitamura[7], Y. Miyoshi[1], T. Nagatsuma[4], N. Nishitani[1], Y. Obana[8], Y. Ogawa[5], H. Ohya[9], M. Okada[5], Y. Otsuka[1], M. Ozaki[10], N. Sato[5], M. Shinohara[11], H. Tadokoro[12], M. Taguchi[13], Y. Tanaka[5], T. Tanimori[14], F. Tsuchiya[15], H. Yamagisi[5], A. Yoshikawa[6], A.S. Yukimatu[5] and K. Yumoto K.[6]

[1] Solar-Terrestrial Environment Laboratory, Nagoya University, Japan
[2] Kibi International University, Japan
[3] The University of Electro-Communications, Japan
[4] National Institute of Information and Communications Technology (NICT), Japan
[5] National Institute of Polar Research, Japan
[6] International Center for Space Weather Science and Education, Kyushu University, Japan
[7] National Institute of Technology, Tokuyama College, Japan
[8] Osaka Electro-Communication University, Japan
[9] Chiba University, Japan
[10] Kanazawa University, Japan
[11] Kagoshima National College of Technology, Japan
[12] Tokyo University of Technology, Japan
[13] Rikkyo University, Japan
[14] Kyoto University, Japan
[15] Tohoku University, Japan

The ERG (Exploration of energization and Radiation in Geospace) project is going on in order to investigate the acceleration process of relativistic particles in the inner magnetosphere and the global dynamics of geospace. The project consists of the ERG satellite, ground network, and modeling/data center. Several ground network groups have joined the ERG project, i.e., HF and FM-CW radar networks, magnetometer networks, optical networks, VLF/LF receiver networks and so on. The remote-sensing of geospace from these ground-based networks are powerful tools which provide two-dimensional distributions of geospace disturbances. Combinations of the global monitoring information with the in-situ measurements by the ERG satellite, together with modeling/simulation efforts, will be essential to understand the mechanisms of particle acceleration and loss in the inner magnetosphere.

Foreshock electron beams and electrostatic waves observed by Cluster

J. Soucek[1], M. Basovnik[1], A. Tomori[1], O. Santolik[1] and A. Fazakerley[2]

[1] Institute of Atmospheric Physics AS CR, Prague, Czech Republic
[2] Mullard SSL, UCL, Surrey, United Kingdom

Solar wind electrons reflected by the bow shock are known to produce intense Langmuir waves in the foreshock region. While the foreshock waves are observed consistently by a number of spacecraft, observations of the beams are more difficult due to their transient nature and low density and very few experimental studies on this topic exist.

Under favorable conditions the PEACE instrument of Cluster can observe some of the field-aligned electron beams and the beam energy can be derived from the observations. At other times, a plateau in the electron distribution resulting from the dissipation of the beam by wave-particle interaction is observed. We analyzed the foreshock events in detail and performed a statistics of beam energies as a function of location within the foreshock. The results were compared to the existing models.

For individual cases, the observed electron distributions were used as an input for dispersion relation calculation and electrostatic PIC simulations and the results were compared with the observed waves. The numerical models confirm that in most cases the foreshock waves follow the beam mode dispersion branch and that the simple electrostatic model can explain the observed signature of waves observed at frequencies well above and below the electron plasma frequency. The effect of non-maxwellian components of solar wind electrons on wave generation is investigated.

Relationships between core radiation belt electrons and seed populations

H.E. Spence, A.J. Boyd and C.L. Huang

Space Science Center, Institute for the Study of Earth, Oceans, and Space, University of New Hampshire, 8 College Road, Durham, NH 03824 USA

We use measurements from NASA's Van Allen Probes mission to explore the relationships between core radiation belt electrons and their seed populations. Using measurements from the two-spacecraft Van Allen Probes mission we estimate the total radiation belt electron content (TRBEC) as a simple, global quantitative measure of radiation belt intensity. The two identically-instrumented spacecraft provide comprehensive energy and pitch angle coverage of radiation belt electrons near the magnetic equator throughout the inner magnetosphere, an advantage over earlier studies by Baker et al. (2004) and Selesnick and Kanekal (2009) that estimated similar quantities. We use electron measurements from the Radiation Belt Storm Probes (RBSP) Energetic Particle, Composition, and Thermal Plasma (ECT) suite to identify both the electron seed populations (a few 10's to a few 100's keV) as well as radiation belt electron populations (>500 keV) with the Magnetic Electron Ion Spectrometer (MagEIS) and the Relativistic Electron Proton Telescope (REPT) sensors. MagEIS provides the electron seed population measurements; MagEIS and REPT together provide the core radiation belt and ultra-relativistic electron populations. Using energy-resolved, locally-measured pitch angle distributions of electrons as a function of L*, we integrate the electrons over energy and pitch angle throughout various spatial volumes to establish the TRBEC for both the electron seed and the core populations. Finally, we show how TRBEC varies as a function of time over the course of the mission, compare these variations to other quantitative measures of inner magnetospheric dynamism (e.g., Dst), solar wind drivers, and electromagnetic wave properties of the inner magnetosphere, as well as compare the seed to core TRBEC values and its time evolution.

Acceleration of solar wind ions to MeV energies by electromagnetic structures in the foreshock

K. Stasiewicz[1,2], M. Strumik[1], M. Grzesiak[1] and D. Przepiorka[1]

[1] Space Research Centre, Polish Academy of Sciences, Warsaw, Poland
[2] Department of Physics and Astronomy, University of Zielona Gora

We present Cluster observations and simulations which show that ions can be accelerated to high energies by electric field structures observed upstream of the bow shock. Cluster observations of electromagnetic fields are modelled in 3D space using method of Radial Basis Functions (RBF), which are used in test particle simulations and make it possible to determine the evolution of the particle distribution function and the heating rate. The acceleration mechanism is related to a critical gradient of the electric field and is different from the classical Fermi acceleration usually invoked in the context of particle acceleration in space plasmas. We present comparison of the heating rates achieved by the Fermi model and the electric gradient mechanism based on real observations. The later may represent the universal, basic mechanism for perpendicular acceleration and heating of ions in the magnetosphere, the solar corona and in astrophysical plasmas.

THEMIS observations of a gap in whistler mode chorus emissions inside the source region

U. Taubenschuss[1], O. Santolik[2,3], Y. Khotyaintsev[1], W. Li[4], A. Vaivads[1], O. LeContel[5] and J. Bonnell[6]

[1] Swedish Institute of Space Physics, Uppsala, Sweden
[2] Faculty of Mathematics and Physics, Charles University, Prague, Czech Republic
[3] Institute of Atmospheric Physics, Prague, Czech Republic
[4] Department of Atmospheric and Oceanic Sciences, UCLA, Los Angeles, California, USA
[5] Laboratoire de Physique des Plasmas, École Polytechnique, Universite Pierre et Marie Curie, Plaiseau, France
[6] Space Sciences Laboratory, University of California, Berkeley, California, USA

We present high resolution observations of THEMIS-D from October 23, 2008 which document the evolution of whistler mode chorus bursts while crossing the source region. Even if THEMIS-D is 2.5 degrees North of the dipole geomagnetic equator, a comparison with the Tsyganenko magnetic field model confirms an immediate proximity to the region where the magnetic field strength reaches a local minimum. Another indication of being inside the generation region is the fact that successive chorus bursts are seen as propagating parallel and anti-parallel to the local magnetic field direction. The data show bursts crossing 0.5fce (half of the local electron cyclotron frequency) as well as an intensity gap in the emission spectra below 0.5fce developing later on. The occurrence of a gap inside the source region is contradicting the recent theory based on nonlinear wave damping of chorus propagating away from the source region. We examine another possible interpretation of the existence of a gap in the source region based on the framework of the wave-guide theory which works for nonlinear damping at density gradients.

The role of low–energy ions in the microphysics of magnetic reconnection

S. Toledo–Redondo, A. Vaivads, M. André and Y.V. Khotyaintsev

Swedish Institute of Space Physics, Uppsala, Sweden

Asymmetric magnetic reconnection is common at the magnetopause and has been widely studied. However, such an important aspect as the role of cold ions (energies up to tens of eV) on the reconnection has not been fully explored. Several case studies indicate that low-energy ions can be quite abundant in the magnetosphere near the magnetopause. Such cold ions introduce new scales to the magnetic reconnection process due to their smaller gyro radii. Cold ions are difficult to observe due to the positive potential of the spacecraft, which is typically larger than the ion energy, preventing ions to reach the spacecraft. We have studied several Cluster magnetopause crossings during spring 2008, when the distance separation between C3 and C4 was less than 50 km, enabling two-spacecraft measurements below the cold ion gyro radius length-scale. We estimate the different terms in the Generalized Ohm's law equation, to see which of the terms balance the electric fields normal to the magnetopause. For each of the crossings we test the presence of cold ions and try to infer their role in the microphysics of the reconnection layer.

Multipoint observations of energetic particle injections from the plasma sheet into the inner magnetosphere

D.L. Turner[1], M. Gkioulidou[2], A. Ukhorskiy[2], A. Runov[1], C. Gabrielse[1] and V. Angelopoulos[1]

[1] University of California, Los Angeles (UCLA)
[2] Applied Physics Laboratory (JHU-APL)

Energetic particle injections involve the rapid inward motion of ions and electrons from 10s to 100s of keV from the near-Earth plasmasheet into the inner magnetosphere (i.e., geosynchronous orbit and within). Here, we analyze preliminary results of multipoint studies of energetic particle injections using NASA's Van Allen Probes and THEMIS missions and the GOES and LANL-GEO spacecraft in geosynchronous orbit. We focus primarily on the importance of energetic particle injections to outer radiation belt dynamics. In particular, energetic particle injections can enhance both the seed population of electrons that can be locally accelerated to relativistic energies forming the core of the outer radiation belt population and the source population of ions and electrons responsible for generating plasma waves that can interact with outer belt electrons, such as electromagnetic ion cyclotron (EMIC) and whistler-mode chorus waves. These waves, generated by the anisotropic drifting energetic particle populations injected into the inner magnetosphere, can play important roles in source and loss processes of outer belt electrons, which we will outline as part of this presentation. Finally, we will also highlight how energetic ion injections contribute to the ring current build-up resulting in the main phase of geomagnetic storms, which also represent some of the most dynamic periods for the outer radiation belt electrons.

This work has received support from the European Unions Seventh Framework Programme (FP7-SPACE-2011-1) under grant agreement no. 284520 for the MAARBLE (Monitoring, Analysing and Assessing Radiation Belt Energization and Loss) collaborative research project.

Understanding the role of EMIC waves in radiation belt and ring current dynamics: recent advances

M.E. Usanova and I.R. Mann

Department of Physics, University of Alberta

Electromagnetic ion cyclotron (EMIC) waves are believed to be important for influencing the dynamics of energetic particles in the inner magnetosphere, especially in relation to ring current and radiation belt dynamics. In relation to the ring current, both the dynamical evolution of ion distributions along their drift paths as well as effects from the solar wind can result in EMIC wave generation from unstable ion distributions. EMIC waves often grow as a result of perpendicular temperature anisotropy, with the ion dynamics and energy and pitch angle distributions in the ring current being modified significantly by the growth of the EMIC instability. EMIC waves are also hypothesized to influence higher energy electrons in the Van Allen belts, through a Doppler shifted cyclotron resonance, including stimulating potential scattering loss into the atmosphere. We will present some of the latest results from selected studies of EMIC wave characteristics and EMIC wave impacts on energetic particles in the inner magnetosphere. We will draw on results from recent satellite missions including the NASA THEMIS and ESA-NASA Cluster missions, as well as some of the very latest results from the NASA Van Allen Probes mission launched on 31st August 2012. We will also highlight the value of data from networks of modern ground-based magnetometers in providing continuous monitoring over local, continental, and even global scales, especially in conjunction with in-situ measurements from satellites. Such coordinated ground-satellite conjunction studies represent a powerful tool for understanding the self-consistent and cross-energy coupling between ions and electrons in the ring current and radiation belt via the intermediary of EMIC waves.

This work has received support from the European Unions Seventh Framework Programme (FP7-SPACE-2011-1) under grant agreement no. 284520 for the MAARBLE (Monitoring, Analysing and Assessing Radiation Belt Energization and Loss) collaborative research project.

M^4 - a mission candidate for ESA M4

A. Vaivads[1] and M^4 team[2]

[1] Swedish Institute of Space Physics
[2] More than 100 scientists

We present a mission concept that will be proposed in the response to the upcoming ESA M4 Call. The working name of the mission is "M^4". The scientific theme of the M^4 mission is turbulent energy dissipation and particle energization. The main focus is on turbulence and shock processes, however areas where the different fundamental processes interact, such as reconnection in turbulence or shock generated turbulence, is also of high importance. The M^4 mission aims to address such fundamental questions as how energy is dissipated at kinetic scales, how energy is partitioned among different plasma components, what is the relative importance of waves and coherent structures in the dissipation processes. To reach the goal a careful design work of the M^4 mission and its payload has to be done and it is based on the earlier mission concepts of Tor, EIDOSCOPE and Cross-Scale. We present the basic concepts of the M^4 mission and its payload as well as illustrate how it will help to address the science questions posed.

An assessment of the quasilinear treatment of equatorial magnetosonic waves.

S.N. Walker[1], M.A. Balikhin[1], K.H. Yearby[1], N. Cornilleau–Wehrlin[2] and C. Carr[3]

[1]ACSE, University of Sheffield, Sheffield, United Kingdom.
[2]LPP - CNRS, Paris, France
[3]IC, London UK

Estimates of the magnitude of the role played by Equatorial Magnetosonic Waves in energization and loss processes of Radiation Belt particles are based the quasi-linear plasma approximation. This methodology assumes that the wave spectrum can be described using a continuous, gaussian frequency distribution. However, recent Cluster observations clearly show the discrete structure of these emissions. The quasilinear treatment of these emissions is still valid provided that the Chirikov resonance overlap criteria is fulfilled. This paper uses this criteria to assess the applicability of quasilinear theory to the recent Cluster observations. The results show that the overlap criteria is not satisfied and so the impact of each harmonic should be considered separately when calculating the energy and pitch angle diffusion coefficients when considering their role in the dynamics of radiation belt electrons.

Nitrogen Ion TRacing Observatory (NITRO) concept: a new direction one step from Cluster

M. Yamauchi[1], I. Dandouras[2] and The NITRO proposal team

[1] Swedish Institute of Space Physics (IRF), Kiruna, Sweden (M.Yamauchi@irf.se)
[2] Institut de Recherche en Astrophysique et Planetologie (IRAP), CNRS/Université de Toulouse, Toulouse, France

Cluster observation revealed that O^+, He^+ and H^+ often behave nearly independently to each other even in the inner magnetosphere where these ions are expected to show similar behavior, in both the pitch angle-energy distribution and the dependence of the abundance on the geomagnetic and solar activities. The obvious next step is understand the difference between O+ and N^+.

Nitrogen is a key element for life as an inevitable part of the amino acid and protein, and its oxidation state (NH_3 or N_2 or NO_X) in the ancient atmosphere is one of the key factors that determine the difficulty in forming amino acid without biological processes. Considering the fact that nitrogen molecule with triple chemical binding is much more difficult to be desolved/ionized than oxygen molecule with double chemical binding, and that dependence of the ion outflow from the ionosphere on the geomagnetic activity is more drastic for cold nitrogen ion than cold oxygen ions, it is important to understand the dynamic of N^+ and N_2^+ at different solar conditions as compared to oxygen dynamics or proton dynamics. However, nearly no such observation exists at low energy less than keV, except very little observations for thermal nitrogen.

One reason for lack of such measurement is difficulty in separating hot N^+ from hot O^+ even with the modern instruments, causing past instruments on board magnetospheric missions not targeting such separation but rather targeting higher temporal and spatial resolutions. However, with recent improvement of mass-separating ion analyser, it is now most likely possible to separate O^+ and N^+ by masking H^+ and He^{++} and by limiting the angular coverage to minimize the contamination. In this sense, the nitrogen study in the magnetosphere requires a dedicated space mission.

At moment there are two options: (1) pioneering single spacecraft mission with minimum instrumentation to detect hot nitrogen ions of missing energy range from 50 eV to 10 keV in the past missions; and (2) multi-spacecraft mission to make a comprehensive understanding of the dynamics of nitrogen ions in the magnetosphere. Here we present necessary spacecraft and instrumentation for the second option because that will be fitted into the M-class mission (450 MEUR) that European Space Agency most likely announces soon this year.

The mission consists of three spacecraft, two mid-altitude satellites for in-situ measurement with gradient information (by the second spacecraft), and one low-altitude satellite for outward remote sensing to obtain line-of-sight integration information. Instrumentation for such a mission also benefits studies on the inner magnetosphere, substorms, and basic plasma physics such as ion energization. We welcome contributions for the model instrumentation fitting into the mission particularly the optical ones toward the coming European M-class announcement. The other ideas to detect the nitrogen ions and their dynamics are also very welcome.

Observations of chorus and hiss by Double Star TC1

K.H. Yearby[1], H. Aryan[1], M.A. Balikhin[1] and V. Krasnoselskikh[2]

[1] ACSE, University of Sheffield, Sheffield, S1 3JD, UK
[2] LC2E/CNRS, Orleans, France

The Double Star TC1 spacecraft was launched on 29 December 2003 into an elliptical equatorial orbit and operated until 14 October 2007. The instruments included a search coil magnetometer measuring magnetic fluctuations up to 4kHz. The orbit allowed extensive coverage of the inner magnetosphere region for L shells of 1.1 upwards, and latitudes up to 35 degrees. Chorus and plasmaspheric hiss are frequently observed in this region and recent work has suggested that chorus is the likely source of hiss. A detailed study of observations of these waves during the nearly 4 years of the Double star mission is presented, including the observed occurrence as a function of L value, MLT, latitude, and magnetic activity.

Understanding geospace dynamics and the effect of magnetosphere-ionosphere (MI) coupling

E. Zesta[1], G. Khazanov[1], A. Glocer[1], L. MacDonald[1], M.C. Fok[1], N. Buzulukova[1] and P. Dixon[2]

[1] NASA Goddard Space Flight Center, Geospace Physics Laboratory
[2] Aberystwyth University

Physical understanding of the near-Earth space environment is restricted by the lack of observations with sufficient spatiotemporal cadence to fully characterize this vast volume of space and its processes. Model simulations of the environment are by necessity the complementary tool that can uncover, in conjunction with observations, the physical processes responsible for observed dynamics. Here we present different topics where the merging of model simulations and observations does just that, and two examples are given below. The two Van Allen Probes sampled multiple, dynamic morning flank crossings from closed to open field lines during the Nov 14, 2012 storm. The short events are characterized by stronger, more stretched field lines, and encounters with lobe plasma present an interesting test of data-model comparison and storm-time magnetic field mapping. Overall, comparison with BATSRUS + CRCM provides a better fit to the observations than other models, however discrepancies on the order of the model time step and an Earth radii of distance between the open-closed boundary prediction and the observations are not uncommon. Diffuse aurora provides the bulk of particle energy into the ionosphere, but the understanding of its source is still elusive. We present the solution of the Boltzman-Landau kinetic equation that uniformly describes the entire electron distribution function in the diffuse aurora, including the affiliated production of secondary electrons ($E < 600$ eV) and their MI coupling processes. We demonstrate that the MI coupling element in theoretical auroral precipitation studies is key in the formation of the entire electron distribution function that is the source of the precipitated electrons in the upper ionosphere.

Contributed Poster Presentations

Long–term trends in the fluxgate magnetometer (FGM) calibration parameters on the four Cluster spacecraft

L.N.S. Alconcel, P. Fox, P. Brown, T. Oddy, E.L. Lucek and C.M. Carr

The Blackett Laboratory, Imperial College London, Prince Consort Road, London, UK, SW7 2BW

The calibration parameters of the outboard fluxgate magnetometer (FGM) sensors on the four Cluster spacecraft have been shown to be remarkably stable. We describe how the parameters are refined on the ground during our rigorous calibration process for the Cluster Active Archive, and examine the drift in the parameters over the course of more than ten years of operation. For the most sensitive ranges of the FGM instrument, we find that the offset drift is typically 0.2 nT per year in each sensor on C1 and negligible on C2, C3 and C4. The observed stability demonstrated in this initial study gives us confidence in the accuracy of the Cluster magnetic field data and the 14+ years of observations that have been archived in the CAA. We are continuing to monitor the parameter evolution as the mission progresses.

Altitude distribution and position of the auroral density cavity in quasi-static potential structures

L. Alm, G.T. Marklund, T. Karlsson and B. Li

KTH Royal Institute of Technology, Space & Plasma Physics, Teknikringen 31, 10044 Stockholm

The connection between the auroral density cavity and the potential structure of the auroral acceleration region is well established. However, the exact nature of this connection is as of yet not entirely understood. A majority of the models and observations has focused on the lower portion and the double layer on the ionosphere-cavity boundary. The upper portion of the density cavity and the cavity-magnetosphere boundary has as of yet not received as much attention.

Cluster data from 2002–2007 was inspected for the presence of clear upward ion beams located between a geocentric altitude of 3–6.5 R_E and 60–80 degrees invariant latitude. Observations of ion beams are indicative of the satellite being located inside the flux tube of the auroral acceleration region with a significant parallel potential drop below. For the time intervals containing upward ion beams, the electron spectrograms were inspected for the presence of inverted-V electrons. In addition the spacecraft potential was determined to serve as a proxy for the electron density and the characteristic energy of the electrons and ions calculated to estimate the parallel potential drops.

Between 4–5.5 R_E there were several direct observations of the satellites crossing the upper edge of the auroral acceleration region. The altitude range 4.75–5.25 R_E exhibiting the highest occurrence rates. The events which have been studied in detail reveals that the electron density continues to decrease after crossing the upper boundary of the auroral acceleration region.

Above 4 R_E several events exhibits clear ion beams but where no inverted-V electrons were observed. Our interpretation is that the satellites are inside the flux tube of the auroral acceleration region but located above the entire auroral acceleration region. A significant increase in the occurrence rate is found at 5.25 R_E which is just above the altitude range with the maximum occurrence rate of crossings of the upper edge of the auroral acceleration region.

The spacecraft potential exhibits a monotonic decrease with geocentric altitude. Above 5.75 R_E the spacecraft potential exhibits a rapid decrease, indicative of entering a region of low electron density. This corresponds to the altitude range where a significant number of events do not exhibit any inverted-V electrons, indicating that the satellite is located above the auroral acceleration region.

We conclude that upper portion of the auroral acceleration region can extend to much higher geocentric altitudes than the 2–3 R_E often cited. The data indicates that the upper edge of the auroral acceleration region is located above 5 R_E. Similarly both individual events and statistics imply that the auroral density cavity can extend above 6.5 R_E and in many cases above the auroral acceleration region.

FORSPEF: an operational service for the prediction of Solar energetic particle events and flares

A. Anastasiadis[1], I. Sandberg[1], A. Papaioannou[1], M.K. Georgoulis[2], G. Tsiropoula[1], K. Tziotziou[1], A.C. Katsiyannis[1,3], P. Jiggens[4] and A. Hilgers[4]

[1] National Observatory of Athens, Institute for Astronomy, Astrophysics, Space Applications and Remote Sensing, Greece

[2] Academy of Athens, Research Center for Astronomy and Applied Mathematics, Greece

[3] Solar-Terrestrial Center of Excellence, SIDC, Royal Observatory of Belgium, Belgium

[4] European Space Agency, European Research and Technology Center, The Netherlands

Solar Energetic Particle (SEP) events resulting from intense eruptive events such as solar flares and coronal mass ejections (CMEs), pose a significant threat for both personnel and infrastructure in stormy space-weather conditions. Of particular concern is the high rate of single event effects on-board spacecraft launchers which can be brought about by large increases in the radiation environment as a result of such solar activity. A new web-based service for the prediction of solar eruptive and energetic particle events is presented. FORSPEF (Forecasting Solar Particle Events and Flares) is designed to perform forecasts and nowcasts of the occurrence and the characteristics of solar flares and SEP events. The service is targeted to launch operators and to the space-weather community. For the prediction of solar flares, an assessment of potentially flaring active-region magnetic configurations is utilized based on sophisticated analysis of a large number of magnetograms of solar active regions. For the prediction of SEP events, a novel reductive statistical scheme is implemented upon a newly constructed database that includes characteristics of SEP events and their parent solar events. The new comprehensive catalogue of SEP events includes solar associations in terms of flare (magnitude, location) and CME (velocity) characteristics, as well as radio burst (Type III and Type II) signatures. The SPE prediction scheme utilizes the output of solar flare forecast, while the SPE nowcast uses real time observations of the solar surface and solar corona. We present and discuss the architecture of the prediction tools integrated in the FORSPEF service as well as the outputs related to the warning of possible solar flares and the prediction of the onset, flux profile and duration of SEP events. The FORSPEF web-based service is expected to be fully operational within the following months.

This work has been funded through the ORSPEF: FORecasting Solar Particle Events and Flares ESA Contract No. 4000109641/13/NL/AK

Comparison of the convection electric field of Saturn with the ones of the Earth's and Jupiter's

M. Andriopoulou[1], E. Roussos[2], N. Krupp[2], C. Paranicas[3], M. Thomsen[4], S. Krimigis[3,5], K.H. Glassmeier[6] and M. Dougherty[7]

[1]Space Research Institute, Austrian Academy of Sciences, Graz, Austria
[2] Max-Planck Institute for Solar System Research, Goettingen, Germany
[3] The Johns Hopkins University Applied Physics Laboratory, Laurel, USA
[4] Planetary Science Institute, Tucson, USA
[5] Office of Space Research and Technology, Academy of Athens, Athens, Greece
[6] Institute for Geophysics and extraterrestrial Physics, Technical University of Braunschweig, Braunschweig, Germany
[7] Space and Atmospheric Physics, Blackett Laboratory, Imperial College London, London, UK

Plasma circulation in planetary magnetospheres has always been a topic of particular interest. Prior to the Cassini arrival at Saturn, the common knowledge had been that there are two distinct types of magnetospheres, the ones that are dominated by the solar wind control, similar to the case of the Earth, and the ones driven by fast rotation and internal sources, such as the Jovian case. Saturn's magnetosphere has been expected to be an intermediate case between the magnetospheres of the Earth and Jupiter, exhibiting both a solar wind and an internal control. However, our findings, which were obtained using the MIMI-LEMMS instrument that is onboard Cassini, have revealed that plasma circulation at Saturn consists no intermediate case of the Earth and Jupiter, but rather a unique case. Specifically, apart from strong flows in the azimuthal direction, as a result of the planet's fast rotation, dawnward flows of a few km/sec have been observed in the inner magnetosphere of Saturn (covering distances up to 10 R_s). The origin of these flows is currently unknown.

In this work we compare the main properties of the recently discovered convection electric field at Saturn with the ones of the Earth's and Jupiter's. Our comparison is not only focused on the average patterns, but also extended on their temporal characteristics.

Finally, we discuss the possible sources driving the convection at Saturn and compare it with theories and global simulations for Saturn.

Combined model of plasmaspheric hiss and whistler-mode chorus wave distribution in the inner magnetosphere

H. Aryan[1], K. Yearby[1], Mi. Balikin[1], O. Agapitov[2,3] and V. Krasnoselskikh[1]

[1] Department of Automatic Control and Systems Engineering, University of Sheffield, Sheffield, S1 3JD, United Kingdom.

[2] Space Sciences Laboratory, University of California, Berkeley, California 94720, USA.

[3] Astronomy and Space Physics Department, Taras Shevchenko National, University of Kiev, Kiev, Ukraine.

[4] LC2E/CNRS, University of Orleans, Orleans, France.

The acceleration and loss of radiation belt electrons is largely effected by the interaction of gyroresonant wave particles with plasmaspheric hiss and whistler-mode chorus waves. This study presents a global model of plasmaspheric hiss ($0.1 < f < 2$kHz), lower band ($0.1fce < f < 0.5fce$) and upper band ($0.5fce < f < fce$) chorus wave intensities as a function of L-shell (L), magnetic local time (MLT), magnetic latitude (MLat), geomagnetic activity (as presented by geomagnetic index Ae) and solar wind parameters (velocity, density and pressure) using almost four years (01, January, 2004 to 29, September, 2007) of STAFF (Spatio-Temporal Analysis of Field Fluctuation) data from Double Star TC1 and Cluster mission combined with geomagnetic index and solar wind parameters from OMNIWeb. Results show that the largest wave intensities are observed during active conditions, high solar wind velocity, low solar wind density and high solar wind pressure. The intensity of plasmaspheric hiss wave is highest in the region of 2 <L< 4 while the intensity of chorus peaks in the region of 4 <L< 9.

Storm time penetration electric fields observed by SWARM and ground based magnetometers

A. Bhaskar and G. Vichare

Indian Institute of Geomagnetism, Plot 5, sector 18, New Panvel, Navi Mumbai, 410218, India

Prompt penetration electric fields (PPEF) have strong influence on the ionosphere. The strength and duration of the geomagnetic storm is controlled by the direction of the interplanetary magnetic field. The associated dusk to dawn or dawn to dusk electric fields are mapped to the high latitude region of the Earth's magnetosphere and then transmit to the lower latitudes. We have investigated the storm time PPEF signatures observed in multi-point measurement of SWARM along with simultaneous measurements by ground based magnetometer data.

Online NARMAX model for electron fluxes at GEO

R.J. Boynton, M.A. Balikhin and S.A. Billings

ACSE, University of Sheffield, Sheffield, United Kingdom

Multi-Input Single-Output (MISO) Nonlinear AutoRegressive Moving Average with eXogenous inputs (NARMAX) models have been derived to forecast the > 0.8 and > 2 MeV electron fluxes at Geostationary Earth Orbit (GEO). The NARMAX algorithm is able to identify mathematical model for a wide class of nonlinear systems from input-output data. The models employ solar wind parameters as inputs to provide an estimate of the average electron flux for the following day. The identified models are shown to provide a reliable forecast for both > 0.8 and > 2 MeV electron fluxes and are capable of providing real-time warnings of when the electron fluxes will be dangerously high for satellite systems.

Magnetopause orientation and motion: comparison of constrained minimum variance and multi–spacecraft triangulation

C.R. Anekallu[1], N. Dorville[2] and S. Haaland[3]

[1] MSSL, University College London, Holmbury St. Mary, U.K.
[2] Laboratoire de Physique des Plasmas, École Polytechnique, Universite Pierre et Marie Curie, Palaiseau, France
[2] Birkeland Center for Space Science, University of Bergen, Norway

Knowledge of orientation, motion and dimensions od plasma structures in space is essential in their study. The advent of multi-spacecraft missions such as Cluster have provided new opportunities to determine these parameters using multiploint observations. Multi spacecraft methods are computationally more complicated and require more data than traditional single spacecraft methods though, and also typically imply strict assumptions about planarity and stationarity of the plasma structure studied. In this paper, we have utilized a large number of Cluster magnetopause crossings to compare triangulation methods with a constrained minimum variance method. The results suggest that the simplified method often provide boundary normal estimations very similar to the more elaborate multi-spacecraft methods.

Ion flux dropout observed near dipolarization front

T. Chen and X. Shi

State Key Laboratory of Space Weather, Center for Space Science and Applied Research, Chinese Academy of Sciences, Beijing 100190, China

An ion flux dropout near the dipolarization front (DF) at around $X_{GSM} = -11\ R_E$ in the Earths plasma sheet was observed by Time History of Events and Macroscale Interaction during Substorms (THEMIS) on March 31, 2009. The ion differential energy fluxes at energies from 450 eV to 150 keV measured by the ESA and SST instruments from THC began to decrease about 2 s before the detection of the DF and reached a local minimum 6 s later. Then, the ion fluxes gradually increased to form a dropout around the DF. The spatial extent of the dropout was about 4000 km. For energies above 20 keV, the ion fluxes after the dropout are greater than those before it, contrary to the fluxes at energies below 20 keV. The associated ion density variation indicates that the ion flux dropout coincides with the ion density dropout. Taking advantage of multipoint observations, THD, THC, and THE detected the same DF consecutively. Only THC detected an obvious ion flux dropout; THD observed an indistinct one about 2 s before THC; no high-energy ($E > 30$ keV) ion flux dropout was observed by THE. Our study suggests that the ion flux dropout may evolve with the earthward-propagating DF and its properties can depend on locations relative to the DF.

Dynamical evolution of the Earth's magnetosphere in response to a sudden ring current injection

G.S. Choe[1] and G. Park[2]

[1] Kyung Hee University, Yongin, Korea
[2] Satrec Initiative, Daejeon, Korea

A numerical simulation study is performed to investigate the dynamical evolution of the Earth's magnetosphere loaded with a transiently enhanced ring current. Two cases with different values of the primitive ring current are considered. In one case, the initial ring current is strong enough to create a magnetic island in the magnetosphere. The magnetic island readily reconnects with the earth-connected ambient field and is destroyed as the system approaches a steady equilibrium. In the other case, the initial ring current is not so strong, and the initial magnetic field configuration bears no magnetic island, but a wake of bent field lines, which is smoothed out through the relaxing evolution of the magnetosphere. The relaxation time of the magnetosphere is found to be about five to six minutes, over which the ring current is reduced to about a quarter of its initial value. Before reaching a steady state, the magnetosphere is found to undergo an overshooting expansion and a subsequent contraction. Fast and slow magnetosonic waves are identified to play an important role in the relaxation toward equilibrium.

The role of the plasmasphere in the generation and propagation of magnetospheric ULF waves with applications to radiation belt modeling

S.G. Claudepierre[1], F. Toffoletto[2], J.G. Lyon[3] and M. Wiltberger[4]

[1] The Aerospace Corporation, El Segundo, CA, USA
[2] Rice University, Houston, TX, USA
[3] Dartmouth College, Hanover, NH, USA
[4] NCAR/HAO, Boulder, CO, USA

Global-scale, three-dimensional simulations of the solar wind/magnetosphere/ionosphere interaction have reached a level of sophistication that permits a consideration of resonant ultra-low frequency (ULF) waves in a realistic magnetospheric configuration. In particular, recent work has successfully coupled the Lyon-Fedder-Mobarry (LFM) global magnetohydrodynamic (MHD) model and the Rice Convection Model (RCM). The coupled LFM-RCM model allows, for the first time, a study of resonant ULF mode coupling in a global- scale, 3D simulation that includes a plasmasphere. We explore the role that solar wind dynamic pressure fluctuations play in the generation of magnetospheric ULF waves, using idealized solar wind configurations to drive the simulations. We present results from both the stand-alone LFM (no plasmasphere) and the coupled LFM-RCM (with plasmasphere), with identical boundary conditions in both simulations. In this numerical experiment, we impose both monochromatic and quasi-broadband ULF fluctuations ($\sim$0-30 mHz) in solar wind dynamic pressure on the magnetosphere. We find toroidal mode field line resonances (FLRs) and cavity/waveguide modes in the magnetospheric response, consistent with well-established mode coupling theory. The inclusion of the plasmasphere in the global simulation has a profound effect on the resonant ULF modes generated. Accurately modeling resonant ULF waves is critical for radial diffusion based models of the Earth's radiation belts, and thus for modeling inner magnetospheric dynamics, in general. To the best of our knowledge, these results are the first to explicitly and unambiguously reproduce such inner magnetospheric resonances using a global simulation of the solar wind/magnetosphere/ionosphere interaction.

Cluster Ion Spectrometry (CIS) data quality indexes at the Cluster Science Archive (CSA)

I. Dandouras[1], A. Barthe[1,2], S. Brunato[1,3], H. Rème[1] and H. Laakso[4]

[1] Institut de Recherche en Astrophysique et Planétologie, Université de Toulouse / CNRS, Toulouse, France
[2] AKKA, Toulouse, France
[3] NOVELTIS, Labège, France
[4] ESA / ESTEC (SCI-RSSD), Noordwijk, The Netherlands

The Cluster Science Archive (CSA) aims at preserving the complete set of the measurements collected by the four Cluster spacecraft, so that they are usable in the long-term by the world-wide scientific community as well as by the instrument teams. This implies that the instrument data, properly calibrated, are filed together with the descriptive and documentary elements making it possible to select and interpret them. The CIS (Cluster Ion Spectrometry) experiment is a comprehensive ionic plasma spectrometry package onboard the Cluster spacecraft, capable of obtaining full three-dimensional ion distributions (about 0 to 40 keV/e) with a time resolution of one spacecraft spin (4 sec) and with mass-per-charge composition determination. For the archival of the CIS data a multi-level approach has been adopted. The CSA archival includes processed raw data, moments of the ion distribution functions, and calibrated high-resolution data in a variety of physical units. The latter are 3-D ion distribution functions, 2-D pitch-angle distributions and 1-D omni-directional fluxes. The CIS data archive includes also experiment documentation, graphical products for browsing through the data, data caveats and data quality indexes. The later constitute a novel product, which has been prepared in order to help the user asses the quality of the data acquired in different magnetospheric regions and during various operational modes. The principle of the CIS data quality indexes will be described and the various issues, that can under some conditions affect the data quality and are thus taken into account in generating the data quality indexes, will be discussed.

Outer radiation belt dynamics following the arrival of an interplanetary shock: what the Cluster–CIS and the Double Star–HIA data can tell us

I. Dandouras[1], N. Ganushkina[2,3] and H. Rème[1]

[1] Institut de Recherche en Astrophysique et Planétologie, Université de Toulouse /CNRS, Toulouse, France
[2] Finnish Meteorological Institute, Helsinki, Finland
[3] University of Michigan, Ann Arbor, USA

Following the launch by NASA of the Radiation Belt Storm Probes (RBSP) twin spacecraft, now named the Van Allen Probes, the discovery of a storage ring was announced: Baker et al., Science, 2013. This transient feature was observed during September 2012, following the arrival of an interplanetary shock, was located between L=3.0 and L=3.5 and consisted of about 4 to 6 MeV electrons. During that period the Cluster spacecraft had a high-inclination orbit, with a perigee just above 2 Re. The CIS experiment onboard Cluster is sensitive to penetrating energetic electrons (energy greater than 2 MeV), which produce background counts and thus allow to localise the boundaries of the outer and inner radiation belts (Ganushkina et al., JGR, 2011). A search was undertaken in the September 2012 CIS data for eventual signatures of the storage ring, and indeed a small increase of the instrument background was observed between L=3.0 and L=3.5. This is clearly separated from the main outer radiation belt, which presents a much stronger background due to higher fluxes of relativistic electrons. A mono-energetic ion drift band was also observed by CIS inside the storage ring, at about 5 keV for He^+ and O^+ ions. This result provides an independent confirmation for the storage ring. In addition, it allows also to examine Cluster and Double Star data from earlier years, covering a solar cycle, for other such signatures of a transient storage ring. It results that this 3-belt structure is seen several times, following the arrival of an interplanetary shock and if the orbital configuration is suitable.

Constraints on plasma entry by impulsive penetration across the magnetopause

J. De Keyser, M. Echim and H. Gunell

Space Physics Division, Belgian Institute for Space Aeronomy, Brussels, Belgium

Spatial inhomogeneities in magnetosheath density and/or flow can result in plasma entities arriving at the magnetopause with excess momentum. Such a plasma entity or blob may penetrate across the magnetopause by the impulsive penetration mechanism. This is made possible by charge separation in the interfaces at the flanks of the penetrating plasma entity creating a polarization electric field in the moving blob that corresponds to the convection electric field. There have been reports of such penetrating blob observations from Cluster, but despite the multiple observation points it remains hard to demonstrate unambiguously that in effect the impulsive penetration mechanism is at work. It is therefore necessary to complement the observations with simulations in order to identify possible observational signatures. We report on such simulations based on a 2-step approach for a simplified geometry, namely a blob that is extended along the magnetic field and in the direction of motion. The lateral flanks of a penetrating blob have been studied with a fully kinetic model. In particular, it is found that these flanks are unstable if the blob is too wide and/or if the penetration speed is too high. These findings are then incorporated into a quasi-static blob model based on the conservation of the total number of particles, of energy, of momentum, and also on pressure balance in the transverse direction. Results of a parameter study of penetration depth, including both adiabatic and non-adiabatic deceleration mechanisms, are reported.

NTC radiation from plasmasphere flanks: local and remote views by the Cluster satellites

P. Décréau[1], P. Canu[2], F. Darrouzet[3], F. El–Lemdani Mazouz[4], S. Rochel Grimald[5], J.L. Rauch[1] and X. Vallières[1]

[1] Laboratoire de Physique et Chimie de l'Environnement et de l'Espace (LPC2E), Orléans, France
[2] Laboratoire de Physique des Plasmas, École Polytechnique, Universite Pierre et Marie Curie, Palaiseau, France
[3] Belgian Institute for Space Aeronomy (IASB-BIRA), Brussels, Belgium
[4] Laboratoire ATmosphère, Milieux, Observations Spatiales (LATMOS), Guyancourt, France
[5] Onera, The French Aerospace Lab, Toulouse, France

The multipoint Cluster constellation explores the Earth's magnetosphere since year 2001. The four WHISPER instruments (measuring electric fluctuations over the 2 to 80 kHz range) have extensively measured radio waves of the Non Thermal Continuum (NTC) type, characterized by a long duration and a weak intensity. WHISPER instruments have revealed that the plasmapause boundary emits NTC radio waves not only near the magnetic equatorial plane, but also at medium magnetic latitudes ($\sim$20 to 40°), along the flanks of the plasmasphere. The latter NTC waves are observed much less frequently than the NTC waves emitted from plasmapause equatorial sources. They display a specific spectral signature: a series of wide frequency bands, in the $\sim$20-80 kHz range, centred at frequencies F separated by a constant referred to as $Fces$. A given series is spatially confined inside narrow beams, which can be crossed successively by the different satellites of the Cluster constellation. The constant $Fces$ observed when a spacecraft approaches the plasmapause layer inbound decreases smoothly in frequency (alternatively, $Fces$ increases when the spacecraft travels away from the layer). The $Fces$ value meets the local electron gyro frequency value, Fce, when the observing spacecraft reaches the plasmapause. For all the analysed events, the plasmapause layer displays, on top of a large density step, clear and numerous density irregularities in the hollows of which intense waves near local plasma frequencies $Fp \sim (n+d)Fce$ $(0 < d < 1)$ seem to be trapped. They are interpreted as the mid latitude radio sources producing the observed F series (hence the chosen term $Fces$, i.e. gyro frequency at source).
In the lower WHISPER frequency range (at and below $\sim$25 kHz), NTC emissions, usually trapped and showing no harmonic structure, display at times a clear harmonic signature associated to low $Fces$ values ($\sim$2-5 kHz). During the one month tilt campaign of the Cluster mission (May 2008), a pair of close by satellites has been able to track the 3D ray path orientation of such NTC emissions. Their sources were observed remotely, this time, but also localized within mid latitude regions of the outer plasmaphere. We discuss the perspectives opened by this finding.

Generic residue analysis and BV method comparison

N. Dorville[1], C.R. Anekallu[2], S. Haaland[3] and G. Belmont[1]

[1] LPP, Ecole Polytechnique, CNRS, UPMC, Université Paris Sud, Palaiseau, France
[2] Mullard Space Science Laboratory, University College London, United Kingdom
[3] Max-Planck Institute for Solar Systems Research, Katlenburg-Lindau, Germany & Birkeland Centre for Space Science, University of Bergen, Norway

Determining the orientation of the normal direction to the magnetopause layer is a key issue for studying in detail the structure of this boundary. Both conservation laws methods and the new iterative BV method, that performs a fit of the magnetic field and ion normal flow velocity with an elliptic model, have been developped for this purpose. These methods have different model assumptions and validity ranges. Unlike the conservation laws methods, the BV method also provides spatial profiles inside the layer. However, it is compatible only with a subset of magnetopause crossings with a single layer current sheet. We compare here statistically their results on a list of flank and dayside magnetopause crossings, and focus on a few case studies to understand the reasons of the similarities and differences between the normal directions found.

Magnetic nulls in the Earth's magnetotail

E. Eriksson[1], A. Vaivads[1], Y.V. Khotyaintsev[1], S. Markidis[2], M. André[1], H. Fu[3] and T. Karlsson[4]

[1] Swedish Institute of Space Physics, Uppsala, Sweden
[2] PDC Center for High Performance Computing, KTH Royal Institute of Technology, Stockholm, Sweden
[3] Space Science Institute, School of Astronautics, Beihang University, Beijing, China
[4] Space and Plasma Physics, KTH Royal Institute of Technology, Stockholm, Sweden

Regions with vanishing magnetic field values, also referred to as magnetic nulls, are of high interest in plasma physics. Near magnetic nulls particles become unmagnetized and can by interacting with electric fields, in proximity of the magnetic nulls, be accelerated up to keV and higher energies. We study magnetic nulls in the Earth's magnetotail using data from four Cluster satellites with a maximum separation of about one ion inertial length (≈1000km). The observed nulls are classified according to their type and a statistical analysis of their distribution in the magnetotail is presented. In addition, we analyze the relation of magnetic nulls to reconnection processes in the magnetotail. These observations will later be used to determine the importance of regions surrounding magnetic nulls to the electron acceleration processes in the magnetotail.

Particle injections near the exterior cusp observed by Cluster

C.P. Escoubet[1], B. Grison[2], E.J. Berchem[3], K.J. Trattner[4], B. Lavraud[5,6], F. Pitout[5,6], R. Richard[3], M.G.G.T. Taylor[1], H. Laakso[1], A. Masson[7], M. Dunlop[8], I. Dandouras[5,6], H. Reme[5,6], A. Fazakerley[9] and P. Daly[10]

[1] ESA/ESTEC (NL)
[2] Institute of Atmospheric (Czech Republic)
[3] UCLA/IGPP (USA)
[4] LASP, Colorado U. (USA)
[5] University of Toulouse, UPS-OMP, IRAP, Toulouse, France
[6] CNRS, IRAP, BP 44346, F-31028, Toulouse cedex 4, France
[7] ESA/ESAC (Spain)
[8] RAL (UK)
[9] MSSL (UK)
[10] MPS (Germany)

The main process that injects solar wind plasma into the polar cusp is now generally accepted to be magnetic reconnection. Depending on the IMF direction, this process takes place equatorward (for IMF southward), poleward (for IMF northward) or on the dusk or dawn sides (for IMF azimuthal) of the cusp. We report a Cluster crossing on 5 January 2002 near the exterior cusp on the southern dusk side. The IMF was mainly azimuthal (IMF-By around -5 nT), the solar wind speed lower than usual around 280 km/s with the density of order 5 cm-3. The four Cluster spacecraft had an elongated configuration near the magnetopause. C4 was the first spacecraft to enter the cusp around 19:52:04 UT, followed by C2 at 19:52:35 UT, C1 at 19:54:24 UT and C3 at 20:13:15 UT. C4 and C1 observed two ion energy dispersions at 20:10 UT and 20:40 UT and C3 at 20:35 UT and 21:15 UT. Using the time of flight technique on the upgoing and downgoing ions, which leads to energy dispersions, we obtain distances of the ion sources between 14 and 20 Re from the spacecraft. Using Tsyganenko model, these sources are located on the dusk flank, past the terminator. The first injection by C3 is seen at approximately the same time as the 2nd injection on C1 but their sources at the magnetopause were separated by more than 7 Re. This would imply that two distinct sources were active at the same time on the dusk flank of the magnetosphere.

High–latitude ionospheric convection from Cluster EDI revisited: interhemispheric differences and solar cycle effects

M. Förster[1] and S.E. Haaland[2,3]

[1] GFZ German Research Centre for Geosciences, Helmholtz Centre Potsdam, Germany
[2] Birkeland Centre for Space Science, University of Bergen, Norway
[3] Max Planck Institute for Solar System Research (MPS), Göttingen, Germany

Much of our knowledge about the magnetosphere-ionosphere interaction is based on measurements from the Northern Hemisphere only. Likewise it is often based on observations of single events or shorter time periods. Here, we present a study of ionospheric convection based on satellite measurements of the Electron Drift Instrument (EDI) on-board Cluster, covering both hemispheres, and obtained over a full solar cycle (2001-2013). The large amount of data allows us to perform more detailed statistical studies.

We demonstrate that flow patterns and polar cap potentials for a given orientation of the interplanetary magnetic field can be very different in the two hemispheres. In particular during southward directed interplanetary magnetic field conditions, and thus enhanced energy input from the solar wind, we find that the southern polar cap has a higher cross polar potential. We also find persistent north-south asymmetries which cannot be explained by external drivers. These persistent asymmetries are probably due to significant differences in the strength and configuration of the geomagnetic field between the Northern and Southern Hemisphere. Since the ionosphere is magnetically connected to the magnetosphere, this difference will also be reflected in the magnetosphere in the form of different feedback from the two hemispheres. Consequently, local ionospheric conditions and the geomagnetic field configuration are important for north-south asymmetries in large regions of geospace.

Examining the polytropic index of the plasma sheet using Cluster

C. Forsyth[1], A.N. Fazakerley[1], I.J. Rae[1], C.E.J. Watt[2], Z. Yao[1] and C.J. Owen[1]

[1] UCL Mullard Space Science Laboratory, Dorking, Surrey, UK
[2] University of Reading, Reading, UK

In order to constrain the ever-deepening equations of magnetohydrodynamics, an equation of state is often applied to a plasma. This is often taken to be of the form $P=kn^\gamma$, with $\gamma = 5/3$, similar to a monatomic gas. Studies using 3 years worth of AMPTE IRM data by Baumjohann and Paschmann (1989) showed that the peak of the distribution of γ observed in the tail was indeed 5/3, although their study examined plasma packets over 30 min to make this determination. Later studies (Goertz and Baumjohann, 1991) showed that the distribution of γ varied with auroral index. In this study, we build on this work using 9 years worth of Cluster tail data by examining how γ varies with sample time, tail region, substorm phase and solar cycle.

Multi–point observations of large scale perturbations on the open–closed field line boundary during a geomagnetic storm, as observed by the Van Allen probes and geostationary satellites

M. Grande[1], P. Dixon[1], E. MacDonald[2], A. Glocer[2], H. Spence[3] and G. Reeves[4]

[1] Aberystwyth University, Aberystwyth, United Kingdom
[2] NASA Goddard Space Flight Center, United States
[3] University of New Hampshire, USA
[4] Los Alamos National Laboratory, USA

We discuss a series of lobe entry events observed by the twin Van Allen Probe spacecraft between 0200 and 0515 UTC during the November 14th 2012 geomagnetic storm. During the events Dst was below -100nT with the IMF being strongly southward (Bz = -15nT) and eastward (By = 20 nT). The events occurred on the southern hemisphere flank between 0400 and 0635 local time and at altitudes between 5.6 and 6.2 RE , and were characterized by significantly diminished electron and ion fluxes and a corresponding strong, highly stretched magnetic field. Both spacecraft crossed into the lobe five times with durations from 3–10 minutes. Four of the events were seen by both Van Allen Probes nearly simultaneously despite separations of up to 45 minutes of local time. In all cases the more tailward satellite sees the boundary crossing first.

The lobe was also encountered at the same time by the LANL geosynchronous satellites, both at dawn in the northern hemisphere and dusk in the southern hemisphere. These multi–spacecraft observations are used to constrain the spatial and temporal extent of the open/closed field line boundary and to compare this topology to that predicted by a range of magnetic field models. We compare to BATS-R-US predictions, and find that the crossings appear to correspond to a large scale wave structure on the boundary.

Significant accelerated field aligned oxygen signatures were measured by the HOPE low energy plasma instrument aboard the probes. Using the multi–point measurements we will examine the source of this acceleration and its role in inner magnetosphere ion dynamics.

Ion acceleration in the vicinity of a near–Earth X–line.

E.E. Grigorenko[1], E.A. Kronberg[2], P.W. Daly[2] and M.S. Dolgonosov[1]

[1] Space Research Institute, Moscow, Russia
[2] Max-Plank Institute for Solar System Research, Gottingen, Germany

Cluster observations near its apogee allow studying of ion acceleration in the vicinity of an active X-line. We investigated CODIF and RAPID observations during several periods, when a magnetic X-line was either located earthward of Cluster spacecraft (s/c) or was propagating tailward by Cluster quartet. CODIF observations showed the presence of the tailward/earthward moving proton and oxygen field-aligned beams only when Cluster s/c was located at some distance from the X-line. This indicates that the ion beams, which are accelerated by the potential electric field in the course of the nonadiabatic interaction with the current sheet, cannot be formed in the very close vicinity of a magnetic X-line. On the contrary, RAPID instruments detected the increases of energetic protons and heavy ions during the periods of X-line passage by Cluster s/c. This denotes the significance of inductive electric fields in ion acceleration in the close vicinity of a magnetic X-line. These electric fields could be generated in the course of magnetic island/plasmoid(s) formation, since multiple bipolar variations of Bz component of the magnetic field were observed simultaneously with the energetic ion fluxes.

Observations of waves in plasmoids in the magnetosheath

H. Gunell[1], G. Stenberg Wieser[2], M. Mella[3], R.Maggiolo[1], H. Nilsson[2], F.Darrouzet[1], M. Hamrin[4], T.Karlsson[5], N. Brenning[5], J. De Keyser[1], M. André[3] and I. Dandouras[6]

[1] Belgian Institute for Space Aeronomy, Avenue Circulaire 3, B-1180 Brussels, Belgium
[2] Swedish Institute of Space Physics, P.O. Box 812, SE-981 28 Kiruna, Sweden
[3] Swedish Institute of Space Physics, Box 537, SE-751 21 Uppsala, Sweden
[4] Department of Physics, Umeå University, SE-901 87 Umeå, Sweden
[5] Space and Plasma Physics, Royal Institute of Technology (KTH), SE-100 44 Stockholm, Sweden
[6] Institut de Recherche en Astrophysique et Planétologie, UPS-CNRS, 31028 Toulouse, France

In recent years, several observational studies of the magnetosheath have revealed plasma entities with a higher anti-sunward velocity component than the surrounding plasma (*e.g. Karlsson et al.*, JGR, **117**, A03227, 2012; *Hietala, et al.*, Ann. Geophys., **30**, 33–48, 2012). We shall call these entities plasmoids, since their spatial extent is limited in three dimensions. The current understanding of the formation of the plasmoids is that the majority of them could be created when a quasi-parallel bow shock is rippled by MHD scale waves, and that other processes such as discontinuities in the solar wind would be required in a minority of cases (*Hietala and Plaschke*, JGR, **118**, 7237–7245, 2013).

We have examined data from the Cluster spacecraft obtained in March 2007. The Cluster spacecraft crossed the magnetopause near the subsolar point thirteen times during that month. Plasmoids with larger velocities than the surrounding magnetosheath were found on seven of these thirteen occasions. We used data from the STAFF instrument to search for waves in the frequency range $10\,\text{Hz} \leq f \leq 500\,\text{Hz}$. In all the plasmoids that were identified in the data, waves were observed, and in the vast majority of these the wave energy density was above the average level in the magnetosheath. Both whistler mode waves and waves in the lower hybrid frequency range were observed.

We observe plasmoids that collide with the magnetopause, causing that boundary to move inward. The magnetospheric plasma on its inside is set in motion with a velocity corresponding to the $\vec{E} \times \vec{B}/B^2$ drift velocity. The thus generated perturbation gives rise to Alfvénic waves that are observed deep in the magnetosphere. These waves reveal the presence of a cold proton population, which is seen only when the wave makes the $\vec{E} \times \vec{B}/B^2$ drift speed large enough for these cold ions to overcome the threshold for detection of the ion instruments.

This work was supported by the Belgian Science Policy Office through the Solar-Terrestrial Centre of Excellence and by PRODEX/Cluster contract 13127/98/NL/VJ(IC)-PEA 90316.

PIC simulation of dipolarization fronts based on magnetic island coalescence

T. Haruki[1], I.I. Vogiatzis[2], A. Isavnin[3], E.T. Sarris[2] and Q.G. Zong[4]

[1] Plasma Simulation Group, Graduate School of Science and Engineering, University of Toyama, Toyama, Japan.

[2] Department of Electrical and Computer Engineering, Democritus University of Thrace, Xanthi, Greece.

[3] Department of Physics, University of Helsinki, P.O. Box 64, FI–00014, Finland.

[4] Institute of Space Physics and Applied Technology, Peking University, Beijing, China.

Near–Earth dipolarization fronts are common phenomena associated with earthward high–speed plasma flows and clear dipolarization signatures which are often preceded by a negative dip in Bz. There is evidence that dipolarization fronts are directly related to earthward propagating flux ropes which are expected to be dissipated through their merging with the background geomagnetic field. By applying PIC simulation on an island-chain equilibrium model we make a first attempt to investigate if magnetic island coalescence could be capable of reproducing the main observational features that are commonly observed during dipolarization fronts.

Data visualization in the Cluster Science Archive

D. Herment[1], B. Martinez[1] and H. Laakso[2]

[1] ESA/ESAC, Spain
[2] ESA/ESTEC, Netherlands

The Cluster Science Archive offers its users online data visualization capabilities which are divided into several graphical users interface;

1. - Cluster key graphical products The most used Cluster data products can be visualized in the form of a stack of panels, selected by the user. Each panel is either a spectrogram or a time series related to the data product measured by one spacecraft (or by four spacecraft for some of the line plots i.e. DC magnetic field measured by FGM). Moreover, users have the choice between two types of visualization:
   (a) * Pre-generated panels: some of the plots have been produced beforehand on the archive servers for three pre-defined time periods (1 hour, 6 hours, 1 day). It enables the users to browse quickly through the data to identify events of interest; it can be very useful for instance to collect similar data signatures.
   (b) * On-demand panels: the plots are generated on-the-fly for any time period shorter than 54 hours. This allows users to focus on a specific event.
2. - Particle distribution functions They can be visualized for each of the Cluster particles experiments (CIS - ion spectrometer, PEACE - electron spectrometer and RAPID - energetic electron and ion spectrometers). Users have the choice between four types of plots: angle/angle plots, pitch-angle/energy plots, Sauvaud plots and wheel plots. The software is being developed by the Cluster Active Archive team and is still considered as a beta version.
3. - Quicklooks plots These plots are different types of pre-generated plots;
   (a) * summary plots originally produced by the Cluster Science Data System as well as similar overview plots produced by the Cluster archive team using the best calibrated data available in the archive
   (b) * a few quicklook plots have been produced by some PI teams, based on their own software
   (c) * cross-calibration plots, produced by the Cluster archive team, which enable to quickly compare the same type of measurements provided by two different instruments (electron density, drift velocity, magnetic or electric field).
   (d) * supporting quicklook plots produced in the framework of FP7-EU projects, like ECLAT or MAARBLE, are there to help the data analysis of scientists.
4. - Inventory plots They give the users an easy way to visualize gaps in the data as well as instrument mode changes (e.g. presence of burst mode) and predicted magnetospheric regions. They can be either pre-generated (1 day, 1 month or 1 year duration) or produced on-demand (up to 7 days).

Extremely high–energy plasma/particle sensor for electron (XEP-e) of the ERG satellite

N. Higashio and H. Matsumoto

Japan Aerospace Exploration Agency, Japan

It is well known that satellites are always in danger in space and especially high-energy radiation damages them. One of the sources that cause them is the radiation belt (the Van Allen belt). It was thought to be static, but in the 1990s it rediscovered the radiation belt fluctuates greatly. There are some reasons to occur this phenomenon, but we have not understood a clear reason of this yet. On the other hand, it is well known that the energetic particle flux vary during geomagnetic disturbances and the relativistic electrons in the other radiation belt change with solar wind speed. Recently solar activity is getting larger, so now we are trying to develop the satellite (ERG) to reveal this mechanism in this solar maximum phase. ERG (Energization and Radiation in Geospace) satellite is the small space science platform for rapid investigation and test satellite of JAXA/ISAS, and our group is developing the instrument (XEP-e) to measure high-energy electrons (400keV 20MeV), that is one of many ERG satellite instruments. The XEP-e (eXtremely high Energy Plasma/ particle sensor for electron) is consists of the 5 SSDs (Solid-State Silicon Detectors) and a GSO single crystal scintillator. It has one-way conic sight and an electric part is unified with a part of sensor that is covered with aluminum to protect from contaminationand and an anti-scintillator to detect it. The front part of the SSDs discriminate a radiation enters into the sensor and the back part of the plastic scintillator get the value of its energy. We can get the data of high-energy electron by using this sensor and it will be useful to reveal the detail of the radiation belts fluctuation.

Reconnection and energy conversion at the magnetopause as influenced by Earth's dipole tilt angle and interplanetary magnetic field

S. Hoilijoki[1,2], V.M. Souza[3], B.M. Walsh[4], P. Janhunen[1] and M. Palmroth[1]

[1] Finnish Meteorological Institute, Helsinki, Finland
[2] University of Helsinki, Helsinki, Finland
[3] National Institute for Space Research/INPE, São José dos Campos, São Paulo, Brazil
[4] Space Sciences Laboratory, University of California, Berkeley, California, USA

We study how the Earth's dipole tilt angle and interplanetary magnetic field (IMF) B_x and B_y components affect the location of reconnection and the energy conversion at the magnetopause. We carry out three sets of runs with different dipole tilt angles using a global MHD model GUMICS-4. Each set consists of IMF parameters satisfying both inward- and outward-type Parker spiral conditions during southward IMF. We also validate the simulation results by comparing them to THEMIS A and Double Star TC1 in situ observations of magnetopause reconnection event and find that the GUMICS-4 dayside reconnection line location is in excellent quantitative accordance with observations. Simulation results show that positive (negative) B_x affects the reconnection line location by moving it northward (southward) and positive (negative) dipole tilt angle by moving the line southward (northward). Additionally, we find that the tilt shifts the dayside load region towards the winter hemisphere and enhances the energy conversion through the generator region in the summer hemisphere. The intensity in the load region is mainly affected by IMF B_x, whereas in the generator regions the dipole tilt angle seems to affect the intensity of the energy conversion more.

Estimation of the location of the source region of the equatorial noise emissions from the Cluster measurements

Z. Hrbackova[1,2], O. Santolik[1,2], J.S. Pickett[3] and D.A. Gurnett[3]

[1] Department of Space Physics, Institute of Atmospheric Physics, Prague, Czech Republic,
[2] Faculty of Mathematics and Physics, Charles University in Prague, Prague, Czech Republic.
[3] University of Iowa, Iowa City, IA.

We report the results of the systematic analysis of the data from 10 years of the Cluster WBD measurements. We have searched for occurrence of the equatorial noise (EN) emissions (also known as the fast magnetosonic waves). These waves interact with ions at their characteristic gyrofrequencies and their harmonics. The frequency spectrum therefore consists of many spectral lines with frequency spacings ranging from a few hertz to several tens of hertz. We have used measurements of the WBD instruments which provide us with high-resolution data of electric and magnetic fields. We have found more than 300 events and we have visually checked them for visibility of the spectral lines. We have recorded frequencies of the spectral lines whose intensities of electric field fluctuations were higher than 10^{-6} nT^2Hz^{-1} and intensities of magnetic field fluctuations were higher than 10^{-7} nT^2Hz^{-1}. We have estimated the locations of the source regions of EN events from the frequency differences of the spectral lines. The results show maximum occurrence rates at distances around 4 R_E.

This work receives EU support through the FP7-Space grant agreement no 284520 for the MAARBLE collaborative research project.

Detailed analysis of the small-scale magnetic island in the near-Earth magnetotail

A. Isavnin[1] and I.I. Vogiatzis[2]

[1] Department of Physics, University of Helsinki, Helsinki, Finland
[2] Department of Electrical and Computer Engeneering, Democrithus University of Thrace, Xanthi, Greece

Plasmoids are known to be produced in association with substorms, when a helical structure is generated between the near-Earth reconnection X-line and the distant-tail neutral line. However, smaller magnetic islands can form in the region of the pre-existing near-Earth neutral line. These secondary magnetic islands, which can be explained in terms of flux ropes, are known to travel both tailwards (plasmoid-type) and earthwards (BBF-type) after their generation and are formed in a multiple X-line reconnection configuration. Though plasmoid-type flux ropes reflect the properties of the reconnection region they originate from, they are not magnetically connected to the ionosphere. BBF-type flux ropes, on the other hand, are at least embedded into the environment which can be magnetically mapped onto the ionosphere.

The *in-situ* measurements of magnetic field and plasma properties that can be interpreted in terms of BBF-type flux ropes can be also explained by other magnetic field configurations, which complicates their identification. We present a thorough analysis of the earthward-propagating flux-rope-like structure registered by the THEMIS spacecraft in the Earth's magnetotail. We apply various modeling and reconstruction techniques to deduce its properties and explain its evolution in terms of the flux rope deterioration model.

The formation of the ion seed population at quasi-parallel shocks

A. Johlander[1], A. Vaivads[1], Y. Khotyaintsev[1], A. Retinó[2], I. Dandouras[3,4], E. Yordanova[1] and M. André[1]

[1] Swedish Institute of Space Physics, Uppsala, Sweden
[2] LPP, Ecole Polytechnique, CNRS, UPMC, Universit Paris Sud, Palaiseau, France
[3] CNRS, Institut de Recherche en Astrophysique et Planetologie, Toulouse, France
[4] University of Toulouse, UPS-OMP, IRAP, Toulouse, France

Shocks in space plasmas are known to be capable of accelerating particles to very high energies. One unsolved issue with this process is the formation of a seed population of suprathermal ions on which Fermi acceleration can act. In this work, we study the formation of this ion seed population as a result of ion reflection off short large amplitude magnetic structures (SLAMS) in the quasi-parallel bow shock. For our analysis, we use data from the Cluster instruments, CIS, EFW and FGM when the separation of the Cluster satellites was short. We use ion subspin data to follow the ion dynamics at faster temporal scale than spin resolution. We also use timing on all four spacecraft to obtain the orientation, speed and spatial scale of the SLAMS. Furthermore, we compare electric field data to the the observed ion acceleration. We compare our observations with the existing models of the formation of the ion seed population.

Solar–terrestrial coupling: an approach based on wavelet analysis

Ch. Katsavrias[1,2], A. Hillaris[2] and P. Preka–Papadema[2]

[1] IAASARS, National Observatory of Athens, Penteli, Greece
[2] Faculty of Physics, University of Athens, Athens, Greece

We study the relationship, in the time–frequency space, of the geomagnetic disturbances (represented by the geomagnetic indices, Kp, DST and AE) and their *drivers*, which are, the Interplanetary Coronal Mass Ejections (ICMEs) and the co–rotating interaction regions (CIR). The time-series analyzed, representing *drivers* and geomagnetic indices, span the Solar cycle 23 and permit examination on time scales shorter than the sunspot cycle. By means of continuous wavelet transform (CWT) intervals of quasi–periodic behavior were thus detected in all time–series, a number which were common to one or both of said *drivers* and the geomagnetic indices. Then wavelet based functions, cross–wavelet spectra (XWT) and wavelet coherence (WTC) in particular, were used in an attempt to quantify relations between the time–series in terms of *common power* and *phase coherence*; significant shared periodicities between ICMEs–Geomagnetic indices follow the sunspot cycle while the shared periodicities between HSSWS/CIR–Geomagnetic indices are close to the 27 days period of solar rotation.

Ion acceleration at the Earth's parallel bow shock: what can we learn from Cluster?

A. Kis[1], M. Scholer[2], B. Klecker[2], O. Agapitov[3], V. Krasnosselskikh[4], E. Kronberg[5], P. Daly[5], I. Dandouras[6], I. Lemperger[1], V. Wesztergom[1] and A. Novak[1]

[1] Research Centre for Astronomy and Earth Sciences, Sopron, Hungary
[2] Max-Planck-Institut fuer extraterrestrische Physik, Garching, Germany
[3] University of California, Berkeley, USA
[4] LPC2E, CNRS, France
[5] MPS, Goettingen, Germany
[6] CNRS, IRAP, Toulouse, France

Using simultaneous multi-spacecraft Cluster data we present individual events that illustrate the details of ion acceleration mechanism and show how the mechanism can differ from event to event. We also analyze the three important requirements of the first order Fermi ion acceleration: injection, diffusive scattering and the way how the ions might be able to escape the system.

Recognition of Cluster bow shock crossings

T. Kłos[1] and H. Laakso[2]

[1] ESA/ESAC, Spain
[2] ESA/ESTEC, Netherlands

The purpose of Cluster mission is to study the small-scale structures of Earth's plasma environment. The four Cluster spacecraft, each equipped with 11 scientific instruments, fly in formation separated by few tens to 10 000 kilometers. The Cluster spacecraft provide a 3-dimentional data of, among others, bow shock, magnetopause, polar cusp and auroral zone regions.

The bow shock is a collisionless shock front formed due to the supersonic solar wind stream hitting the Earths magnetic field. As a result, the supersonic solar wind is rapidly decelerated, being subsonic in the downstream side of the shock, called the magnetosheath. The nature of the bow shock and the regions upstream and downstream of the bow shock depends strongly on the direction of the interplanetary magnetic field with respect to the local normal of the bow shock.

A spacecraft leaving solar wind region and entering magnetosheath (and vice versa) detects sudden changes in total magnetic field and electron and ion densities and velocities, among other parameters. Most parameters, although changing at the shock front, do not change in any consistent manner that they could be used for the automatic detection of the shock. There are two main difficulties in detecting the bow shock crossings. Firstly, the sudden jumps don't occur at exactly the same time in all physical parameters. They can be separated by up to a few minutes. The second difficulty comes from the fact that solar wind is much faster than the spacecraft itself (400 km/s on average compared to around 3 km/s). As a consequence, even a small change in solar wind velocity causes the bow shock to move with high speed. This results in multiple crossings within one orbit and, quite often, within a couple of minutes.

The algorithm developed in the CAA searches for the bow shock crossings by identifying sudden jumps in data from six variables coming from four instruments. If these jumps occur at approximately the same time in at least 3 variables, a bow shock crossing is detected. Some additional checks are performed to ensure consistency of the results. A GUI application has also been developed to provide an easy method for manual corrections of the detected boundaries.

Cleaning Double Star magnetic field data

T. Kłos[1] and H. Laakso[2]

[1] ESA/ESAC, Spain
[2] ESA/ESTEC, Netherlands

Double Star was the first scientific mission done in collaboration between ESA and Chinese National Space Agency. Half of the instruments are flight spares of the Cluster instruments. The purpose of the mission was to study, together with Cluster, physical processes in the Earth's magnetosphere. Two Double Star satellites (TC-1 and TC-2), launched in Dec 2003 and Jul 2004, were operational for almost four years. Each spacecraft carries 8 experiments including a dual Flux-Gate Magnetometer.

Due to a wrong wiring of the solar panels, large magnetic interferences occur on TC-1 while for TC-2 the solar array wiring was corrected. On both spacecraft there are plenty of telemetry errors particularly when the data were collected through Chinese ground stations (data through ESAC antennas were much cleaner) that affect the quality of the measurements. Due to these two problems the magnetic field measurements available until now to the community are spin averaged products. The goal of the project is to clean high resolution observations and archive them in Cluster Active Archive (CAA).

The poster shows the main processing steps developed in the CAA:

1. removing the highly varying magnetic interference of the solar arrays from the magnetic field measurements and

2. detecting and removing bad data points.

Both are based on the usage of dual-magnetometer technique and all processing software has been written in C.

Systematic analysis of whistler mode waves in plasmaspheric plumes

I. Kolmasova[1], O. Santolik[1,2], F. Darrouzet[3], M. Usanova[4] and N. Cornilleau–Wehrlin[5,6]

[1] Institute of Atmospheric Physics ASCR, Prague, Czech Republic
[2] Faculty of Mathematics and Physics, Charles University, Prague, Czech Republic
[3] Belgian Institute for Space Aeronomy (IASB-BIRA), Brussels, Belgium
[4] Department of Physics, University of Alberta, Edmonton, Alberta,Canada
[5] LPP - CNRS - Ecole Polytechnique, Palaiseau, France
[6] LESIA - Observatoire de Meudon, Meudon, France

Occurrence rates and propagation properties of whistler mode waves in plasmaspheric plumes are analyzed based on a large database of measurements of the Cluster STAFF-SA instruments and on a list of crossings of plasmaspheric plumes which was compiled using the data of the WHISPER instrument from 2001 to 2006. Amplitudes of the whistler mode waves in plumes are investigated in connection to the geomagnetic activity. The whistler mode waves are analyzed together with the database of electromagnetic ion cyclotron (EMIC) wave events found using the same list of plume crossings. Comparison of amplitudes of EMIC and whistler mode waves leads us to the investigation of the possibility of simultaneous generation of the two kinds of waves.

This work receives EU support through the FP7-Space grant agreement no 284520 for the MAARBLE collaborative research project.

Van Allen Probes observations of wave–particle interactions in the pre–midnight sector of the magnetosphere

G.I. Korotova[1,2], D.G. Sibeck[3], H.E. Spence[4], C.A. Kletzing[5], J.R. Wygant[6], K.J. Hwang[3,7], R. Redmon[8] and P.S. Moya[3,7]

[1] IZMIRAN, Moscow, Russia
[2] University of Maryland, College Park, Maryland, USA
[3] NASA Goddard Space Flight Center, Greenbelt, Maryland, USA
[4] EOS, New Hampshire, USA
[5] Iowa University, Iowa, USA
[6] University of Minnesota, Minnesota, USA
[7] University of Maryland, Baltimore County, Baltimore, Maryland, USA
[8] STPD/NOAA, Colorado, USA

Van Allen Probe B, located pre-midnight near L=5 observed quasi-periodic variations in the flux of energetic protons that were accompanied by Pc4 pulsations with similar periods on May 1, 2013. The IMF was strongly southward with many possible triggers and GOES recorded the compression of the nightside magnetosphere. The energetic electrons did not show any significant variations. We discuss a mode of the wave and possible mechanisms of generation of Pc4 pulsations.

Fermi acceleration through stochastic electric fields

S. Kovaios, V. Tsiolis, Th. Pisokas, H. Isliker and L. Vlahos

Section of Astrophysics, Astronomy and Mechanics, Department of Physics
Aristotle University of Thessaloniki, GR 541 24 Thessaloniki, Greece

The random motion of a particle is one of the fundamental physical processes that appear widely in nature. Our work focuses on the main concepts of normal and anomalous diffusion from the perspective of the random motion. In particular, we show how Brownian motion can be mathematically described in terms of a simple random walk model. Furthermore, we derive analytically the distribution function $P(\mathbf{r}, \mathbf{t})$ as the solution to the corresponding Fokker-Planck equation with the diffusion coefficient D. The model has been tested in 1D, 2D, and 3D, giving results consistent with the theory. We furthermore examine the random walk on grids: a Cartesian, and a spherical grid. The numerical results for the diffusion coefficient as well as the distribution function are in total agreement with the theoretical ones. We then implement the above scenario on a grid where random electric fields appear and particles can escape from the simulation box, in order to simulate Fermi acceleration. Such simulations support our efforts to comprehend the dynamic behavior of plasma in the magnetosphere.

Electron densities inferred from plasma wave spectra obtained by the Van Allen Probes EMFISIS Waves instrument

W.S. Kurth[1], S. De Pascuale[1], J.B. Faden[1], S. Thaller[2], C.A. Kletzing[1] and J.R. Wygant[2]

[1] University of Iowa, Iowa City, IA 52242, USA
[2] University of Minnesota, Minneapolis, MN, USA

The twin Van Allen Probes spacecraft, launched in August 2012, carry identical scientific payloads. The Electric and Magnetic Fields Instrument Suite and Integrated Science (EMFISIS) includes a plasma wave instrument (Waves) that measures three magnetic and three electric components of plasma waves in the frequency range of 10 Hz to 12 kHz using triaxial search coils and the Electric Fields and Waves (EFW) triaxial electric field sensors. The Waves instrument also measures a single electric field component of waves in the frequency range of 10 to 500 kHz. A primary objective of the higher frequency measurements is the determination of the electron density n_e at the spacecraft, primarily inferred from the upper hybrid resonance frequency $f_{uh}^2 = f_{ce}^2 + f_{pe}^2$ where f_{ce} and f_{pe} are the electron cyclotron and electron plasma frequencies, respectively. The Van Allen Probes orbits are inclined to the geographic equator by about 10 degrees and the apoapses are near 5.8 R_E. The density profiles observed fall under two broad categories. First, on many orbits, the spacecraft do not leave the plasmasphere and the electron density remains relatively high throughout the orbit. Second, the spacecraft leave the plasmasphere during the apoapsis portion of the orbit. This typically occurs during active times when the plasmapause is pushed into smaller L shells.

Considerable work has gone into developing a process for identifying and digitizing the upper hybrid resonance frequency in order to infer the electron density as an essential parameter for interpreting not only the plasma wave data from the mission, but as input to various magnetospheric models. Good progress has been made in developing algorithms to identify f_{uh} and create a data set of electron densities. However, even using the EFW potential data as a guide, it is often difficult to interpret the plasma wave spectrum during active times to identify f_{uh} and accurately determine n_e. In some cases there is not a clear signature of the upper hybrid band and the low-frequency cutoff of the continuum radiation is used. In this case, it is assumed that the continuum is at least partially propagating in the ordinary mode and the cutoff is at f_{pe}. This cutoff, however, may not be local to the spacecraft, hence, this can only be used to determine an upper limit to the electron density. In other cases, the spectrum can be confused by multiple bands at $(n + 1/2)f_{ce}$ (Bernstein modes), f_q resonances, or harmonics related to clipping of strong signals in the Waves instrument. We describe the expected accuracy of n_e and issues in the interpretation of the electrostatic wave spectrum.

DC electric fields measured by CIS and PEACE

H. Laakso

ESA/ESTEC

This presentation compares the DC Electric Fields and Drift Velocities from five different Cluster experiments which have been recently made available to the science community. Comparisons are shown in different plasma regions along Cluster orbit. The experiments are the EDI and EFW electric field experiments and the HIA, CODIF and PEACE particle experiments. The detailed comparisons show clearly where the given instrument has problems in its measurements.

Cold and hot ion distributions in the Earth's magnetosphere

K. Li[1], P. Daly[1], M. André[2], S. Haaland[1], E. Kronberg[1], A. Eriksson[2] and Y. Wei[3]

[1] Max-Planck Institute for Solar System Research, Göttingen, Germany
[2] Swedish Institute of Space Physics, Uppsala, Sweden
[3] Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing, China

The cold ion with energy lower than tens of eV was considered to be hardly detected. Because the spacecraft is positively charged in the magnetic tail lobes, the ions with low energies are scattered away and cannot reach the detector onboard the spacecraft. The cold ions are recently found to dominate the ion population in the lobes. In this work, we compare the distributions of hot and cold ions in the magnetotail, to investigate if they can coexist, and how much of the hot ions are energised from the cold ions. To achieve this, we use the extended dataset (2001-2010, the method is described in [Engwall et. al., 2009]) from Cluster 1 and 3. The hot ions (energies higher than 27 keV) are directly measured by RAPID on Cluster. The 3-d distribution of hot and cold ion fluxes are retrieved. Our preliminary results suggest the distribution changes in the solar cycle with corresponding to geomagnetic activities.

The current system of dipolarizing flux bundles

J. Liu[1], V. Angelopoulos[1], A. Runov[1], X. Zhou[1] and Z. Yao[2]

[1] Department of Earth, Planetary and Space Sciences and Institute of Geophysics and Planetary Physics, University of California, Los Angeles, CA 90095-1567, USA
[2] Mullard Space Science Laboratory, University College London, Dorking, UK

A dipolarizing flux bundle (DFB) is a small magnetotail flux tube (typically$<\sim$ 3 R_E in X_{GSM} and Y_{GSM}) with a significantly more dipolar magnetic field than its background. A DFB's leading edge always shows a sharp jump of B_z, known as the "dipolarization front". As they appear most often during substorms, DFBs may play an important role in the substorm current system. To reveal what currents they carry, we investigate the magnetic field and plasma pressure perturbations caused by them using THEMIS observations from four tail seasons. We found that the magnetic field perturbations are consistent with local field-aligned current (FAC) generation of region-2 sense ahead of the DFB and stronger region-1 sense at the dipolarization front. The plasma pressure distribution around the DFB also requires such an FAC configuration. This FAC configuration is similar to that of a substorm current wedge (SCW). In addition, as few as approximately three DFBs can carry sufficient total current that, if redirected into the auroral ionosphere, can account for the SCW's peak current for a sizable substorm ($\sim$ 1 MA). A DFB can thus be an elemental SCW, or "wedgelet".

Cold plasma density: asymmetries and solar cycle effects

B. Lybekk[1], S. Haaland[2] and A. Pedersen[1]

[1] Department of Physics, University of Oslo, Norway
[2] Max-Planck Institute for Solar Systems Research, Göttingen, Germany

Cold plasma constitute a significant and sometimes dominant part of the total plasma population in geospace. Using a large dataset generated from 13 years of carefully calibrated spacecraft potential measurements from the Cluster EFW instruments, we have investigated properties of cold plasma in the nightside magnetosphere and their dependence on geomagnetic and solar activity. We find a clear correlation between cold plasma density and solar activity, suggesting an ionospheric contribution with solar irradiance modulated ionization and outflow. There are also indications of small, persistent dawn-dusk and north-south asymmetries, though the exact mechanisms responsible for these persistent asymmetries are not yet well understood.

Ionospheric outflow above a sunlit and a dark polar cap

L. Maes[1], R. Maggiolo[1], S. Haaland[2], I. Dandouras[3], J. De Keyser[1], R. Fear[4] and D. Fontaine[5]

[1] Belgian Institute for Space Aeronomy, Brussels, Belgium
[2] Max-Planck Institute for Solar Systems Research, Katlenburg Lindau, Germany / Department of Physics and Technology, University of Bergen,Bergen, Norway
[3] Institut de Recherche en Astrophysique et Plantologie, CNRS, Toulouse, France
[4] Department of Physics and Astronomy, University of Leicester, Leicester, UK
[5] Laboratoire de Physique des Plasmas, Velizy, France

Beams of upward accelerated ionospheric ions are often encountered by the Cluster spacecraft above the polar caps during periods of prolonged northward IMF. These ions have been accelerated by quasi-static field-aligned electric fields associated with small scale polar cap arcs. Using the on-board mass resolving ion spectrometer CODIF, we analyze the composition of these ions. The cold ions flowing up from the polar cap, called the polar wind, are difficult to detect due to the spacecraft potential typical in these low density plasmas. The field-aligned electric fields in polar cap arcs, however, accelerate ionospheric ions to energies high enough for them to be easily measured, therefore acting as an extension of the experiment on the spacecraft and effectively probing the upflowing ion flux above the polar ionosphere, at the bottom of the acceleration region.
We examine the origin of the ions based on a statistical analysis of the composition for a set of almost 70 events. A first hypothesis is that the observed flux and composition is determined by solar illumination of the underlying ionosphere, as the illumination affects the density, temperature, and ion content of the upper ionosphere. The observed flux and composition would then depend on the solar zenith angle of the corresponding field line footpoint in the ionosphere. Our data show a weak variation of the H^+ flux, however there is an abrupt change in the O^+ flux at a solar zenith angle of around 100°. This angle coincides with the solar zenith angle of the terminator at 100 km altitude (ionospheric altitude) suggesting an outflow modulated by the difference between a sunlit and a dark ionosphere. A second hypothesis is that the cold plasma accelerated upward in polar cap arcs has its origin in the cusp. We therefore examine how the composition changes with the footpoint's distance from the cusp. The first hypothesis appears to fit the observations best.
In the light of this difference between a sunlit and a dark ionosphere, we then set up a simple model to investigate the effect of seasonal variations and changes of the polar cap size. The portion of the polar cap which is sunlit varies throughout the year. Because the terminator at ionospheric altitude is at a solar zenith angle of 100°, this will still be true when considering both hemispheres together. Therefore the O^+ dependency on solar illumination evidenced by Cluster suggests that ionospheric outflow will exhibit seasonal variations. We may expect a higher amount of O^+ ions escaping the polar ionosphere into the magnetosphere during spring/autumn than during winter/summer.

Modulation of the plasmasheet O^+ density by the solar wind

R. Maggiolo[1], L.M. Kistler[2] and J. De Keyser[1]

[1] Belgian Institute for Space Aeronomy, 3 Avenue Circulaire, B-1050, Brussels, Belgium
[2] Space Science Center, University of New Hampshire, Durham, NH 03824, USA

Magnetospheric plasma consists of a mixture of ions of solar wind origin and of ions originating in the ionosphere. Ionospheric plasma is cold and needs to be accelerated to escape Earth′s gravity. Part of this ionospheric material reaches the plasmasheet where it may be further energized. Contrary to solar wind, ionospheric material is rich in O^+ ions. We can thus use O^+ ions as tracers of the ionospheric material. The ionospheric ion outflow rate, its composition and the transport of ionospheric ions from the ionosphere to the plasmasheet are modulated by solar wind conditions. These processes are associated with relatively long time scales, from a few minutes to some hours. Consequently, plasmasheet composition may not respond immediately to changes in solar wind conditions. In order to quantify the ionospheric contribution to the plasmasheet plasma, we use long-term O^+ density measurements from the CODIF ion detector onboard the Cluster spacecraft. CODIF data are mapped along magnetic field lines to assess the spatial distribution of O^+ ions at the magnetospheric equatorial plane. We focus on two regions, the inner magnetosphere at geocentric distances between 7 and 8 R_E and the mid-tail region at distances between 15 and 20 R_E. In these two regions, we make a multi-correlation analysis between the O^+ density and solar wind parameters. We analyze the variation of the correlation coefficient between solar wind parameters and plasmasheet O^+ density as a function of the time delay between plasmasheet density measurements and solar wind measurements. From this analysis we are able to identify the solar wind parameters that have the strongest impact on the plasmasheet O^+ density -and thus on ionospheric ion outflow and transport, as well as on the associated response times.

Cluster data access through Cluster Science Archive

B. Martinez[1], P. Escoubet[2], D. Herment[1], H. Laakso[2], A. Masson[1], S. McCaffrey[2] and P. Osuna[1]

[1] ESA, Villanueva de la Canada, Spain
[2] ESA, Noorwijk, The Netherlands

The Cluster Science Archive (CSA) is the ESA long-term science archive of Cluster and Double Star missions, together with other value added products. It is located along with the other ESA science archives at the European Space Astronomy Centre (ESAC), near Madrid, Spain. CSA is providing user services since November 2013 in parallel to the Cluster Active Archive (CAA).

In order to download data a user must be registered at CSA. CSA registration, FAQs, documentation, software and other useful information are available at *www.cosmos.esa.int/web/csa*. Two interfaces at the Cluster Science Archive provide access to the data: the Graphical User Interface and the Archive Inter-Operability subsystem or command line. The first one is a Java Web Start application (*http://csa.esac.esa.int/csa/csa.jnlp*) that allows users to download data, either directly (up to 1Gb) or in asynchronous mode (up to 40Gb); to visualise Graphical Products and Inventory plots; and to make use of user profiles. The second one allow users to request data via command-line either synchronously, asynchronouslly or in streaming. Examples of the use of this second interface with a browser, wget, IDL or MATLAB can be found at *http://csa.esac.esa.int/csa/aio/index.html*. This poster describes those user services available at the CSA.

The Cluster Science Archive and its value added products

A. Masson[1], C.P. Escoubet[2], H. Laakso[2], C. Perry[1], D. Herment[1], B. Martinez[1], S. McCaffrey[2] and T. Klos[1]

[1] ESAC/ESA, Madrid, Spain
[2] ESTEC/ESA, Madrid, Spain

The science data archive of the Cluster mission is a major contribution of the European Space Agency (ESA) to the International Living With a Star program. Known as the Cluster Active Archive (CAA), its availability since 2006 has resulted in a significant increase of the scientific return of this on-going mission.

The Cluster science archive (CSA) has been developed in parallel to CAA over the last few years at the European Space Astronomy Center (ESAC) in Madrid, Spain. It is the long-term science archive of the Cluster mission, developed and managed along with all the other ESA science archives. Publicly opened in November 2013, CSA is available in parallel with CAA during a transition period until CAA public closing in early autumn 2014.

Our goal here is to present what has been put in place to help geophysicists in their research. We will first talk about some aspects of the CSA user interface (data visualisation including particle distribution; user data profiles) and how users can access data remotely (data streaming in Matlab, or via IDL or Python).

The second goal is to present unique value added datasets that are now available on the CSA/CAA. These data have been produced by the scientific community thanks to two EU FP7 projects: ECLAT and MAARBLE.

For instance, the polarization and propagation parameters of ULF Pc waves measured by Cluster and Themis (since 2007) are available and cover more than a decade; along with magnetic spectra of Pc waves measured simultaneously by CHAMP and ground-based magnetometers. These data are clearly an outstanding data resource for low frequency waves researchers.

Other datasets will be presented to show that CSA/CAA allow much more than downloading Cluster data from a graphical user interface. It's a single point entry that allows studies from micro-scale physics in the tail (e.g. catalogues of dipolarization fronts), to meso- and large-scale M-I coupling studies (e.g. Cluster magnetic footprints based on T96 and TS05; selected SuperDARN maps, MIRACLE network data and NASA IMAGE FUV auroral images). Plasma regions crossed on the nightside and very soon on the dayside are also there to ease the user in its data mining. Upcoming data and services will also be evoked.

EMIC wave occurrence and wave property statistics from Cluster and THEMIS

M. Mella, Y. Khotyaintsev, A. Vaivads and M. Andre

IRF, Uppsala, Sweden

Using the EU FP7 MAARBLE project database of derived high-level wave products, we perform a statistical study of electromagnetic ion cyclotron (EMIC) waves in the Earth's magnetosphere using data from both the Cluster and THEMIS spacecraft. The combined data from these two missions provides extensive coverage of Earth's magnetosphere. EMIC wave occurrence is presented with respect to spatial location and geomagnetic activity. Distributions of EMIC wave properties are shown, including ellipticity, propagation parameters, and wave intensity.

This work has received funding from the European Union under the Seventh Framework Programme (FP7-Space) under grant agreement n 284520 for the MAARBLE (Monitoring, Analyzing and Assessing Radiation Belt Energization and Loss) collaborativeresearchproject.

Slow electron holes: magnetotail observations

C. Norgren[1,2], M. André[1], A. Vaivads[1] and Y. Khotyaintsev[1]

[1] Swedish Institute of Space Physics
[2] Department of Physics and Astronomy, Uppsala Universitet

Electron phase space holes are ubiquitous in nature, and are manifestations of strongly nonlinear processes. We report multi-spacecraft observations of slow electron holes in the magnetotail, with velocities below 500 km/s, clearly anchored in the ion motion. Their electrostatic potential is of the order $e\phi/k_BT_e \sim 10\%$, indicating that they can affect electron motion and further couple the electron and ion dynamics. We estimate that the electron holes are associated with a magnetic signature, but that this signal is weak compared to background fluctuations. Simultaneously with the electron holes we observe low-energy electrons, drifting along the magnetic field, possibly related to the generation of the electron phase space holes.

VNC long–term modelling of the outer radiation belt

I.P. Pakhotin[1], M.A. Balikhin[1], Y.Y. Shprits[2,3,4], A.Y. Drozdov[2,5] and R.J. Boynton[1]

[1] Department of Automatic Control and Systems Engineering, University of Sheffield, Sheffield, South Yorkshire, United Kingdom.

[2] Department of Earth and Space Sciences, UCLA, Los Angeles, CA, USA.

[3] Department of Atmospheric and Planetary Sciences, MIT, Cambridge, MA, USA.

[4] Skolkovo Institute of Science and Technology, Moscow, Russia.

[5] Lomonosov Moscow State University, Skobeltsyn Institute of Nuclear Physics, Moscow 199991, Russia.

Data-driven radiation belt prediction methodologies are accurate but cannot predict outside their operating parameters. Meanwhile, physics-driven methodologies have superior predictive range but some of the driving inputs are difficult to acquire empirically. Combining the two offers the possibility of having the accuracy of one and the prediction range of the other. VNC (VERB-NARMAX Coupling) is one such algorithm, combining the data-driven NARMAX geostationary orbit flux predictor with the physics-driven Versatile Electron Radiation Belt (VERB) code. The system has been successfully tested against Van Allen probes and GOES-13 data for a range of geomagnetic condition. This study expands on that and focuses on long-term simulations of several months duration, comparing results with data from the Van Allen probes.

Particle acceleration and field–aligned currents in the cusp: preliminary results from GI programme

F. Pitout[1], M. Berthomier[2], B. Grison[3], A. Marchaudon[1], P. Canu[2], M. Dunlop[4] and A.N. Fazakerley[5]

[1] IRAP, CNRS/UPS, Toulouse, France
[2] LPP, Palaiseau, France
[3] IAP, ASCR, Prague, Czech Republic
[4] SSTD, RAL, Didcot, United Kingdom
[5] MSSL, Dorking, United Kingdom

Following our proposal in response to the first Cluster GI programme call, the Cluster orbits were slightly modified in such a way that two spacecraft would find themselves on top of each other along the same cusp magnetic field lines. The first campaign occurred in the Fall-Winter 2013 and was not as successful as expected because Cluster crossed the dayside magnetosphere at too low latitude. Still, on 25 December 2013, a strongly southward IMF eroded the magnetosphere enough to move the cusp at Cluster latitude. We present in this poster the preliminary results of the event. Around 13:30 UT, all four Cluster spacecraft entered a region of open-field lines and their instruments detected magnetosheath-like particles and field-aligned currents. We particularly focus on C1 and C2, which were in very close magnetic conjunction at respectively 3.72 and 3.17 R_E geocentric distance. Electron beams observed at both spacecraft are accompanied by broadband low frequency waves with which they may interact.

Heavy ions density deduced from wave propagation properties and particle measurement: a comparison between STAFF, WHISPER and CIS instruments on board CLUSTER spacecraft

J.L. Rauch[1], P. Robert[2], P.M.E. Décréau[1], I. Dandouras[3], X. Vallières[1], I. Galkina[1], A. Denazelle[1], S. Aoutou[1], P. Canu[2] and N. Cornilleau–Wehrlin[2,4]

[1] LPC2E/CNRS, 3A av. de la Recherche Scientifique, 45071 Orleans Cedex 2, France
[2] LPP/CNRS, Ecole Polytechnique, 91128 Palaiseau Cedex, France
[3] IRAP/CNRS/Universite de Toulouse, Toulouse cedex 4, France
[4] LESIA/observatoire de Paris, 92195 Meudon Cedex principal, France

The Wave of High frequency and Sounder for Probing of Electron density by Relaxation experiment (WHISPER) performs the measurement of the electron density on the four satellites of the CLUSTER project. The two main purposes of the WHISPER experiment are to record the natural waves and to make diagnostic of the electron density using the sounding technique. The various working modes and the fourier transforms calculated on board provide a good frequency resolution obtained in the bandwidth 2-83 kHz and a well instrumental adaptability to determine the electron density in various plasma.
The Spatio Temporal Analysis of Field Fluctuations experiment (STAFF) consists of a three-axis search coil magnetometer to measure magnetic fluctuations at frequencies up to 4 kHz, a waveform unit (up to either 10 Hz or 180 Hz) and a Spectrum Analyser (up to 4 kHz). In this work, we will use the data coming from the wave form unit.
The aim of this presentation is to show the possibility to determine the ratio of the ion H+, He+, O+ species using the propagation characteristic of the ULF waves inside the plasmasphere. In a multicomponent plasma, the wave dispersion relation is strongly modified. The propagation modes are split into several parts with various polarizations. Cut-off and resonance frequencies appear : their the values are a tracer of the ratio of the density species. Moreover, crossover frequencies happen where the polarization changes from right-handed to become left-handed. This wave property allows us to have another way to evaluate the rate of the different ion species. STAFF waveform measurements of the three magnetic components in the ULF bandwidth give us an access to the total wave energy, polarisation properties and wave propagation direction. A carefully analysis of the spectra allow us to determine these characteristic frequencies. An interpretation is proposed with the aim to determine a realistic estimation of the ion density background using, in addition, the absolute electron density deduced from active WHISPER data with the assumption of global plasma neutrality. Moreover, the CIS instrument RPA mode provides the low energy ion fluxes, separately for each ion species, and allows a comparison between wave results and direct ion measurements.

In situ observations of energetic ion acceleration in the near–Earth jet braking region

A. Retino[1], Y. Khotyaintsev[2], A. Vaivads[2], O. Le Contel[1], H. Fu[3], B. Zieger[4] and R. Nakamura[5]

[1] Laboratoire de Physique des Plasmas, École Polytechnique, Universite Pierre et Marie Curie, Palaiseau, France
[2] Swedish Institute of Space Physics, Uppsala, Sweden
[3] Space Science Institute, School of Astronautics, Beihang University, Beijing, China
[4] Center for Space Physics, Boston University, Boston, USA
[5] Space Research Institute, Austrian Academy of Sciences, Graz, Austria

Plasma jet fronts and braking regions are sites of substantial particle energization in planetary magnetospheres. Jet fronts are the boundaries separating ambient from jetting plasma (e.g. due to reconnection) while jet braking regions is where jets are eventually stopped/diverted/dissipated. A number of recent in situ observations in the Earths magnetotail have allowed studying in detail energetic electron acceleration mechanisms at jet fronts/braking regions. Yet, observations of energetic ions are scarce. Here we show Cluster spacecraft observations of suprathermal ion beams up to 1 MeV (about 10 times the thermal energy) in the near-Earth jet braking region. Observations indicate that ions are trapped between large-scale oppositely-directed jets and accelerated therein by strong electric fields.

New and reprocessed products derived from NOAA GOES and POES particle flux measurements

J.V. Rodriguez[1,3], J.C. Green[2] and R.J. Redmon[3]

[1] CIRES, University of Colorado, Boulder, Colorado USA
[2] GeoSynergy LLC, Golden, Colorado USA
[3] National Geophysical Data Center, NOAA, Boulder, Colorado USA

NOAA's operational particle measurements in low-earth (polar) and geostationary orbits provide a multiple solar cycle record of the radiation environment in these orbits and contribute essential boundary condition observations for science missions such as Van Allen Probes. Historically, the NOAA National Geophysical Data Center (NGDC) has been responsible for archiving and disseminating the geostationary (GOES) and polar-orbiting (POES) particle fluxes processed by the Space Weather Prediction Center (SWPC). This existing data set includes the set of fluxes used by SWPC to issue space weather alerts. Recently, NGDC's role in data processing has expanded, as has the set of products that it offers. Several examples are given here. (1) The responsibility for processing the POES fluxes has been transferred from SWPC to NGDC. Moreover, the outputs of this processing now include calibrated fluxes, pitch angles calculated from the International Geomagnetic Reference Field (IGRF) model updated using the secular variation terms, and error estimates that include the effects of counting statistics and spectral variations. (2) In the area of geostationary measurements, an example of a new product is the set of pitch angles now being calculated for the nine-telescope Magnetospheric Electron and Proton Detectors (MAGED/PD) on GOES 13-15. These pitch angles are calculated from the relative orientation of the telescopes and the magnetic field measured by the co-manifested fluxgate magnetometer. (3) An example of a reprocessed data set is the set of highly relativistic electron fluxes (including the > 2 MeV channel) measured by GOES since 1994. While the SWPC processing removes galactic cosmic ray backgrounds and attempts to correct for contamination by solar proton fluxes, the contamination can be too severe to remove effectively. Despite documentation of this effect in NGDC's metadata, user feedback has emphasized the need to add quality measures to the data set itself. To this end, the reprocessed data set includes error bars and data quality flags and replaces severely contaminated fluxes and instrument backgrounds with fill values. In addition, the angular response function of the instrument is provided after transformation into pitch angle space. (4) The GOES and POES particle flux measurements are being converted into cleaned phase space densities (PSD) relevant for understanding radiation belt physics as well as internal spacecraft charging effects. The benefit of PSDs is that they should remain constant even as the global magnetic field topology changes, making it easier to identify true global changes in the radiation belts as well as the internal charging hazard. We are working closely with the NASA Space Physics Data Facility (SPDF) to make available the existing, reprocessed and new data sets via CDAWeb. The purpose of this presentation is to provide an overview of these products and to chart our path forward.

An instrument dedicated for measurements inside the radiation belts–radiation protection of the ELMAVAN instrument for the Resonance mission

O. Santolik[1,2], I. Kolmasova[1], R. Lan[1] and L. Uhlir[1]

[1] Institute of Atmospheric Physics ASCR, Prague, Czech Republic
[2] Faculty of Mathematics and Physics, Charles University, Prague, Czech Republic

The Electromagnetic Wave Analyzer (ELMAVAN) instrument is being prepared at the Institute of Atmospheric Physics, Prague for the Resonance multi-spacecraft mission. Resonance is a Russian project with international participation, currently scheduled to be launched in 2018. The aim of this four-spacecraft mission is to investigate plasma waves, wave-particle interactions and plasma dynamics in the inner magnetosphere of the Earth with the focus on phenomena occurring along the same field line and within the very same flux tube of the Earth's magnetic field. Radiation protection is an important issue for space instrumentation. The ELMAVAN instrument is designed to mainly use COTS components which have been tested for other projects, military class components, and naturally non-sensitive components (as MRAMs - Magneto - resistive random access memories). Mechanical design of the instrument takes into account specific requirements for the orbit inside the radiation belts. The instrument box is manufactured from 10-mm thick aluminum plates with an inner barrier separating the connectors from the rest of the electronics. The most sensitive integrated circuits will be locally protected by hybrid metallic plates composed of three layers: KOVAR (54% Fe, 29% Ni, 17% Co), tungsten, and titanium. We have implemented an extensive system of latch-up and error reporting as a part of the instrument housekeeping data. From this point of view this instrument will also be important as a technological experiment.

Size and shape of the distant magnetotail

D.G. Sibeck

NASA/GSFC

We employ a global magnetohydrodynamic model to study the effects of the interplanetary magnetic field (IMF) strength and direction upon the cross section of the magnetotail at lunar distances. The anisotropic pressure of draped magnetosheath magnetic field lines and the inclusion of a reconnection generated standing slow mode wave fan bounded by a rotational discontinuity within the definition of the magnetotail result in cross sections elongated in the direction parallel to the component of the IMF in the plane perpendicular to the Sun-Earth line. Tilted cross-tail plasma sheets separate the northern and southern lobes within these cross sections. Greater fast-mode speeds perpendicular than parallel to the draped magnetosheath magnetic field lines result in greater distances to the bow shock in the direction perpendicular than parallel to the component of the IMF in the plane transverse to the Sun- Earth line. The magnetotail cross section responds rapidly to variations in the IMF orientation. The rotational discontinuity associated with newly reconnected magnetic field lines requires no more than the magnetosheath convection time to appear at any distance downstream, and further adjustments of the cross section in response to the anisotropic pressures of the draped magnetic field lines require no more than 10-20 min. Consequently, for typical ecliptic IMF orientations and strengths, the magnetotail cross section is oblate, while the bow shock is prolate.

Boundary conditions at L*=8 for use in radiation belt models

A. Sicard–Piet[1], V. Maget[1], D. Lazaro[1], D. Turner[2] and S. Bourdarie[1]

[1] ONERA, The French Aerospace Lab, 2. Av. E. Belin 31055 Toulouse, France
[2] UCLA

Particle flux data from SST instrument onboard Themis-A to E have been processed from the beginning of mission to present. 11 electron channels, covering the 31 keV - 719.5 keV energy range and being pitch angle resolved are available throughout the mission. The data have been sorted out in L*, equatorial pitch-angle, MLT and Kp to further extract boundary conditions at L*=8 in the midnight sector for various magnetic activity conditions. The amount of data allows to perform statistics (mean, median) and to compute correlation coefficients as well as a covariance matrix between the 11×4, energy $\times$ equatorial pitch-angle, channels. It is then straightforward to deduce a set of probable and realistic boundary conditions for a given magnetic activity condition at L*=8 in the midnight sector.
This study shows that a unique, well defined boundary condition cannot reproduce the variety of observations at L*=8 in the midnight sector. For comparable magnetic activity conditions, the obtained spectra vary by more than one order of magnitude. Such a set of probable and realistic boundary conditions deduced from the median and the covariance matrix are very much suitable for radiation belt data assimilation tools using Monte-Carlo sampling.

Acknowledgements: MAARBLE has received fundings from the European Community's Seventh Framework Programme (FP7-SPACE-.2010-1, SP1 Cooperation, Collaborative project) under grant agreement n284520.

O^+ escape from the terrestrial magnetosphere

R. Slapak[1], H. Nilsson[2] and L.G. Westerberg[3]

[1] Division of Space Technology, Luleå University of Technology, Luleå, Sweden
[2] Swedish Institute of Space Physics, Kiruna, Sweden
[3] Division of Fluid and Experimental Mechanics, Luleå University of Technology, Luleå, Sweden

The most direct interaction between the solar wind and the ionosphere is constrained to the magnetospheric cusps, causing ion outflow into the magnetosphere. These outflowing ions flow along magnetic field lines leading downstream in the magnetotail, where they may convect to the plasma sheet and be brought back towards Earth. However, if the ion energization in the cusp is sufficient the ions will escape into the solar wind. Cluster observations of ions and electromagnetic fields in the high altitude cusp/mantle and in the high latitude dayside magnetosheath has been analyzed in order to study heating, outflow and escape of O^+.

Measurements in the in the cusp/mantle reveal O^+ fluxes of the order $\sim 10^{25}$ s^{-1} and with parallel bulk velocities too high to convect to the plasma sheet, and therefore eventually will escape further downstream in the tail. Further studies show that a significant amount of O^+ ($\sim 0.7 \cdot 10^{25}$ s^{-1}) escapes immediately from the high altitude cusp and mantle into the dayside magnetosheath. This escape flux flows downstream and approximately tangentially to and often close to the magnetopause. A comparison with observed cusp outflows ($\sim 2 \cdot 10^{25}$ s^{-1}) points to that escape of O^+ both in the downstream tail and directly from the cusp into the dayside magnetosheath are important loss routes.

There are also evidence of clear asymmetries in the O^+ escape flows in the dayside magnetosheath when comparing southward and northward IMF. The asymmetries can be understood when considering the different magnetic topologies that arise due to the fact that the reconnection scenarios in favour depend on the IMF direction. During southward IMF a clear majority of the observed magnetosheath O^+ flow is directed downstream. In contrast, for northward IMF we observe both O^+ flowing downstream and O^+ flowing equatorward towards the opposite hemisphere. The flow patterns for northward IMF is also strongly dependent on the clock angle $\theta_{cl} = |B_y|/|B_z|$, as a small θ_{cl} is correlated to downstream flows and high θ_{cl} to flows towards the equatorial plane on the dayside. A possible consequence is that double lobe reconnection may trap and bring magnetosheath O^+ back into the magnetosphere during northward IMF.

Multi–spacecraft study of the geometry of mirror type magnetic fluctuations

M. Tatrallyay and G. Erdos

Wigner Research Centre for Physics, Budapest Hungary

Linearly polarized magnetic field oscillations (or series of dips or peaks) can be observed in different high beta space plasma regions where the temperature is anisotropic. They frequently occur in the magnetosheath, but sometimes they are present in the interplanetary field, too. Identical magnetometers aboard the four Cluster spacecraft are used to study the three-dimensional structure of these oscillations based on case studies. The reconstruction of the geometry of the magnetic structure is based on the assumption that they are frozen into the plasma and they are elongated in the average direction of the field.

In cases when the magnetic field depressions can be identified by all four spacecraft, the correlation between the magnetic field profiles allows to determine the wave propagation velocity by triangulation. When comparing this value with the plasma velocity measured by the CIS instrument, the assumption can be tested that these structures are frozen into the plasma.

In the interplanetary field, individual magnetic depressions are usually observed with reasonably good axial symmetry around the field lines. On the other hand, wave trains show no axial symmetry, they are likely to be planar waves. Axially symmetric magnetic holes may be be related to the decay process of mirror mode waves.

The development of mirror type fluctuations is investigated from the bow shock to the magnetopause whether they first form as planar waves and later decay to more axially symmetric structures around the main magnetic field in the inner magnetosheath. The relation between the direction of the wave vector and the bow shock normal is investigated addressing the problem whether the generation of the waves behind the bow shock is part of the shock formation process.

Wave normal angles of whistler mode chorus rising and falling tones

U. Taubenschuss[1], Y. Khotyaintsev[1], O. Santolik[2,3], A. Vaivads[1], C.M. Cully[4], O. LeContel[5] and V. Angelopoulos[6]

[1] Swedish Institute of Space Physics, Uppsala, Sweden
[2] Faculty of Mathematics and Physics, Charles University, Prague, Czech Republic
[3] Institute of Atmospheric Physics, Prague, Czech Republic
[4] Department of Physics and Astronomy, University of Calgary, Calgary, Alberta, Canada
[5] Laboratoire de Physique des Plasmas, École Polytechnique, Universite Pierre et Marie Curie, Palaiseau, France
[6] Institute of Geophysics and Planetary Physics/Earth and Space Sciences, UCLA, Los Angeles, California, USA

We present a study of wave normal angles (θ_k) of whistler mode chorus emission as observed by THEMIS during the year 2008. The three inner THEMIS satellites THA, THD and THE usually orbit Earth close to the dipole magnetic equator ($\pm 20°$), thereby covering a large range of L-shells from the plasmasphere out to the magnetopause. High resolution waveform measurements of electric and magnetic fields in the so-called "waveburst mode" enable a detailed polarization analysis of chorus below 4 kHz. When displayed in a frequency-θ_k histogram, four characteristic regions in occurrence are evident, which are separated by gaps at $f/f_{c,e} \approx 0.5$ (f is the chorus frequency, $f_{c,e}$ is the local electron cyclotron frequency) and at $\theta_k \sim 40°$. Below $\theta_k \sim 40°$, the average value for θ_k is predominantly field aligned, but slightly increasing with frequency towards half of $f_{c,e}$ (up to 20°). Above half of $f_{c,e}$, the average θ_k is again decreasing with frequency. Above $\theta_k \sim 40°$, wave normal angles are usually close to the resonance cone angle. Furthermore, we present a detailed comparison of electric and magnetic fields of chorus rising and falling tones. Falling tones exhibit peaks in occurrence solely for $\theta_k > 40°$, and are propagating close to the resonance cone angle. Nevertheless, when comparing rising tones to falling tones at $\theta_k > 40°$, the ratio of magnetic to electric field shows no significant differences. Thus, we conclude that falling tones are generated under the same conditions as rising tones, with common source regions close to the magnetic equatorial plane.

Simulation of the inner magnetosphere electrodynamics in the presence of magnetospheric substorms

C. Tsironis[1], A. Anastasiadis[2], I.A. Daglis[3,2] and Ch. Katsavrias[3,2]

[1] Department of Physics, Aristotle University of Thessaloniki, Greece
[2] Institute for Astronomy, Astrophysics, Space Applications and Remote Sensing, National Observatory of Athens, Greece
[3] Department of Physics, University of Athens, Greece

We present results from numerical simulations of the electric and magnetic fields and the energetic ions in the inner magnetosphere under the effect of magnetic storms and/or magnetospheric substorms. Our particle-tracing model employs a dynamic, solar wind-driven magnetic field, with a description of the electric field due to convection/corotation and to temporal variation of the magnetic field. We address the physics of our computation of the total field driving the plasma dynamics, cast in a form suitable for use with particle-tracing codes, as well as the particle motion solver. Test-particle simulations are conducted and a statistical analysis of the particle kinematic data is performed as a function of the initial conditions. An estimation of an ensemble-averaged disturbance index stemming from the ring current population is given. Our model may serve as a final link in a Sun-to-Earth modeling chain of major solar eruptions, providing an estimation of the inner magnetosphere response.

This research has been co-nanced by the European Union (European Social Fund - ESF) and Greek national funds through the Operational Program "Education and Lifelong Learning" of the National Strategic Reference Framework (NSRF) - Research Funding Program: Thales. Investing in knowledge society through the European Social Fund.

WHISPER products at the Cluster Science Archive

X. Vallières, J.L. Rauch, P.M.E. Decreau and the WHISPER team

Laboratoire de Physique et Chimie de lEnvironnement et de lEspace (LPC2E), Orlans, France

The CLUSTER Science Archive (CSA) has been created to house data delivered from all of the CLUSTER instruments and to make these data available to the wide scientific community. In this context, the WHISPER (Waves of HIgh frequency and Sounder for Probing of Electron density by Relaxation) team was expected to provide two principal datasets: electric field spectra in the frequency range 2-82 kHz, and the total electron density, at standard resolutions of 2.15 s and 52 s.

Details are provided about WHISPER datasets available at CSA and the production pipelines, with a particular insight on the electron density. This parameter can be deduced from the characteristics of natural waves monitored whenever WHISPER is in natural mode (transmitter off) and/or from resonances triggered in the sounding mode. Natural and active signatures and corresponding methods are described as well as the quality and usability of the datasets.

Microscale dynamics within Kelvin Helmholtz waves: a probe of localized reconnection occurrence

A. Varsani[1], C.J. Owen[1], A.N. Fazakerley[1], I.J. Rae[1], C. Forsyth[1], A.P. Walsh[2], M. André[3], I. Dandouras[4] and C.M. Carr[5]

[1] UCL, Mullard Space Science Laboratory, Holmbury St. Mary, Dorking, RH5 6NT, UK
[2] Science and Robotic Exploration Directorate, European Space Agency, ESAC, Villanueva de la Cañada, Madrid, Spain
[3] Swedish Institute of Space Physics, Uppsala, Sweden
[4] IRAP, CNRS / Université de Toulouse, Toulouse, France
[5] Blackett Laboratory, Imperial College, London, UK

Interactions between the solar wind and the Earth's magnetosphere at the magnetopause are the key to the mixing of these two plasma regimes. During periods of northward IMF, an absence of low latitude reconnection at the magnetopause is expected. However, this gives rise to questions as to how the low latitude boundary layer (LLBL) can be populated with magnetosheath-like plasma under these conditions. Cluster multi-spacecraft observations have shown the existence of non-linear waves at the magnetopause that are thought to be results of Kelvin-Helmholtz instability; these waves can grow and form rolled-up vortices. It has been postulated that reconnection within these vortices may be the cause of transfer the solar wind plasma into the magnetosphere. However, the particle behaviour at these small scales is yet to be fully understood. In December 2007, Cluster encountered on-going KH waves as the four spacecraft crossed the Earth's dusk flank magnetopause through its LLBL. During this event, the particle instruments returned a full 3D plasma distribution once every 4 s while the magnetic field remained closely aligned with the spacecraft spin axis. In this study, we are thus able to use the 3D particle data to reconstruct near-full pitch angle distribution of electrons and ions at sub-spin resolution. These high-time resolution observations (up to 32 times faster than normal mode data) provide new insights into particle dynamics during the inbound-outbound movements of Cluster across the magnetopause. We present the multi-spacecraft measurements by Cluster (the macroscale), as well as high-time cadence observation by each spacecraft (the microscale) to demonstrate the plasma behaviour within Kelvin-Helmholtz waves. The observations show multiple separate regions, where boundary plasma population were travelling faster than sheath, a signature for potential rolled up vortices. Within these regions, there are intervals when ion populations were accelerated along the magnetic field, and were predominantly field-aligned. Using the above technique (subsecond pitch angle distribution), we have identified field-aligned electrons just before the observations of field-aligned ions. Such observations are evidence for locally-driven reconnections, and essential for distinguishing from those which are rather globally generated. This is, perhaps, the key to understanding if reconnection bursts within the growing KH waves are able to make a significant contribution to transferring magnetosheath plasma into the magnetosphere.

Dipolarization fronts in the near-Earth space and substorm dynamics

I.I. Vogiatzis[1], A. Isavnin[2], Q.G. Zong[3], E.T. Sarris[1], S.W. Lu[3] and A.M. Tian[4]

[1] Department of Electrical and Computer Engineering, Democritus University of Thrace, Xanthi, Greece.

[2] Department of Physics, University of Helsinki, P.O. Box 64, FI-00014, Finland.

[3] Institute of Space Physics and Applied Technology, Peking University, Beijing, China.

[4] School of Space Science and Physics, Shandong University, Weihai, China.

During magnetospheric substorms and plasma transport in the Earth's magnetotail various magnetic structures can be detected. Dipolarization fronts and flux ropes are the most prominent structures characteristic for substorm dynamics. However, they are treated as separate magnetotail features independent of each other. In this paper we analyze a number of dipolarization fronts observed by THEMIS spacecraft at different geocentric distances by applying the magnetohydrostatic Grad-Shafranov reconstruction technique. Our analysis shows that there is a possibility for dipolarization fronts to originate from highly dissipated flux ropes which are in the late stage of their evolution, subjected to a continuous magnetic deterioration due to reconnection process. These results may improve our understanding of magnetoplasma processes in Earth's magnetotail.

Fate of cold ions in the inner magnetosphere: energization and drift inferred from morphology and mass dependence

M. Yamauchi[1], I. Dandouras[2], H. Reme[2], and Y. Ebihara[3]

[1] Swedish Institute of Space Physics (IRF), Kiruna, Sweden (M.Yamauchi@irf.se)
[2] Institut de Recherche en Astrophysique et Planetologie (IRAP), CNRS/Université de Toulouse, Toulouse, France
[3] Research Institute for Sustainable Humanosphere, Kyoto University, Uji, Japan

Ionospheric origin cold ions in the inner magnetosphere and plasma sheet can easily be energized through many processes. The most efficient one is the traditional adiabatic energization through DC magnetic and electric field, which applies to all ions in the entire plasma sheet and accelerates cold ions to several tens keV in the westward drifting domain and to few keV in the eastward drifting domain. In addition, there are many localized energization at both equatorial region and region slightly away from the equator.

Although the existence of such energization has long been suggested, actual behaviors of acceleration processes and results are not well studied in the real data in the inner magnetosphere where many different ion signatures are convoluted. Here we classified all H^+ signatures and He^+ signatures during the Cluster perigee traversals during 2001-2006 when the orbit was nearly north-south symmetric. To de-convolute drifting signatures, we used particle drift simulation starting with warm ions (temperature of tens eV with zero bulk velocity). We have so far identified, in addition to (1) adiabatic energization through drift motion, (2) heating of ions in mainly the perpendicular direction to the magnetic field near equator, (3) heating of ions in mainly the field-aligned direction, and (4) pulsing injection of ions near midnight. Other signatures fall into one of these categories. For example, the ion-zipper signature is most likely the combination of (1) and (4). In the presentation, we show all these examples and their statistics.

We also examined He^+ signature and O^+ signature, and found that He^+ and O^+ sometimes experience the energization in an independent manner from H^+ energization. This independency still needs reasonable explanations.

2D current sheet configuration: Cluster observations vs. laboratory experiment.

E.V. Yushkov[1,2], A.G. Frank[3], A.V. Artemyev[2], A.A. Petrukovich[2] and I.Y. Vasko[2]

[1] Faculty of Physics, Moscow State University, Moscow, Russia.
[2] Space Research Institute, Russian Academy of Sciences, Moscow, Russia.
[3] Prokhorov General Physics Institute, RAS, Moscow, Russia.

In the presentation we discuss the formation of 1D current sheet in the course of current sheet thinning. We compare Cluster observations in the Earth magnetotail and results of laboratory experiments carried out with the device CS-3D at the Institute of General Physics in Moscow. We show that current sheets of in the Earth magnetotail and in laboratory experiments share several common properties: dimensionless spatial scales, distributions of the transverse magnetic field component along the sheet, dependence of the current density amplitude on the transverse magnetic field component. Our comparison of observed and modelled current sheets gives us an opportunity to derive several predictions about the structure and evolution of the magnetotail current sheet.