

# Optical Collector-Analyzer-Detector; Observations

Hakim L. Malasan

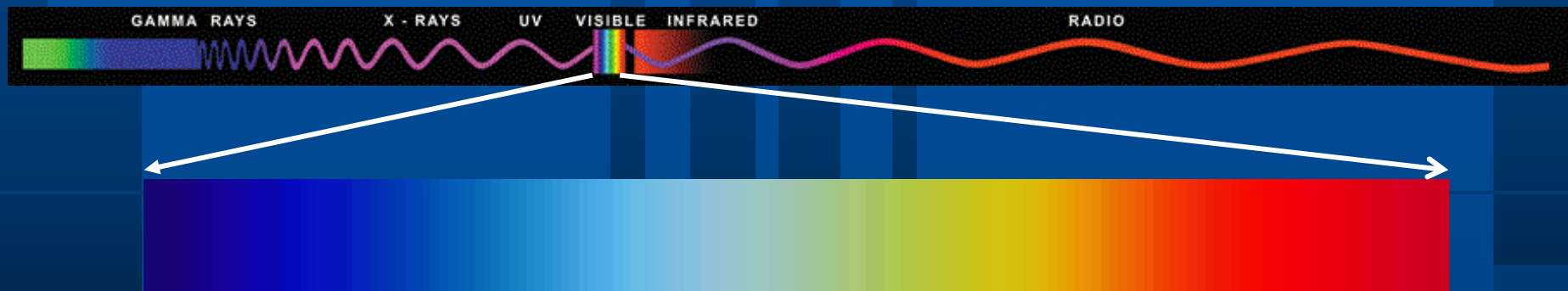
Astronomy Division & Bosscha Observatory,  
Institut Teknologi Bandung

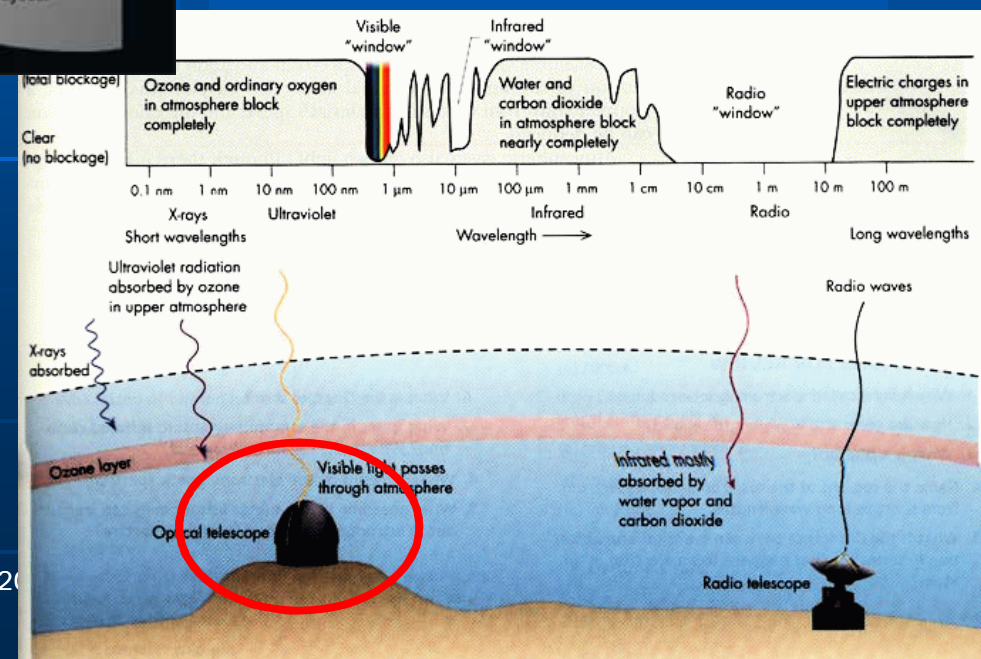
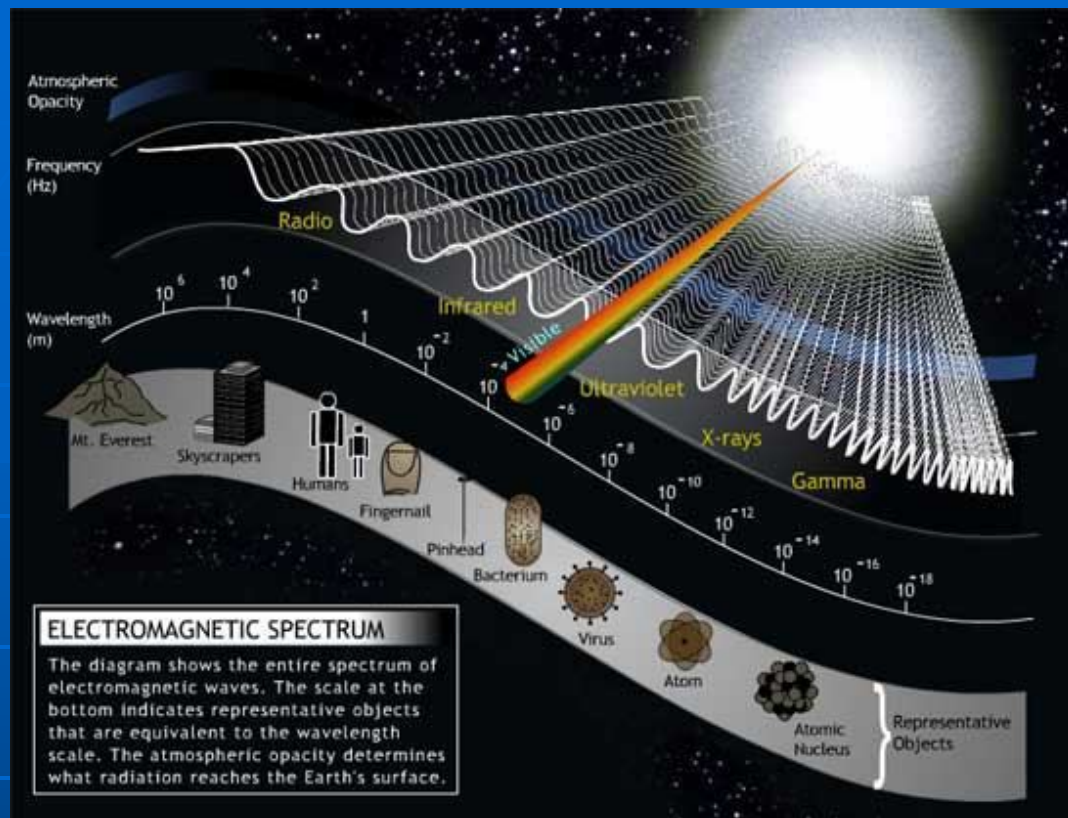
# The essence of astronomical observation

- *Observatory*: A place to conduct *observational activities* of astronomical objects  $\Rightarrow$  A place where astronomers carry out astronomical researches
- *Astronomical observations is not similar to laboratory experiments*
  - Passive observers, collecting signal + noise
  - Untouchable objects
  - Unrepeatable measurement process
  - Observing conditions depend on weather

# Astronomical instruments

- **Collectors** : Collecting electromagnetic radiation (light)
- **Analyzers**: Analysis (filtering or dispersing) light
- **Detectors**: Converting light energy onto other form of energy





2012/9/17

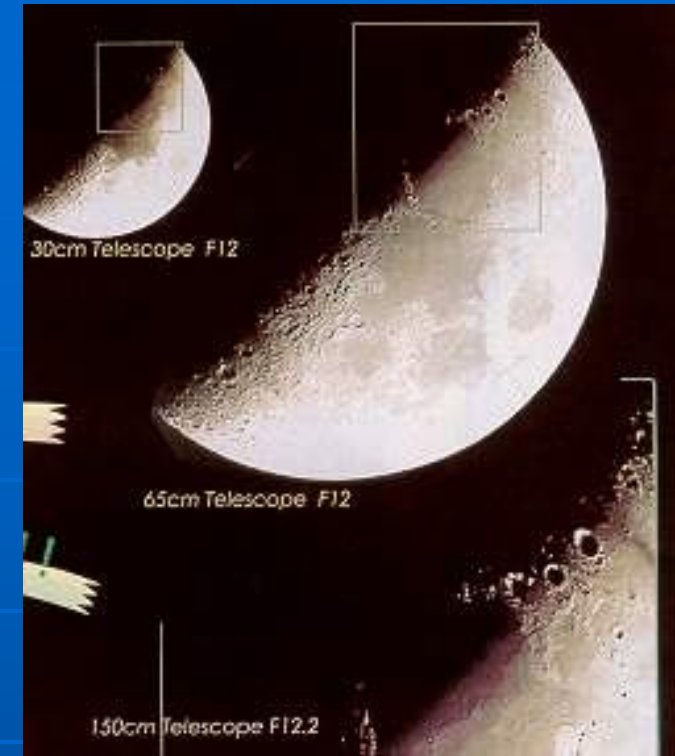
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# Astronomical telescopes

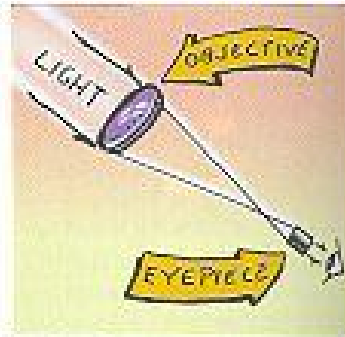
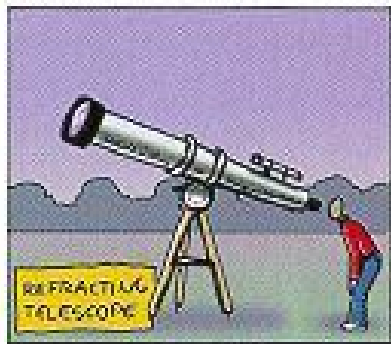
## Main functions

- Energy collection within an area → faint objects can be detected and measured with high accuracy
- Attain the highest angular resolution → detailed spatial information

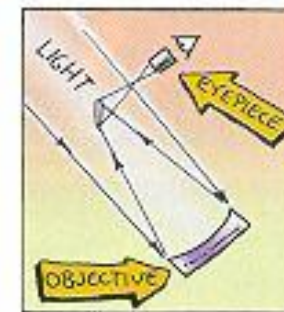
→ **Function of diameter**



# Refractor



# Reflector





# Anatomy of optical telescope

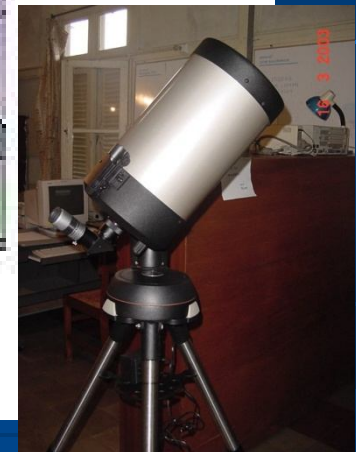
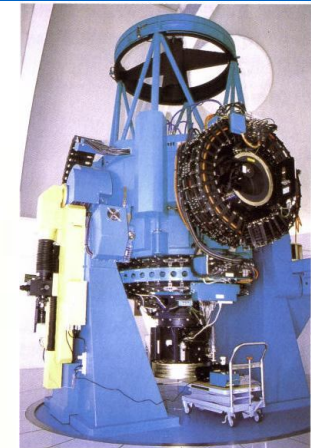
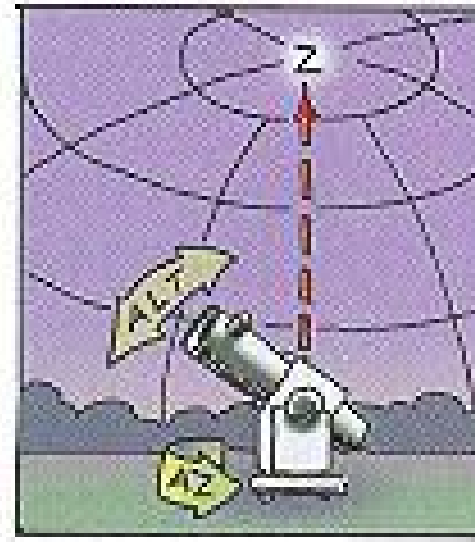
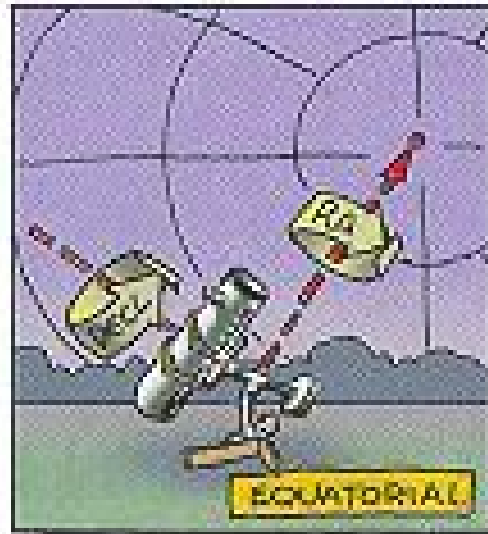
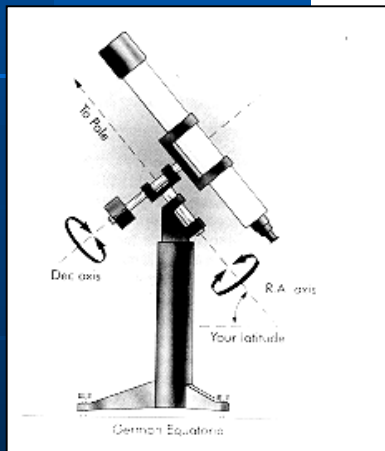
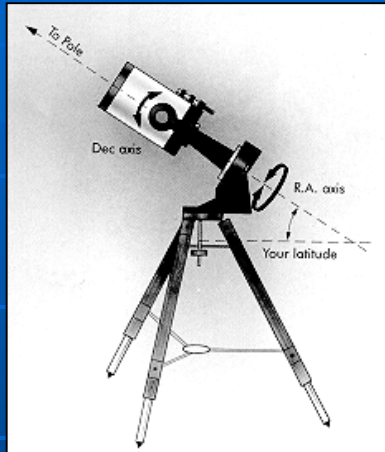
- **Objective lens or mirror:** Diameter &  $f_{\text{objective}}$   
 $f/D$  : Focal ratio



- **Eyepiece:**  $f_{\text{eyepiece}}$  & apparent field-of-view



# Telescope mounts



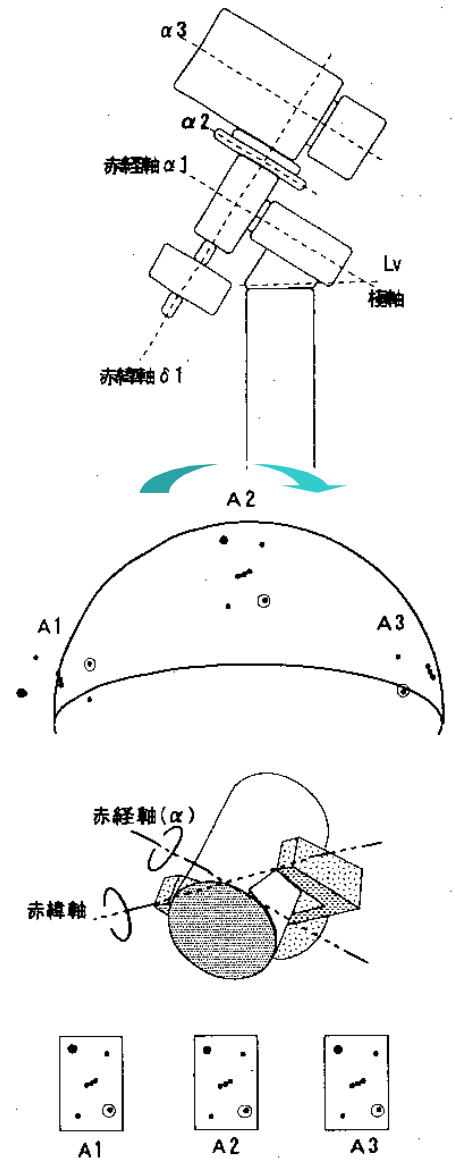


# Coordinate system

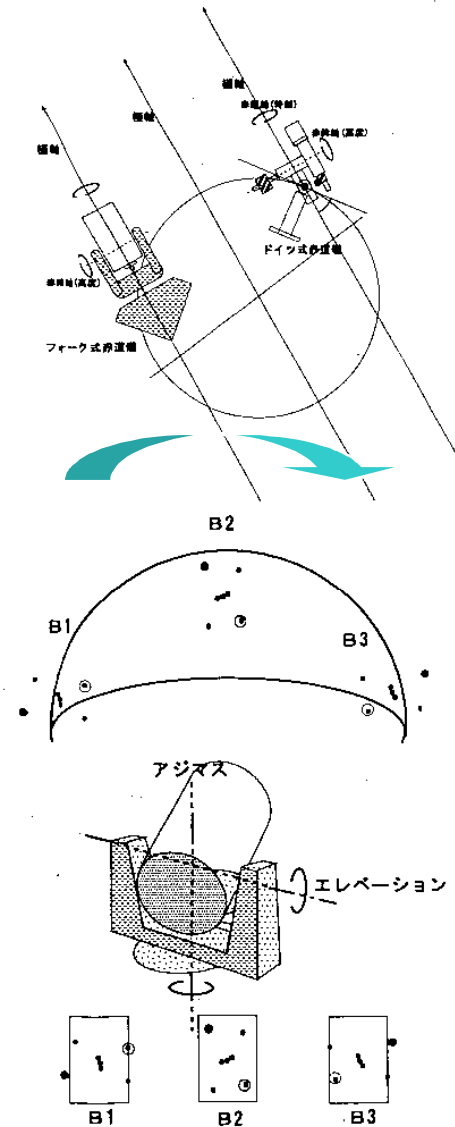
## Movement of celestial bodies

## Telescope axes

## Appearance in focal plane

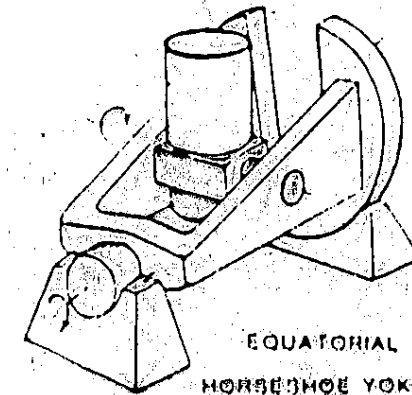
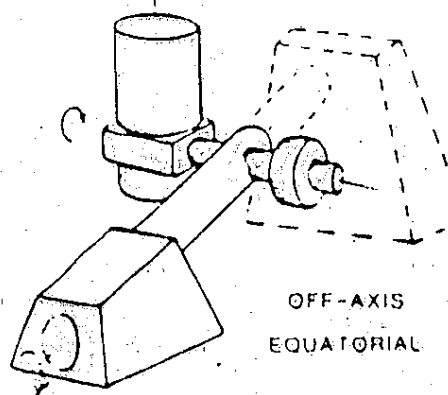
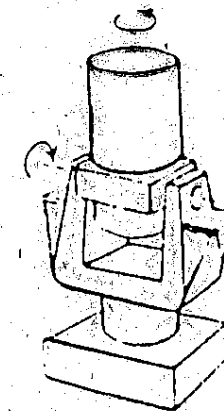
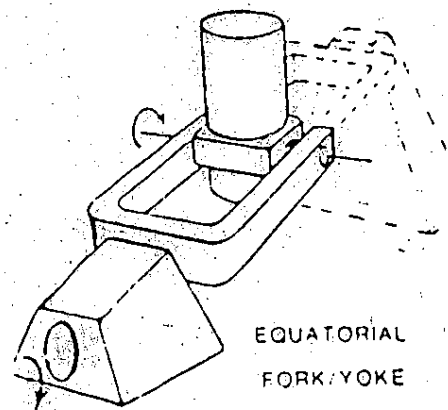


**Equatorial**



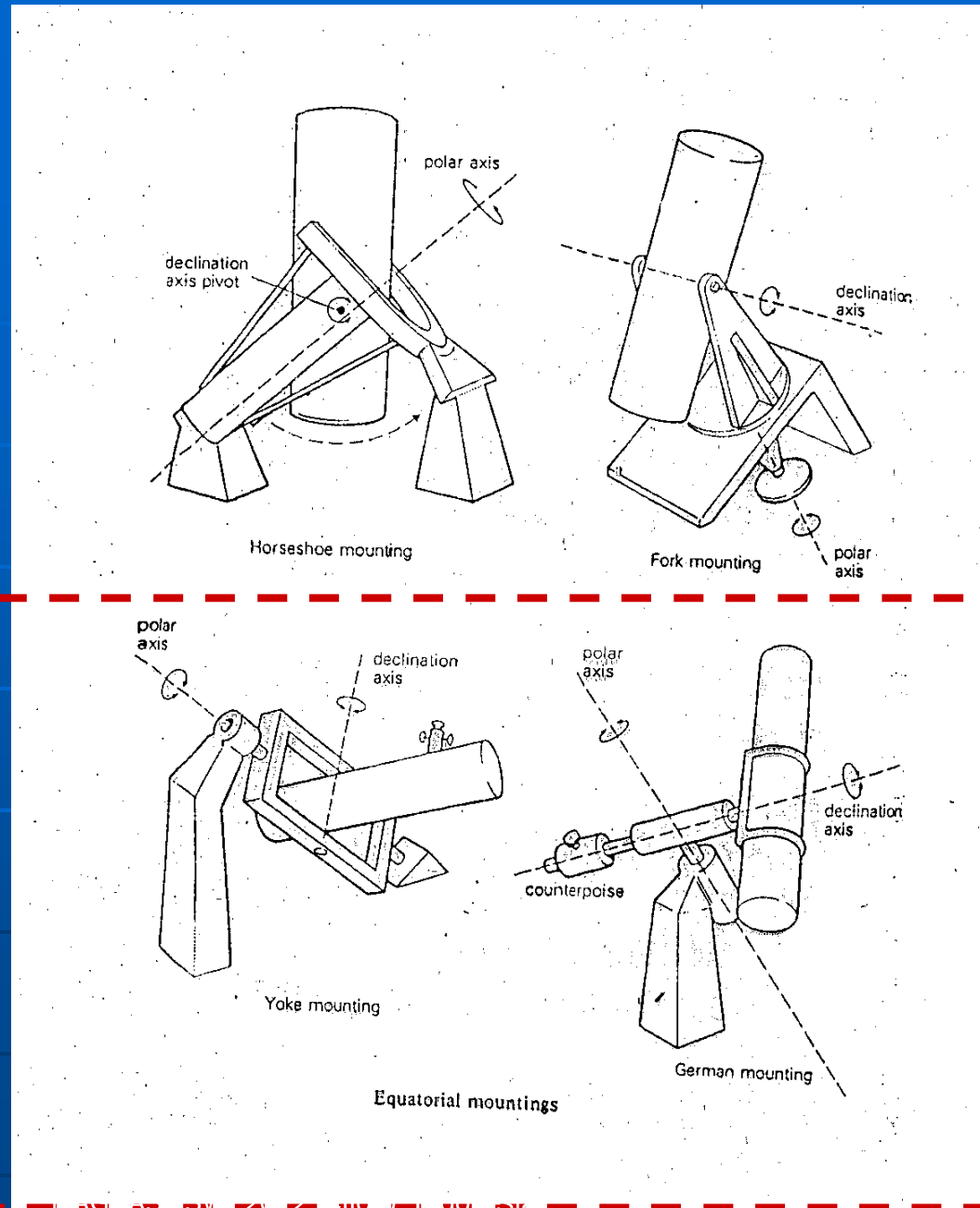
**Alt-azimuth**

# Static telescope mounting

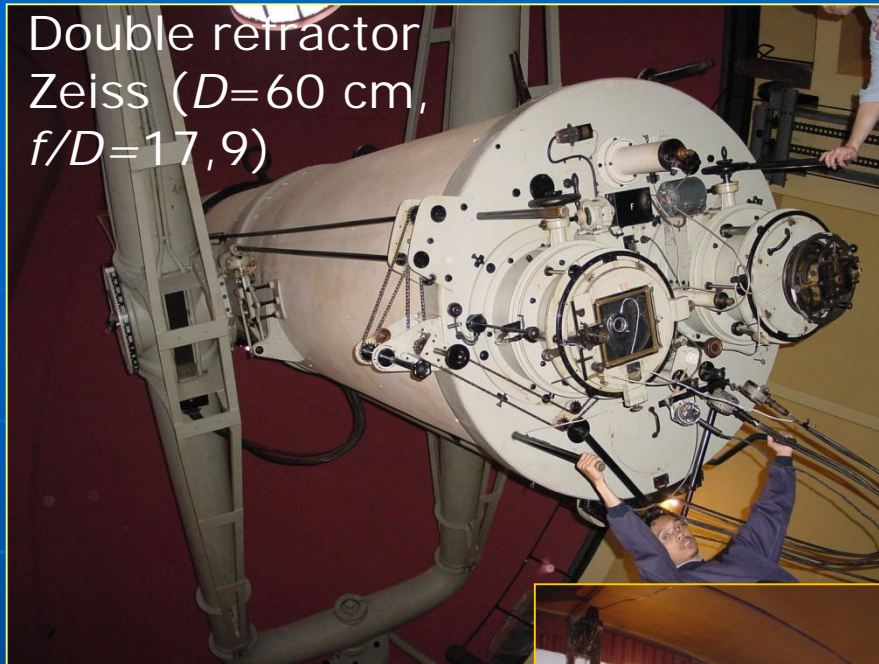


Basic telescope mounting styles in popular use. Numerous variants on each style are in existence.

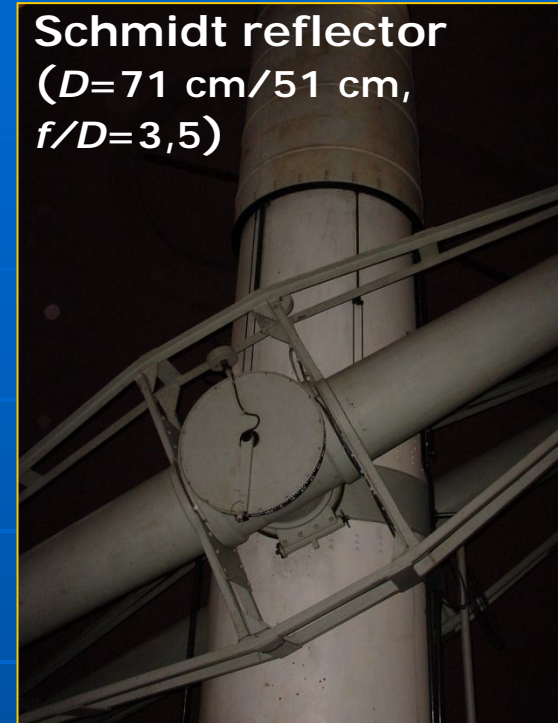
# Telescope mountings at Bosscha Observatory



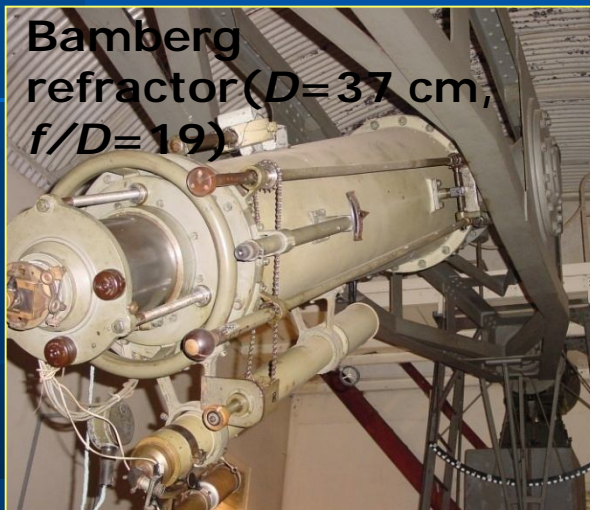
Double refractor  
Zeiss ( $D=60$  cm,  
 $f/D=17,9$ )



Schmidt reflector  
( $D=71$  cm/ $51$  cm,  
 $f/D=3,5$ )



Bamberg  
refractor ( $D=37$  cm,  
 $f/D=19$ )



GOTO reflector ( $D=45$   
cm,  $f/D=12$ )



Unitron refractor ( $D=10$   
cm,  $f/D=12$ )







**Takahashi refractor**  
( $D=10.2\text{cm}$ ,  $f/D=8.0$ )



**GAO-ITB Remote Telescope**  
**Schmidt-Cassegrain**  
**Celestron ( $D=20\text{ cm}$ ,  $f/D=10$ )**  
**reflector**



**IAO Schmidt-Cassegrain**  
**Celestron Nexstar8 ( $D= 20$**   
**cm,  $f/D=10$ )**



**Dynamax ( $D=8\text{ cm}$ ,**  
 **$f/D=12$ )**



MAGDAS-ISWI 2012, Ciloto, Indonesia  
**Satellite tracker**



**Unitron ( $D=10\text{ cm}$ ,  $f/D=12$ )**  
**refractor**

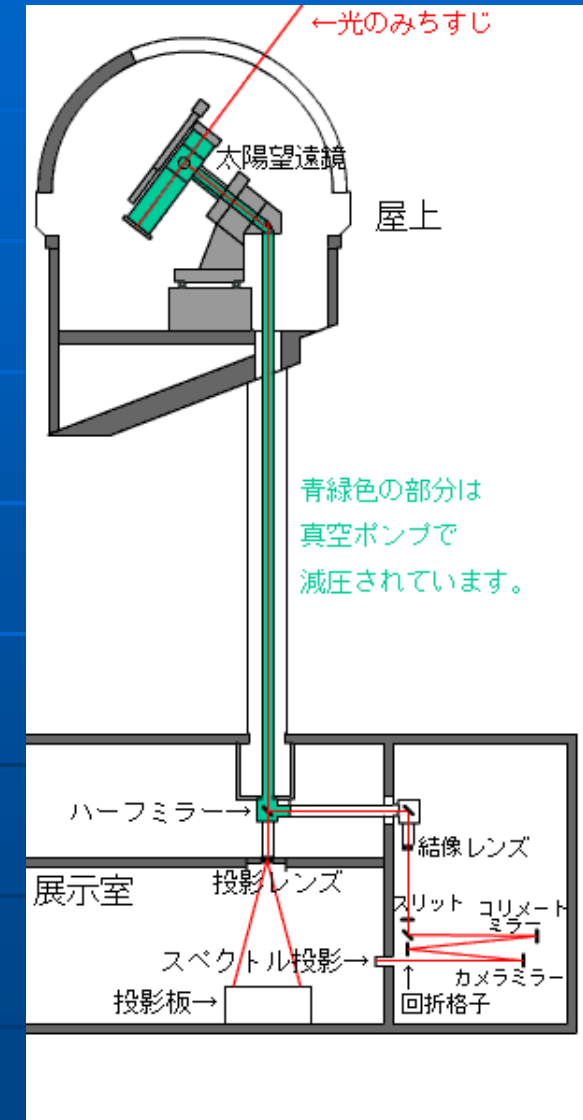
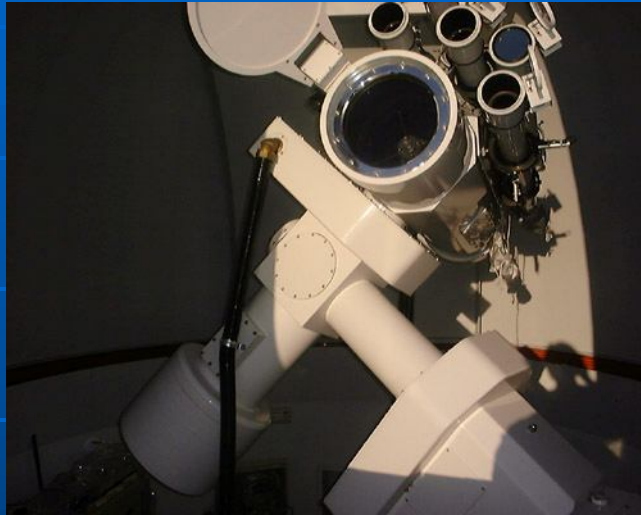
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# Peripherals of an astronomical telescope

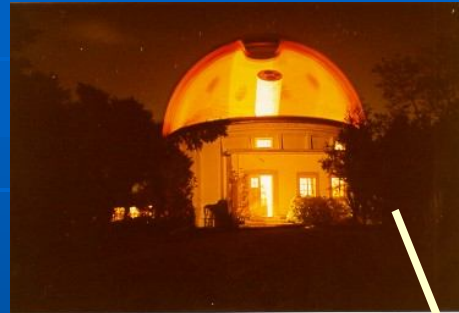
- Optical tube assembly (OTA):  
Lenses/Mirrors, Body/Frame, eyepiece
- Mounting
- Clockdrive
- Enclosure (*dome, roof, wind shield*)
- Accessories for telescope operation:
  - Solar and siderial clocks
  - Computer
  - Field note / log book

# A typical example: Solar telescope at Gunma Astronomical Observatory



# Enclosure teleskop

*Dome*



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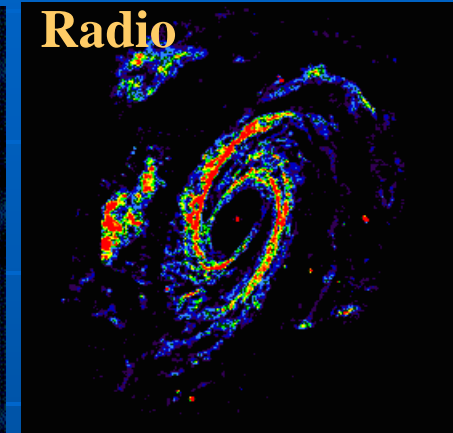
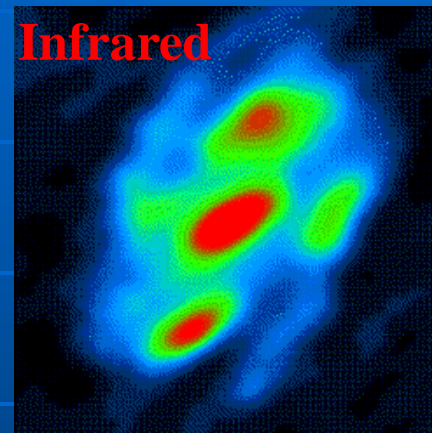
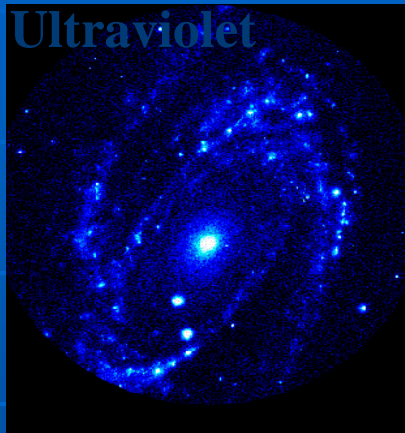
*Sliding roof*



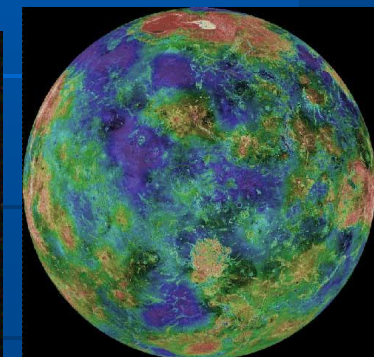
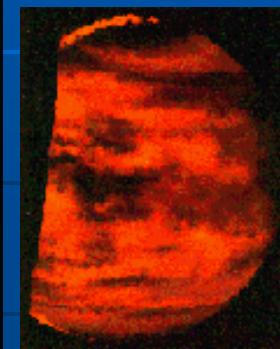
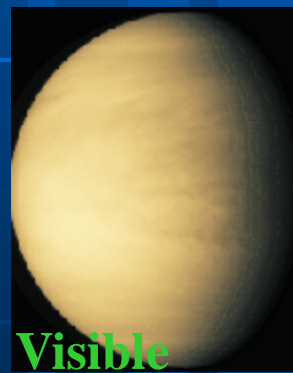
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# Why an analyzer is needed?

## M 81: Spiral galaxy

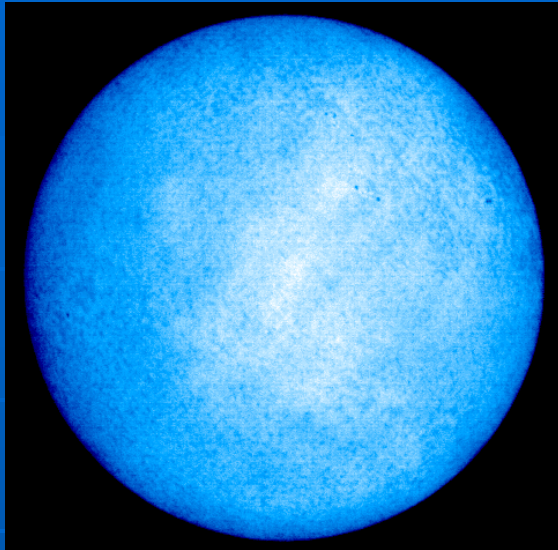


## Venus



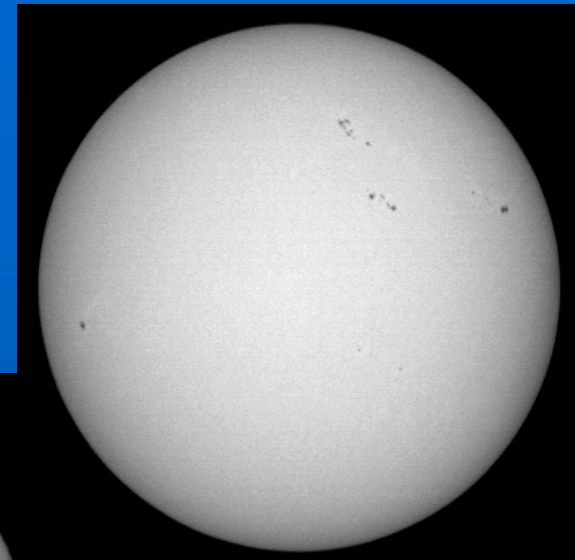


## Shibata (2007) 5 modes observation of FMT

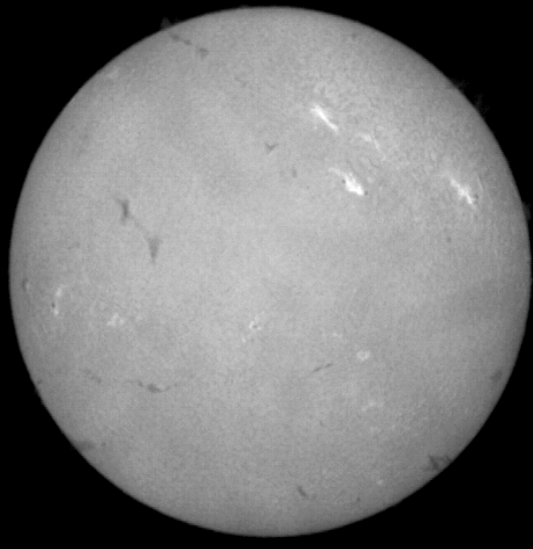


$H\alpha - 0.8\text{\AA}$

$H\alpha + 0.8\text{\AA}$

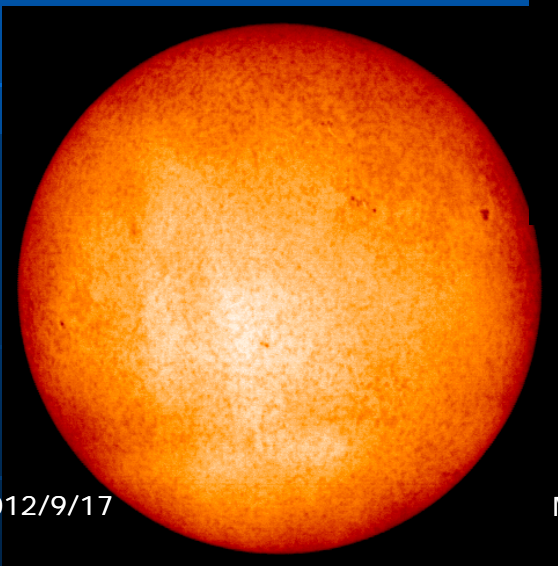


Red Continuum



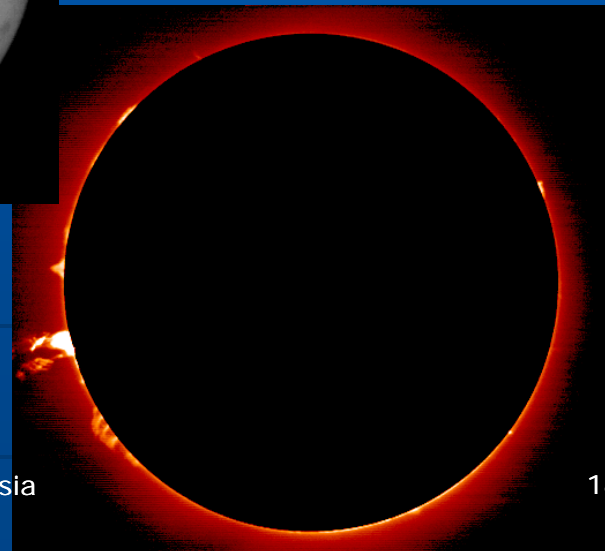
$H\alpha$  LineCenter

$H\alpha$  Prominence



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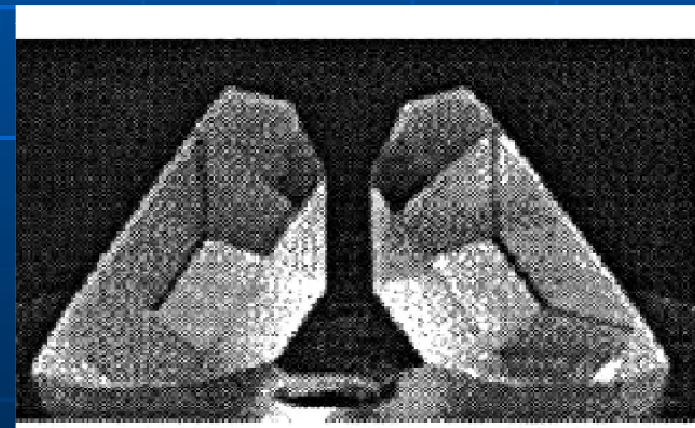
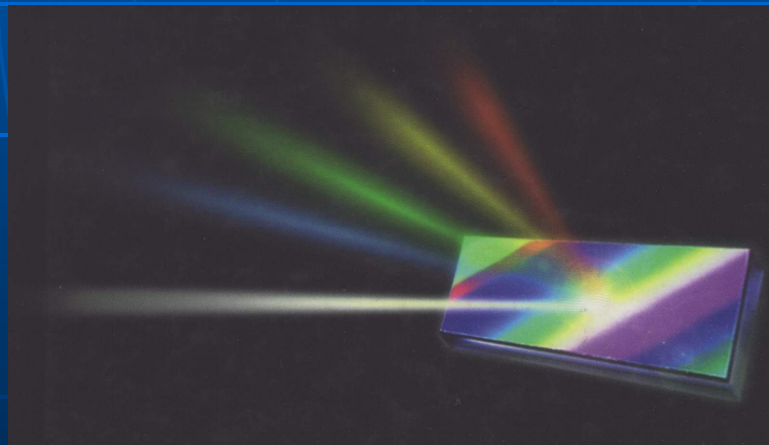
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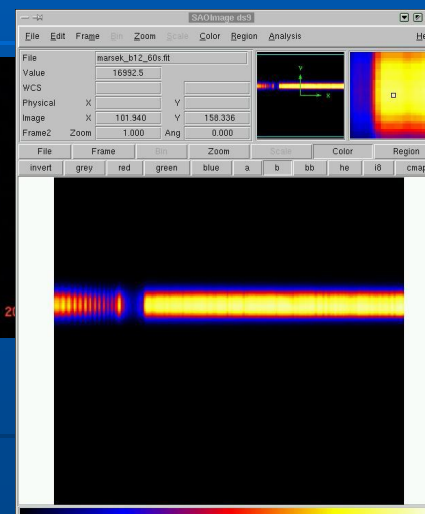
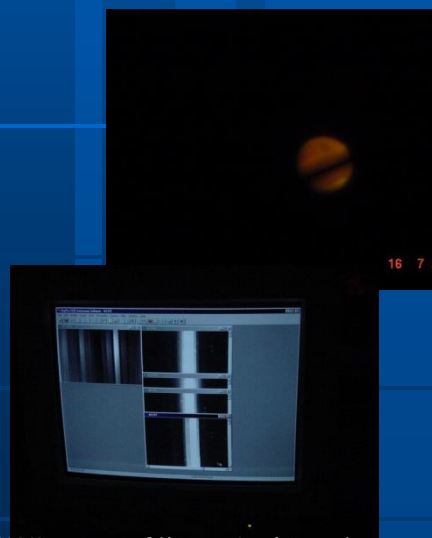
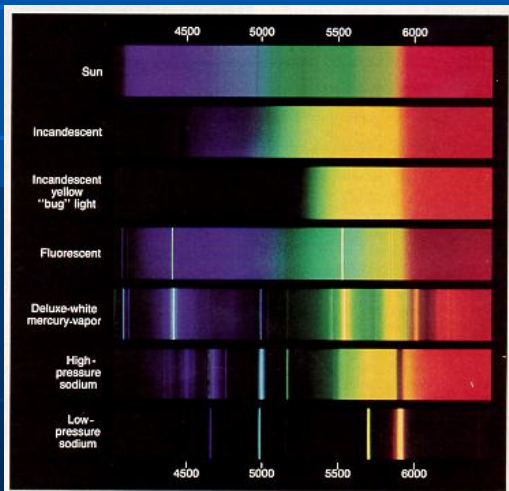




## ■ Analysis devices

- **Filter**: polychromatic  $\Rightarrow$  monochromatic
  - Broad-band filters ( $U, B, V, R, I, \dots; R, G, B$ )
  - Intermediate-band filters (Strömgren *uvby*)
  - Narrow-band filters (*interference filters*)
- **Disperser**: Polychromatic light  $\Rightarrow$  Spectrum
  - Prism
  - Grating
- **Polarizer**: Transmission of particular wave of electromagnetic radiation





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# What is a detector?

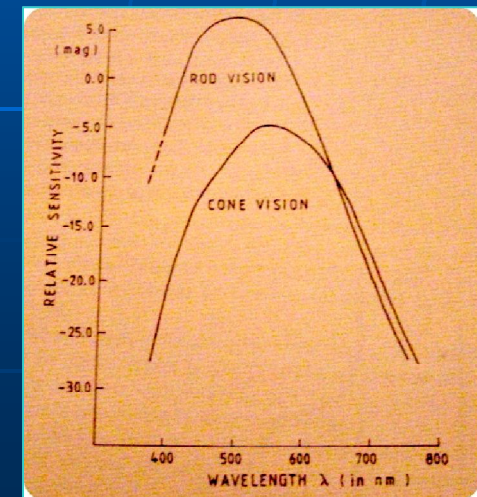
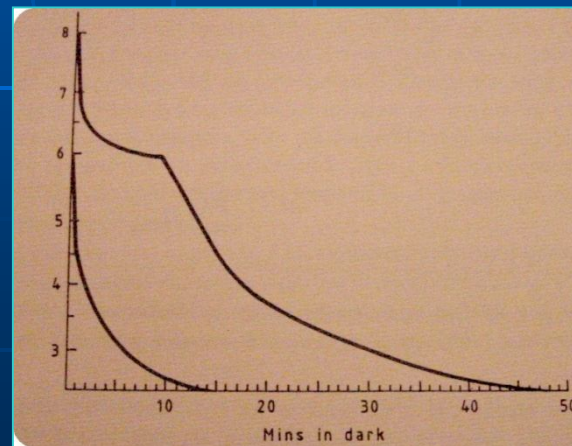
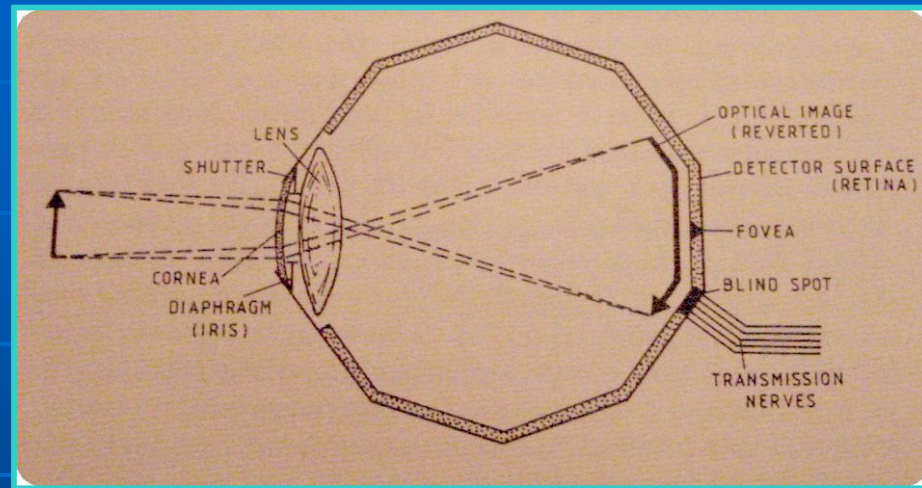
Sensing device that create a signal if illuminated by light pattern

- ✓ Used to study radiation
- ✓ Convert radiation energy → Other form of energy : Thermal, photochemistry, electric



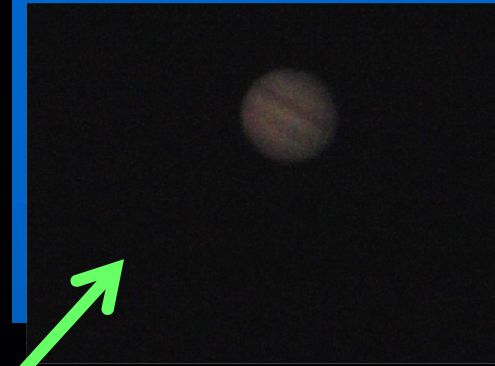
# Versatile natural detector: Eyes

- Eye ball  $\equiv$  Camera (diameter 25 mm)
- Aperture diameter = 6-8 mm
- Focal length = 15 mm
- Components of eye:
  - ✓ Cornea
  - ✓ Retina
  - ✓ *Rods & cones cells*





**Digital  
camera/Astro  
-Video :**  
Potential  
commercial CCD  
camera



# Video for astronomical observations

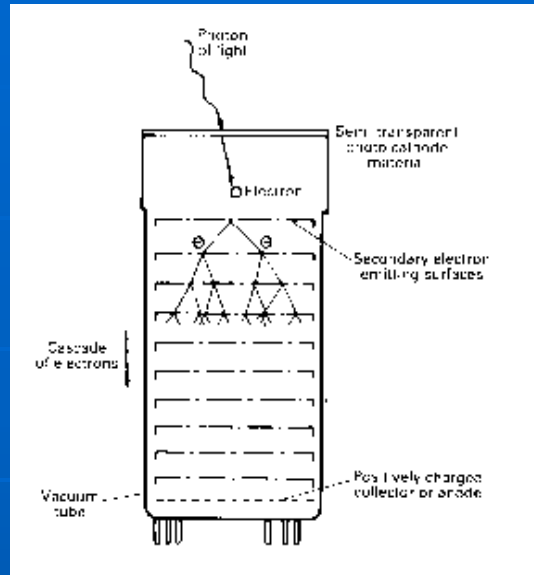


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# Photoelectric Photometer:



Photomultiplier

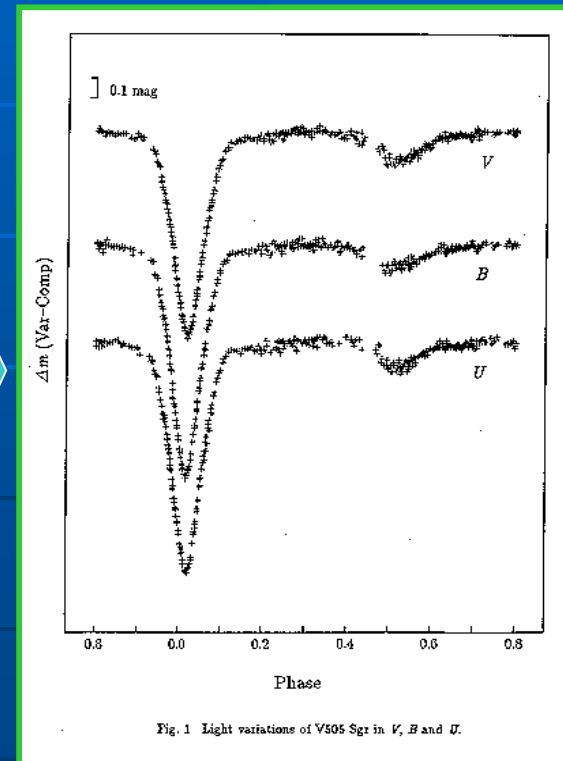
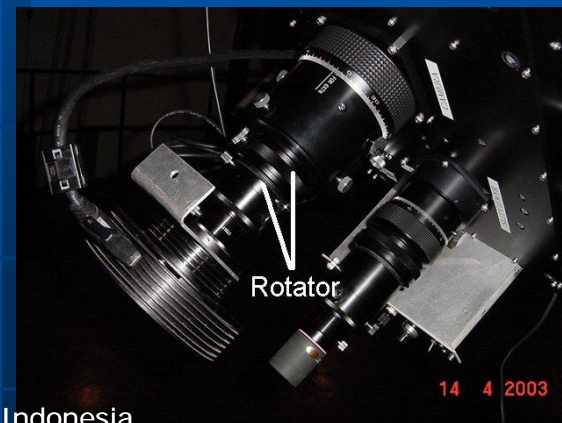
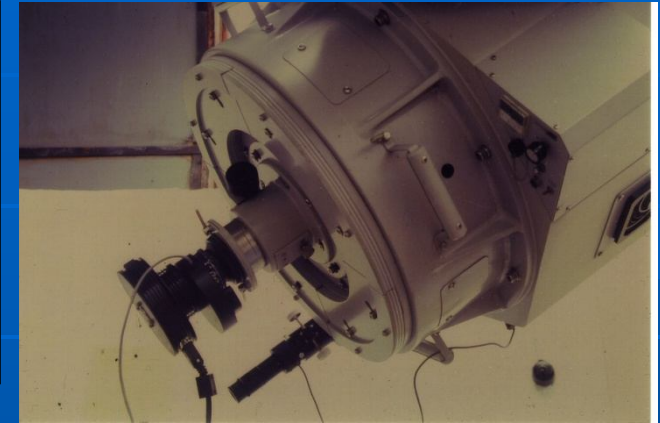
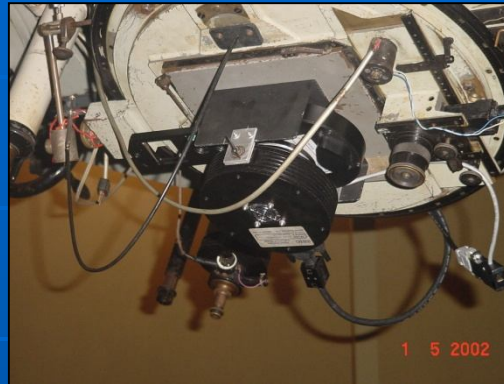


Fig. 1 Light variations of V505 Sgr in V, B and U.



# CCD cameras at Bosscha Obs.



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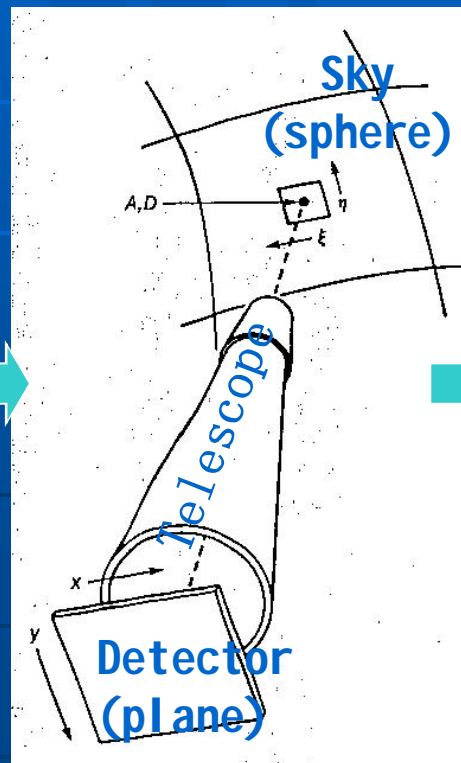
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# Astrometry

Accurate position measurement of celestial body in the image



From astronomical  
photography through  
telescope one gets  
image



General expression:

$$\alpha(1950.0) = 20^{\text{h}}:02^{\text{m}}:49.7^{\text{s}}$$

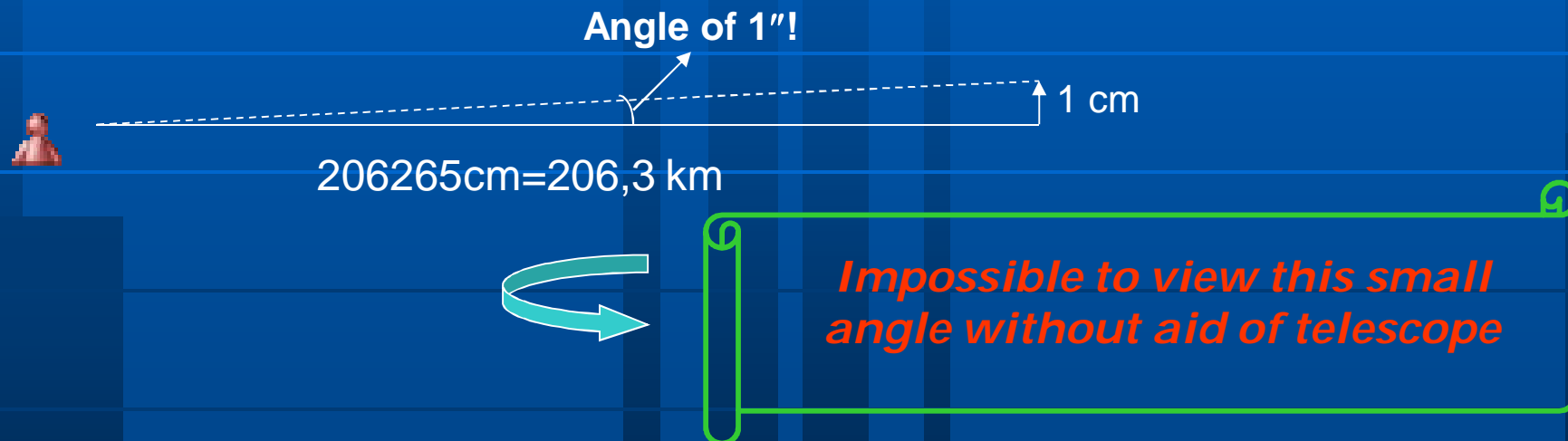
$$\delta(1950.0) = -14^{\circ}:09':38.1''$$



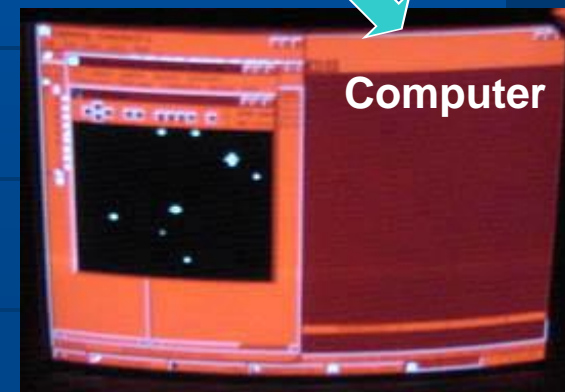
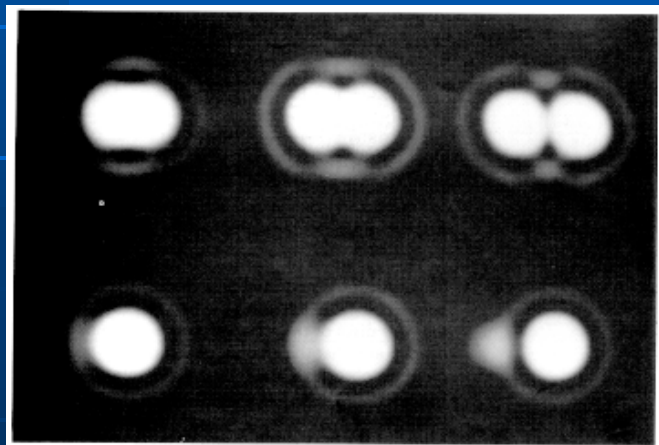
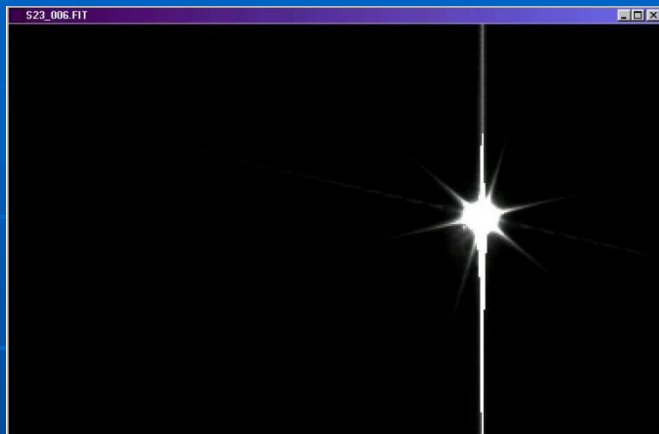
# What is 1" ?

$\pi(=3,14159265\dots)$  radian =  $180^\circ=648.000$   
"

Thus  $1''=3,14159265/648000=1/206265$  radian



# Measuring tools



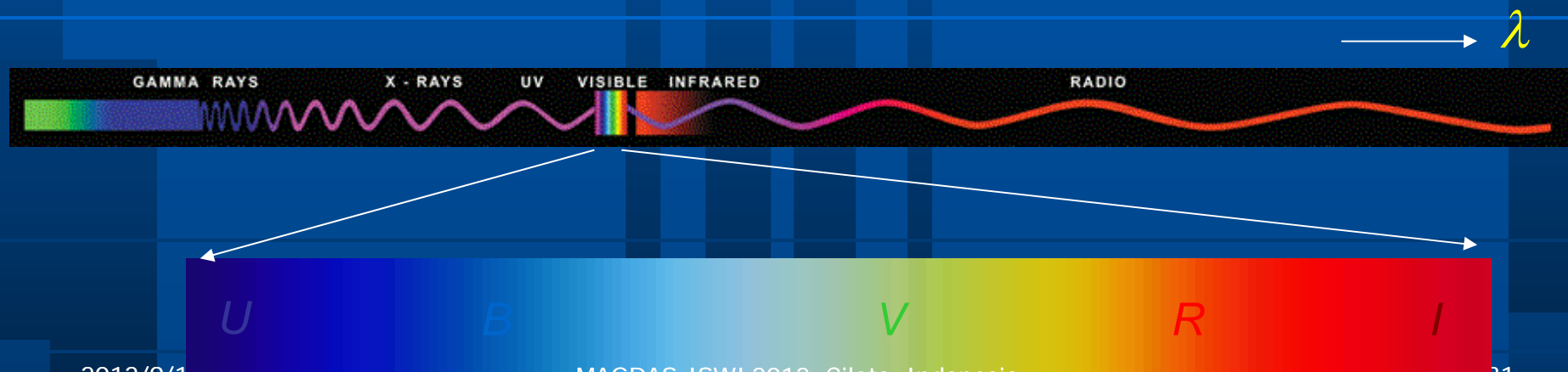
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# Photometry

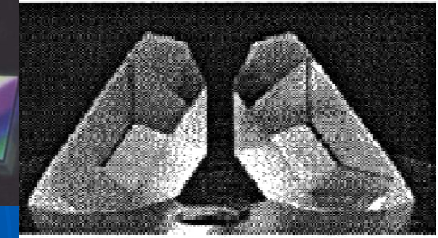
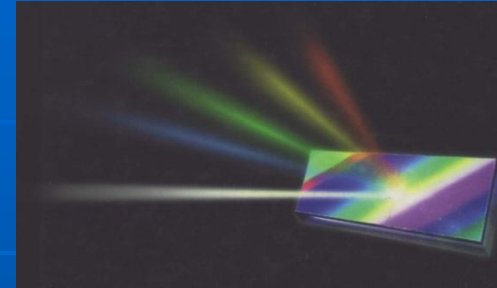
Accurate measurement of celestial body's intensity in various wavelength

Light=electromagnetic wave: composed of spectral colors corresponding to each wavelength ( $\lambda$ )

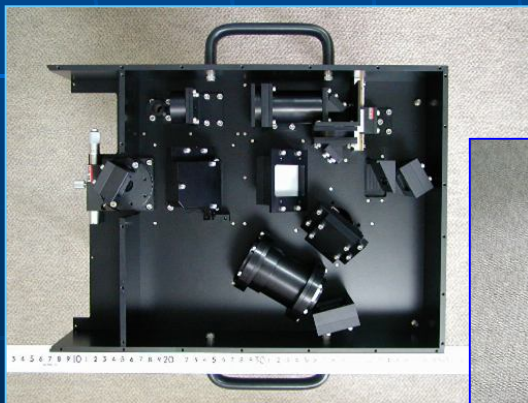


# Spectroscopy

Light analysis as a function of wavelength



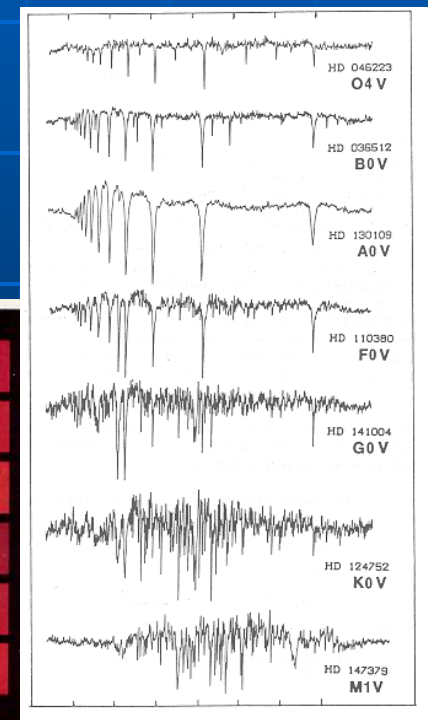
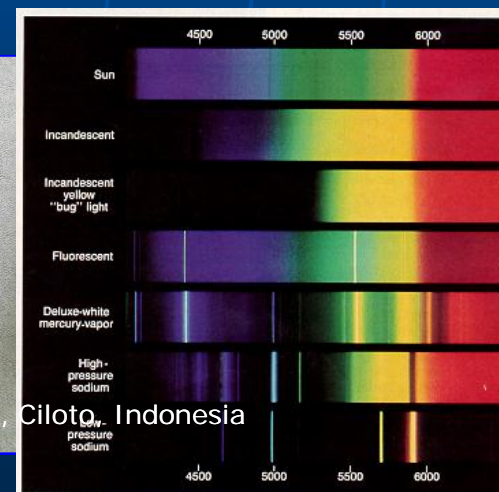
Astronomical spektrograph : Instrument for spectroscopy



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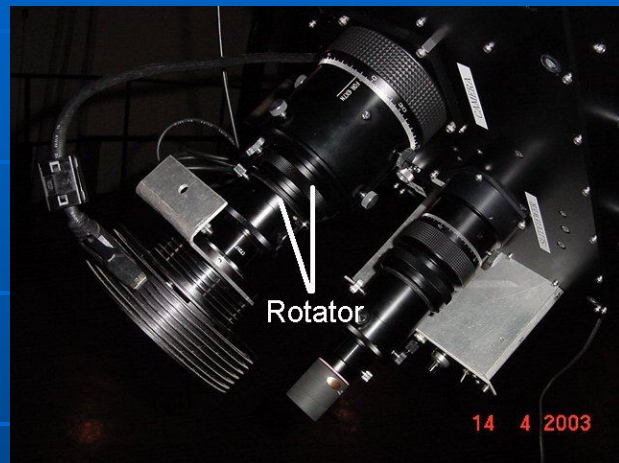


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# Spectroscopy of Saturn

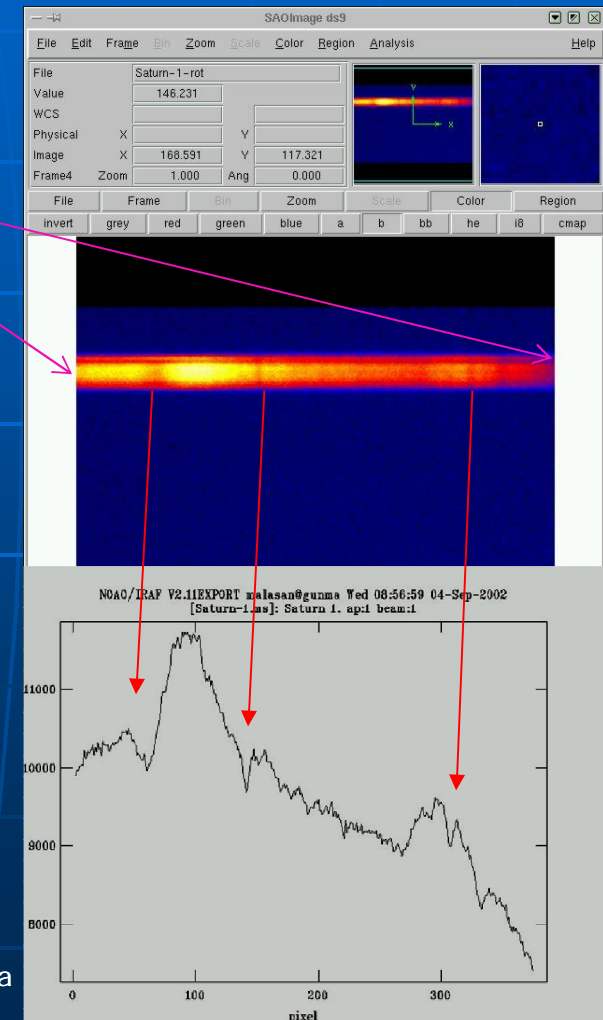
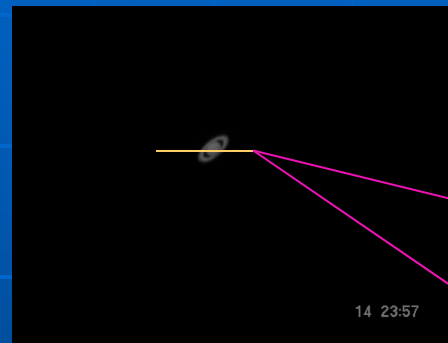


**Zeiss 60-cm f/17.9 refractor**

**Grating: 300 grooves/mm**

**Wavelength:  $\sim 5000 \text{ \AA}$**

**Center part of Saturn**



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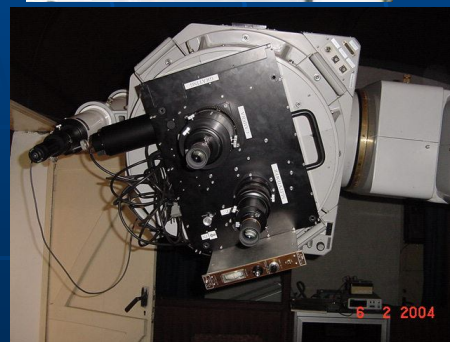
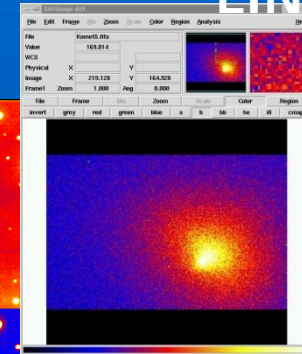
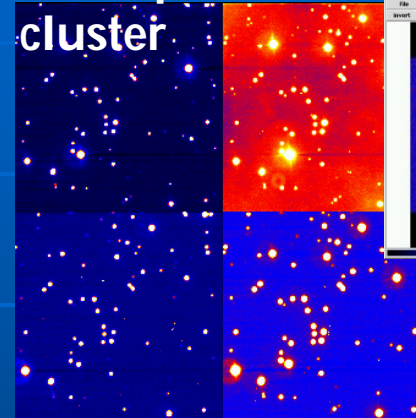
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# Astrophysical information

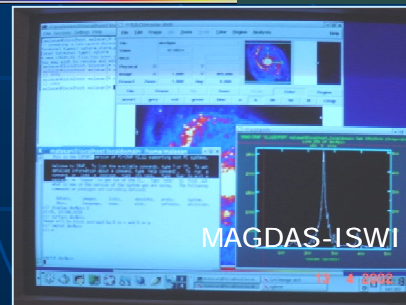
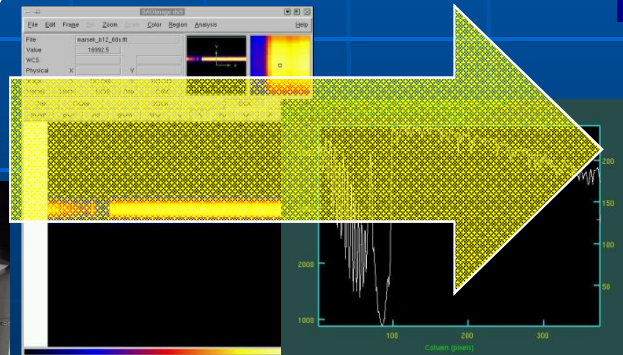
LINEAR



M67 open cluster



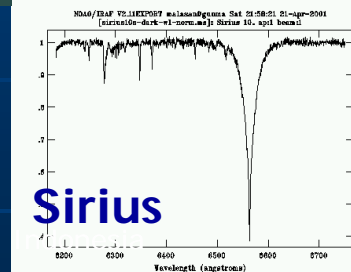
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Sirius



*Appearance at various wavelength:*

*Morphology, Temperature, Density and its variation*