"The Planets"

Astro/EPS C12 (CCN 17045 or 32505)

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LEC: 2 LeConte TWTh, 2:40–5:00pm
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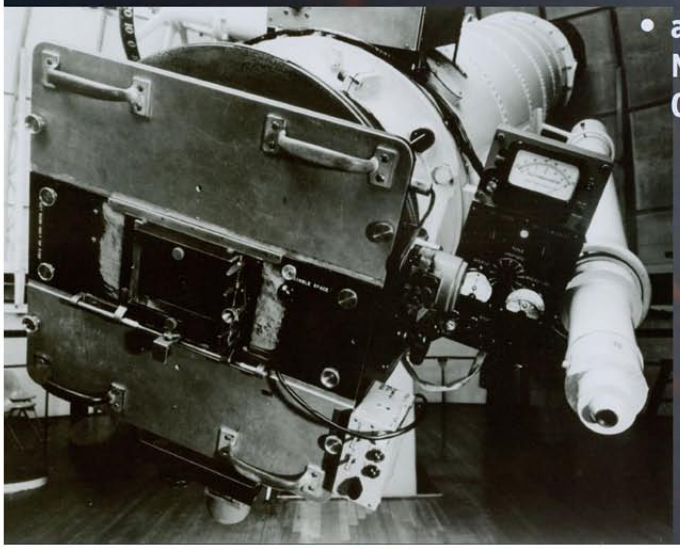
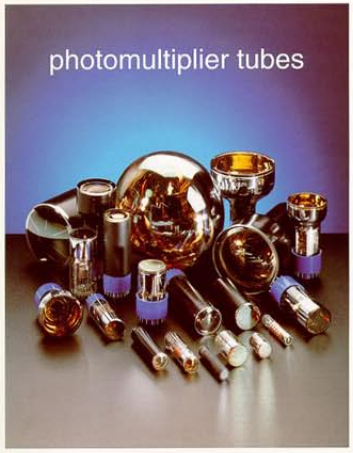
Mon 3–4 and Tue 5–6

PHOTOGRAPHIC PLATES



- at US Naval Observatory



Philips Photonics

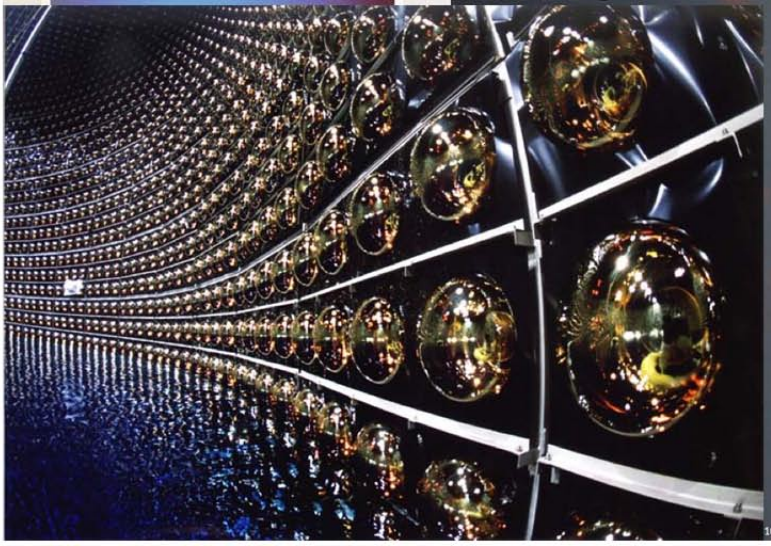
PHILIPS

PMTs

- linear response
- only one "pixel" so poor spatial resolution
- became popular in 1950s

photomultiplier tubes
Super-Kamiokande neutrino detector

PMTs



PLUTO'S LIGHTCURVES

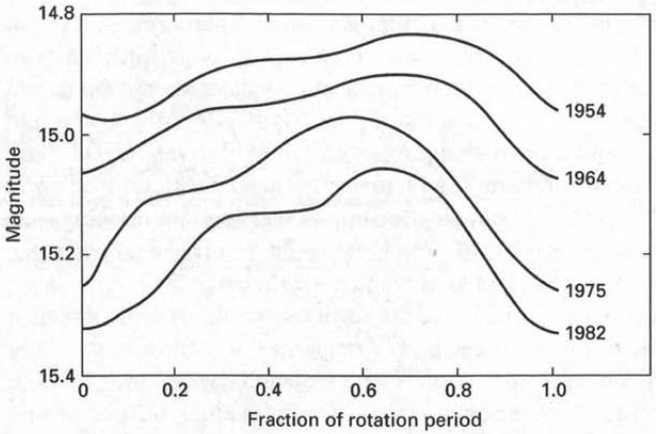


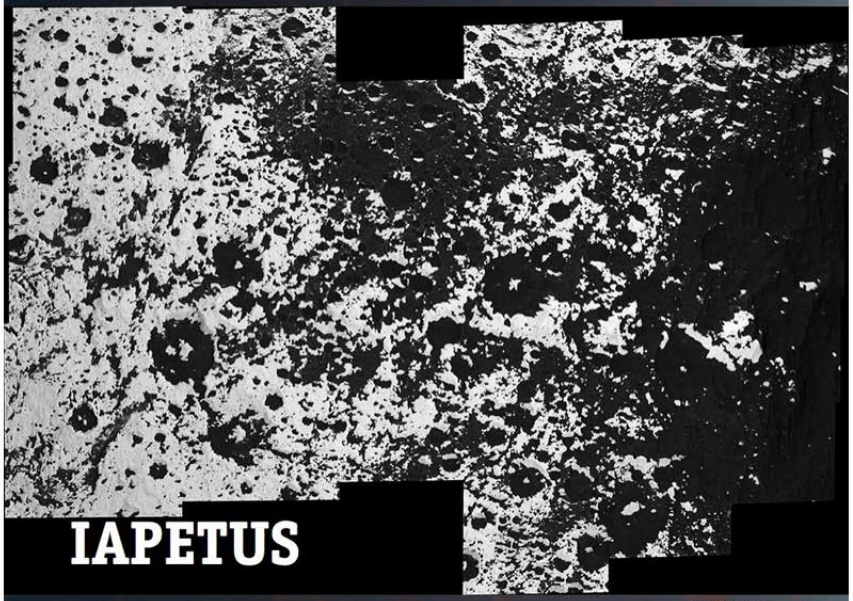
Fig. 2.2: The change in Pluto's lightcurve over almost 30 years, from 1954 to 1982.

IAPETUS

- Cassini image
- moon of Saturn
- discovered 1671 by Giovanni Cassini

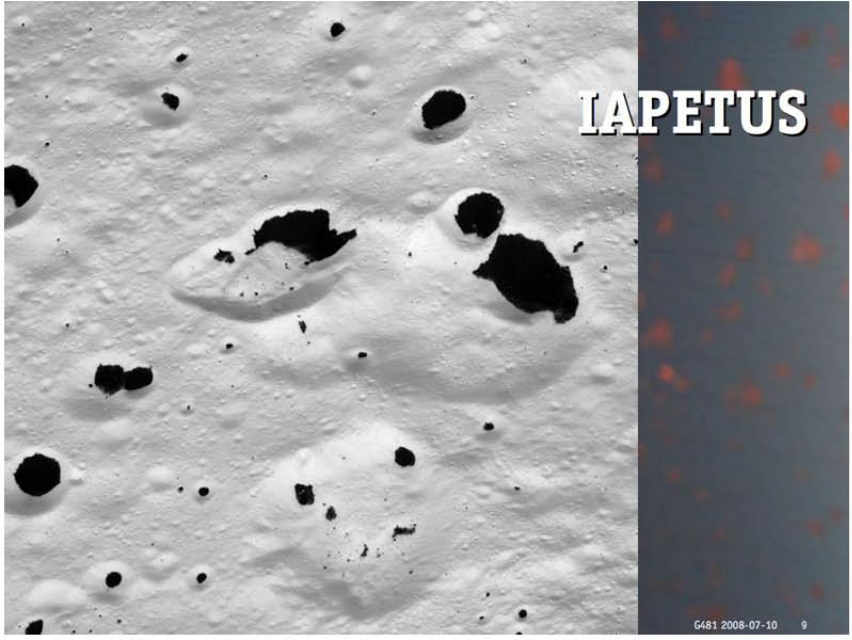
IAPETUS

- leading hemisphere is dark !!

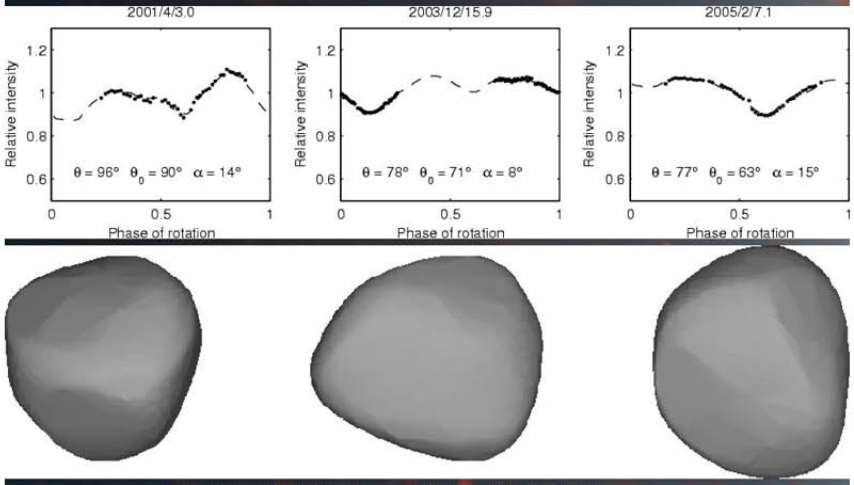


IAPETUS

IAPETUS

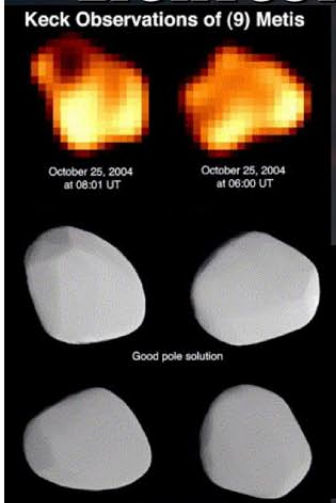


LIGHTCURVE INVERSION

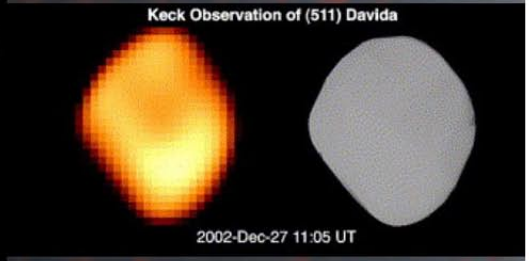


Durech et al., *Astronomy and Astrophysics* 2007

LIGHTCURVE INVERSION



- adaptive optics imaging verifies accuracy of shape inversion



Marchis et al., *Icarus* 2006

PLUTO'S LIGHTCURVES

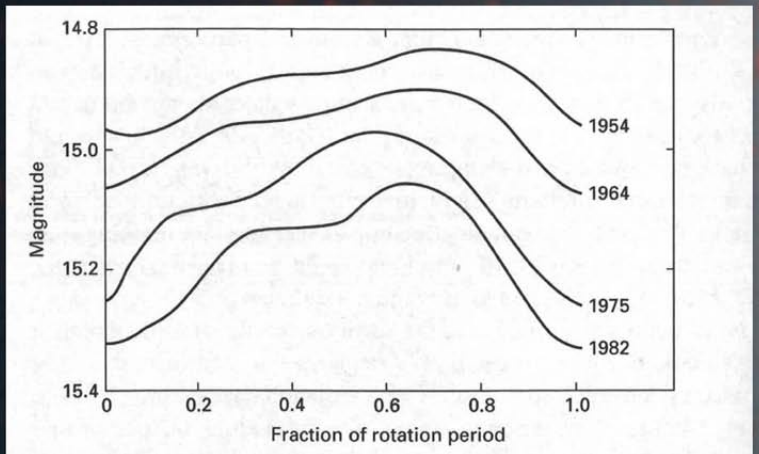


Fig. 2.2: The change in Pluto's lightcurve over almost 30 years, from 1954 to 1982.

OBLIQUITY

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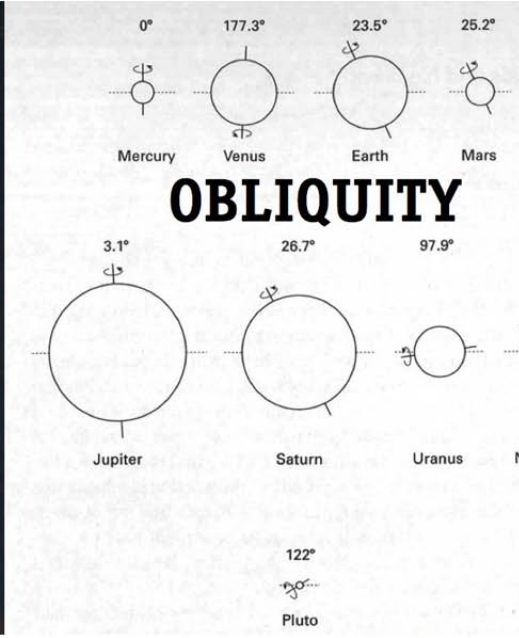
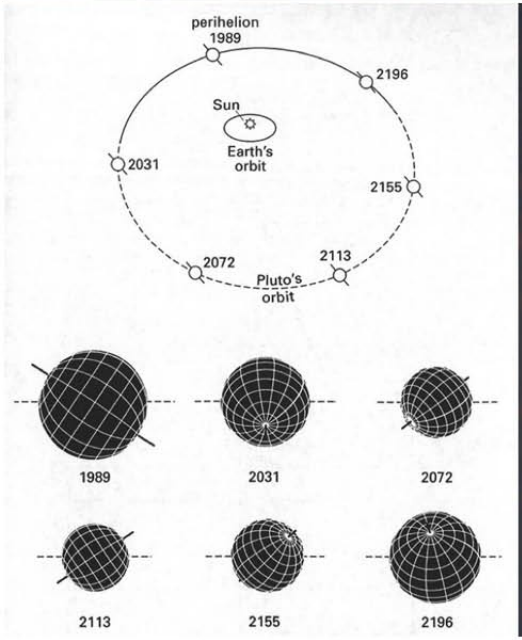
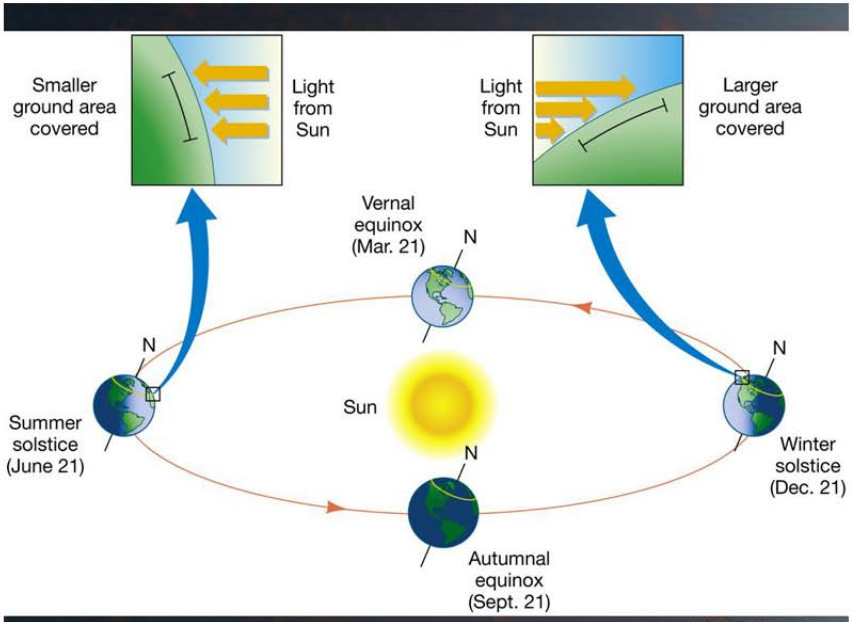
OBLIQUITY is the angle between an object's ROTATIONAL axis and its ORBITAL axis.





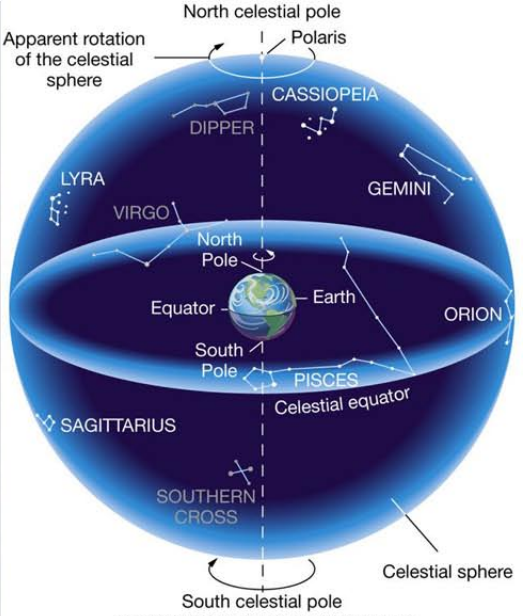
PLUTO'S OBLIQUITY

- first estimated using the changes in Pluto's lightcurve



COORDINATES ON THE GLOBE

CELESTIAL SPHERE



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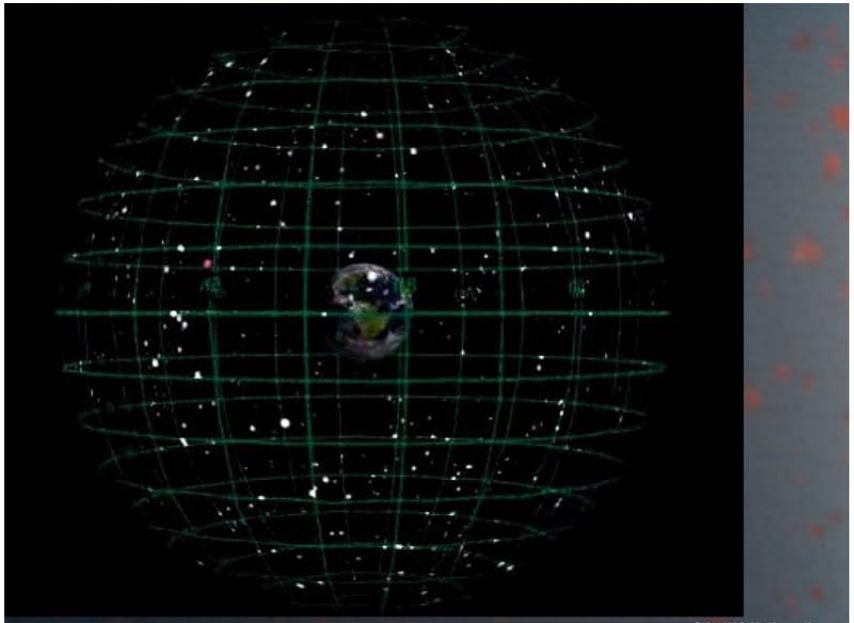
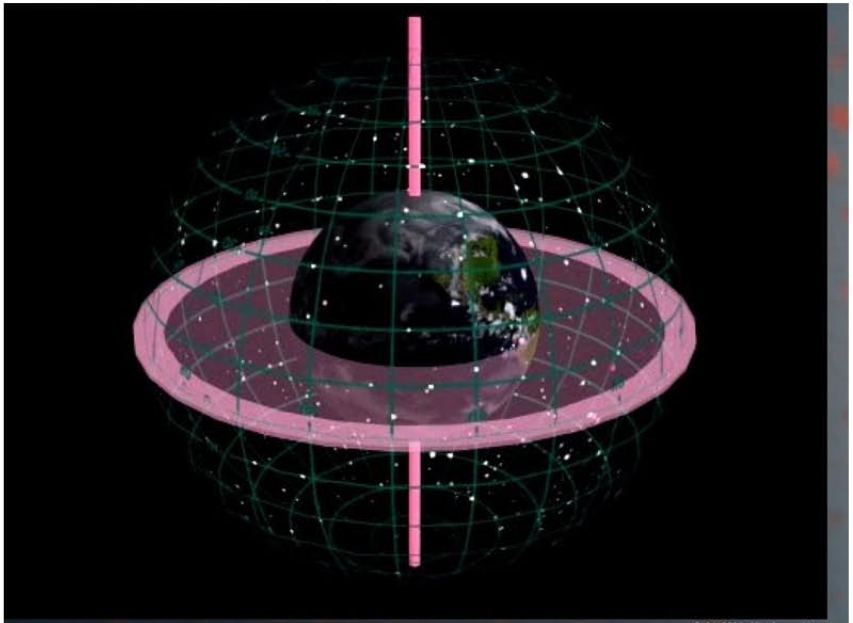
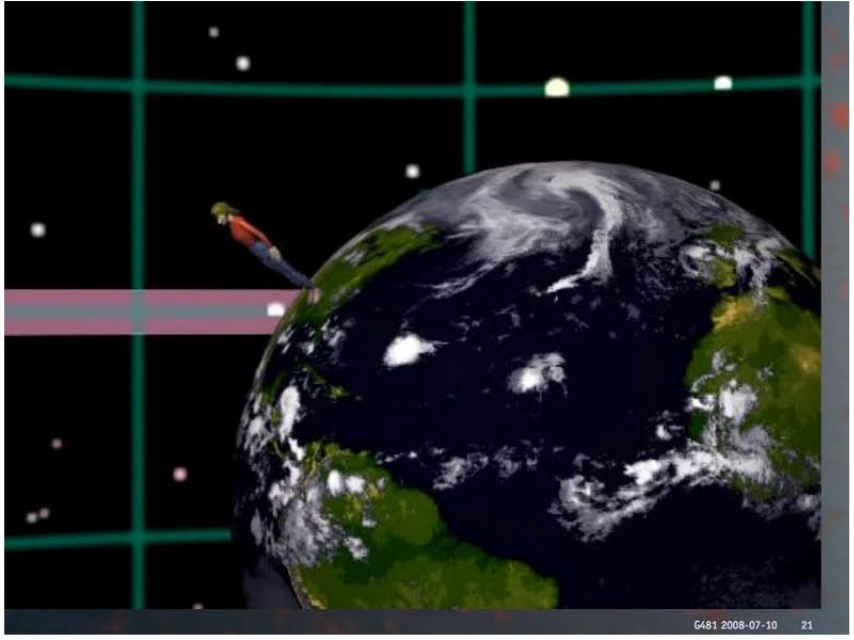
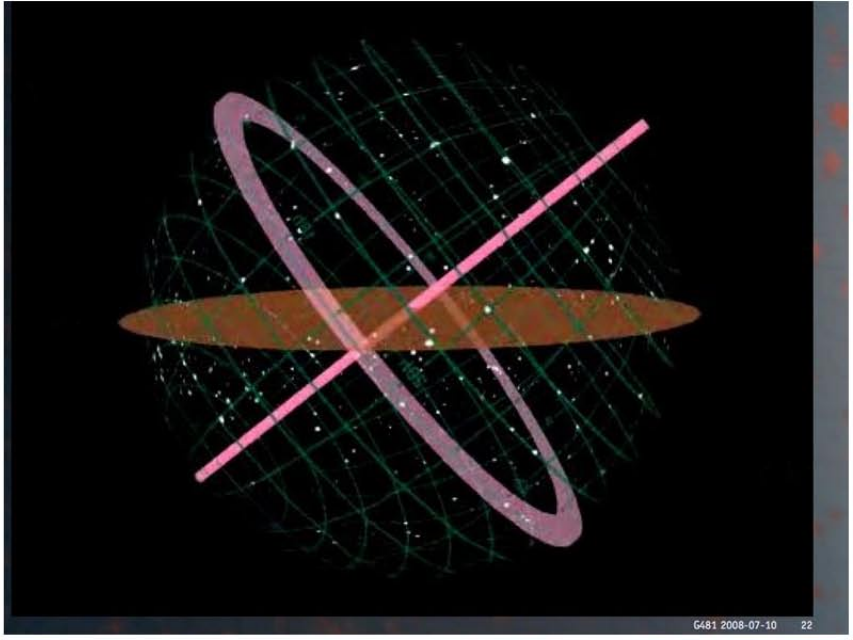





G481 2008-07-10 21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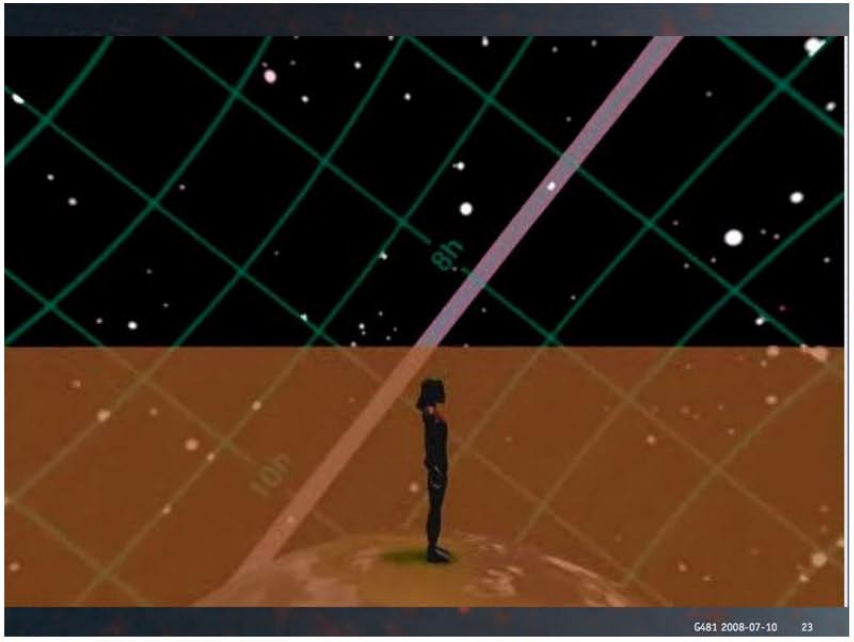
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10h
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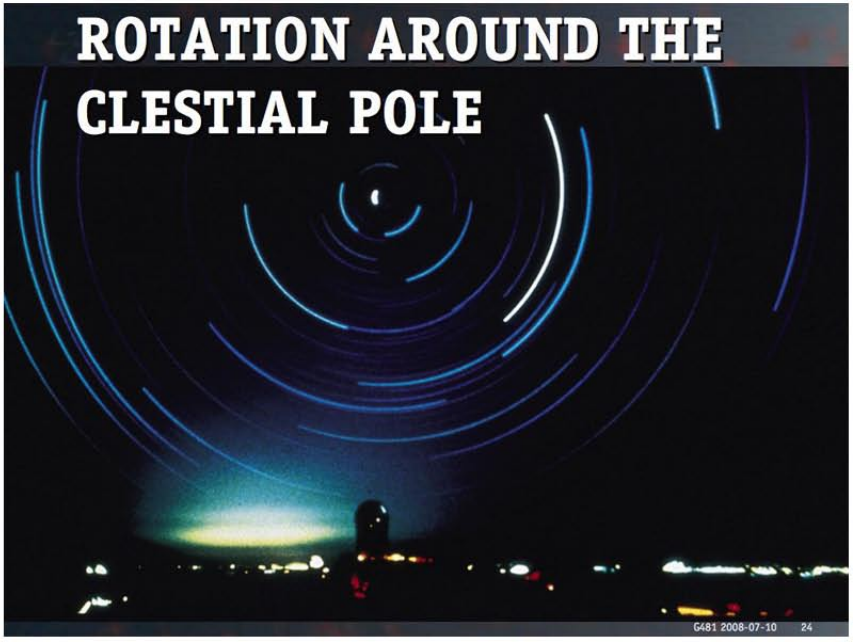
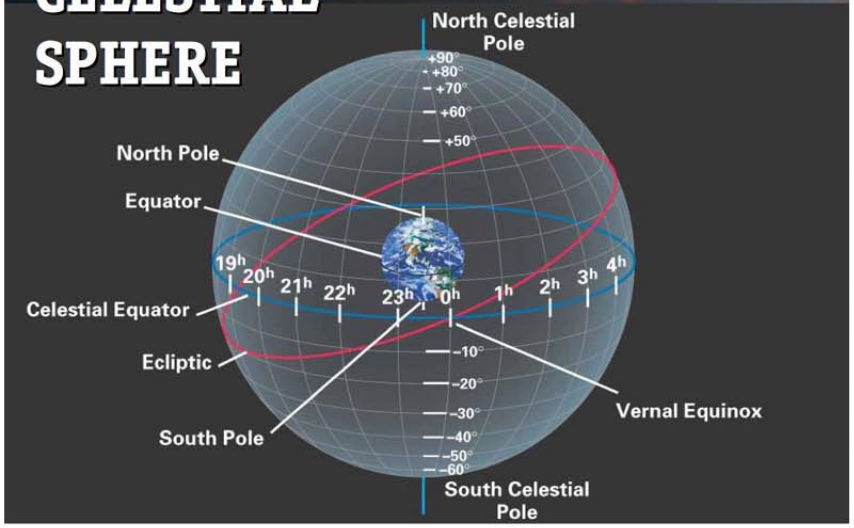

ROTATION AROUND THE
CLESTIAL POLE
G481 2008-07-10 24

CELESTIAL SPHERE



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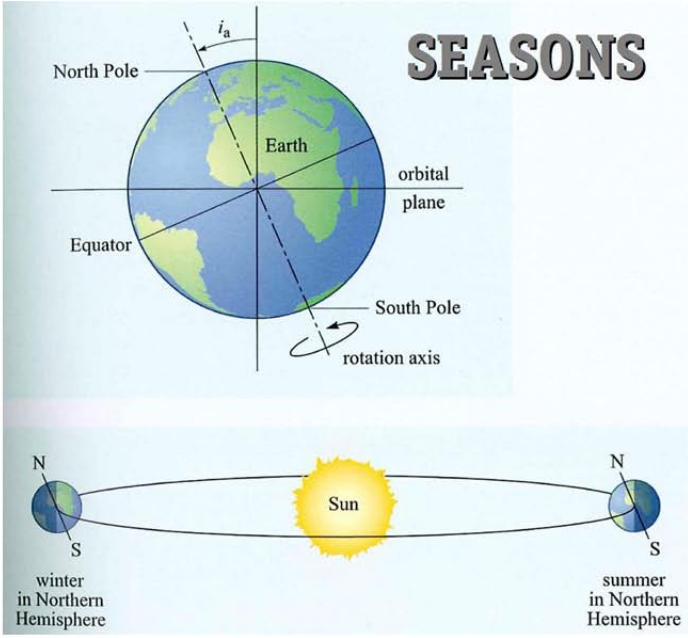
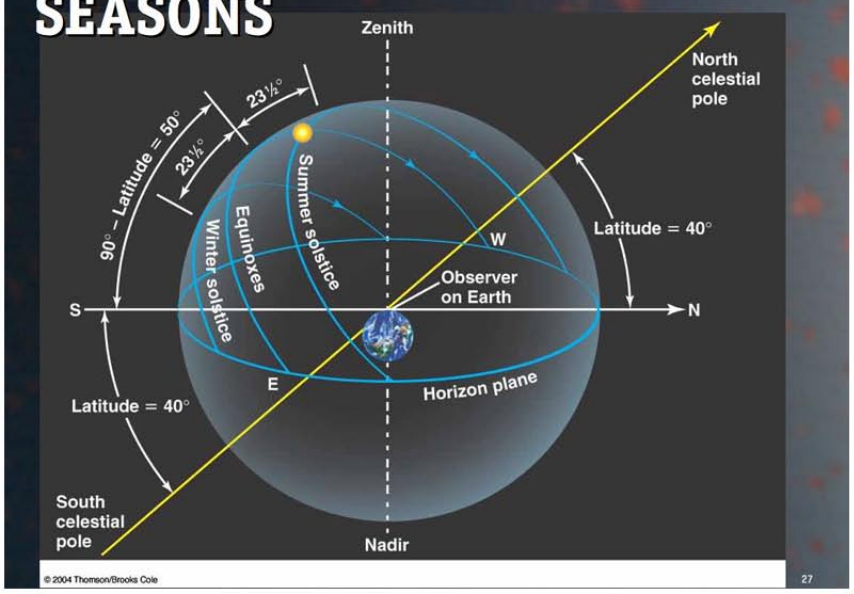
SEASONS



SEASONS



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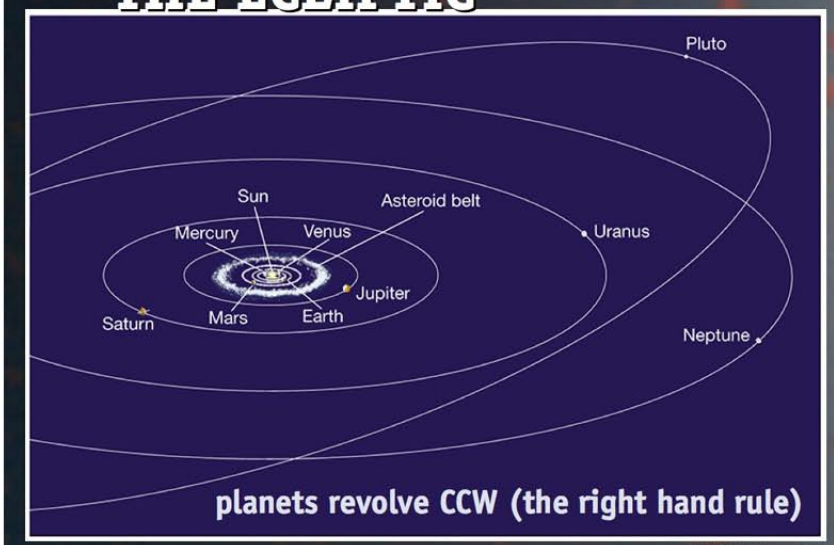
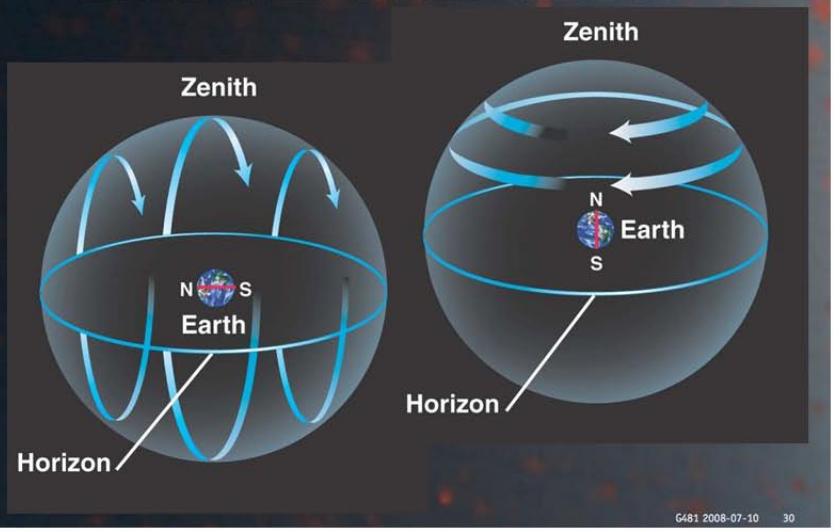
THE ECLIPTIC



SEASONS

EXTREME LATITUDES



Summer above the Arctic Circle

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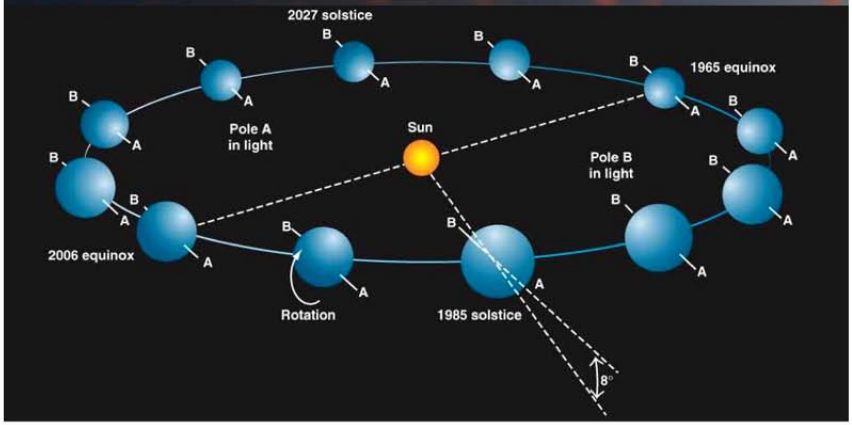
SEASONS ON URANUS



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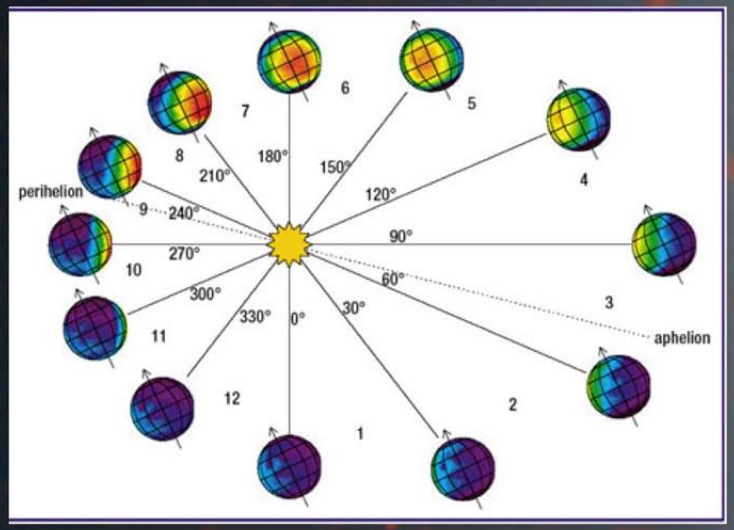
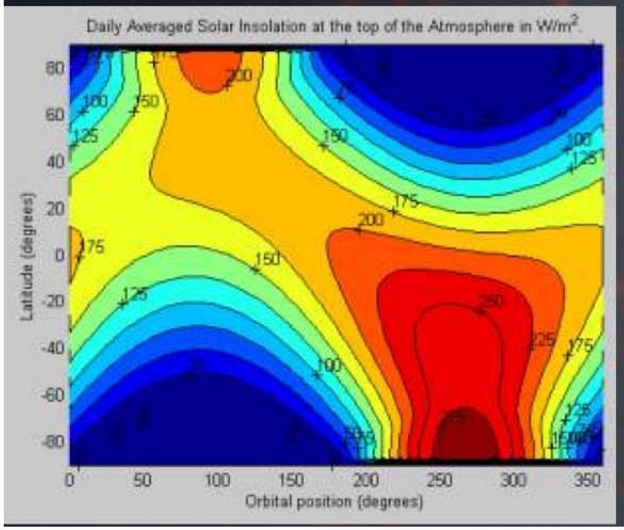
SEASONS ON MARS

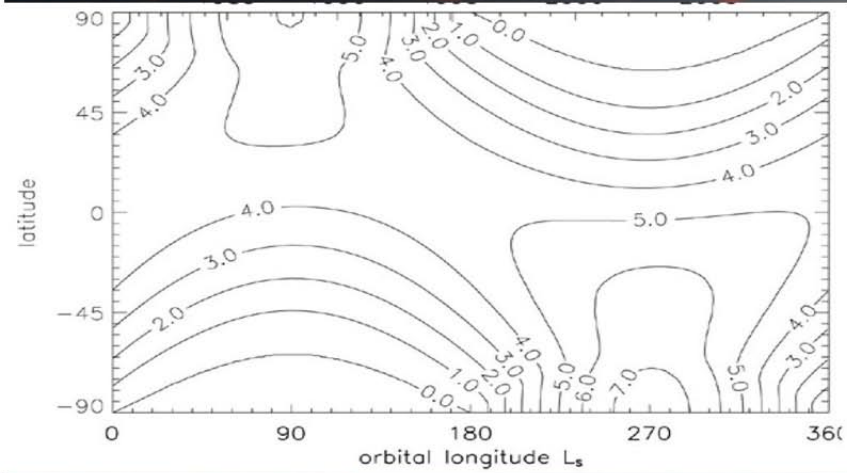


MARS SEASONS



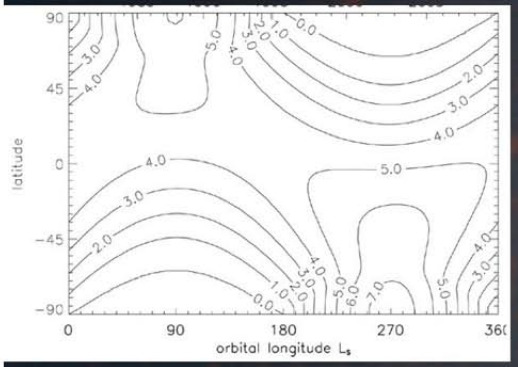
- plot shows amount of solar radiation received at Mars (color) at different latitudes (y-axis) and times of year (x-axis)

MENTAL EXERCISE



ESTIMATE OBLIQUITY AND ECCENTRICITY FOR THIS OBJECT

MENTAL EXERCISE



OBLIQUITY

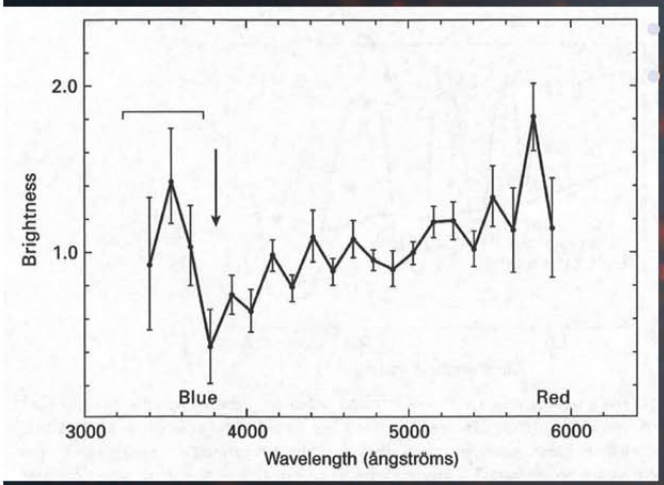
A. ~0°
B. ~25°
C. ~90°
D. not enough info

ORBITAL ECCENTRICITY

A. ~0.0
B. ~0.05
C. ~0.25
D. not enough info

ESTIMATE OBLIQUITY AND ECCENTRICITY FOR THIS OBJECT

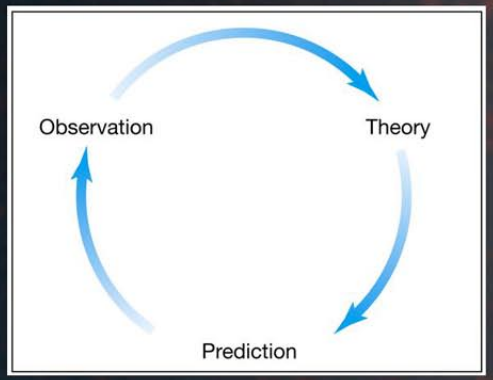
FIRST PLUTO SPECTRUM



- 1970
- error bars quantify uncertainty in the results

SCIENCE

- scientific method: results that can be repeated and verified
- data -> hypothesis -> theory



SCIENCE

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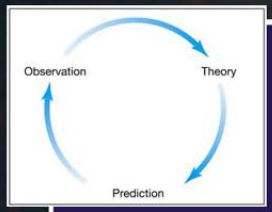
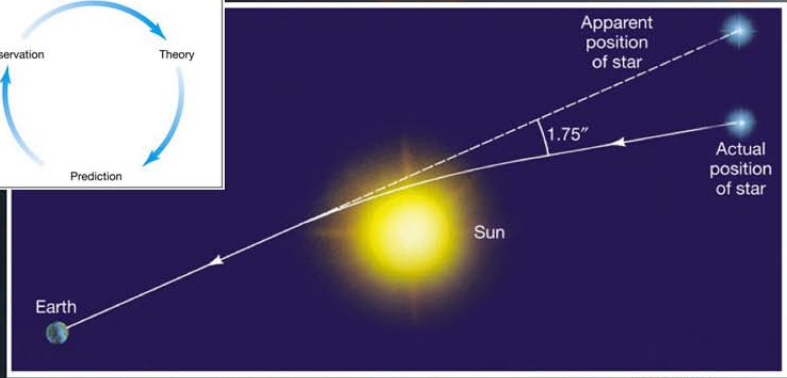
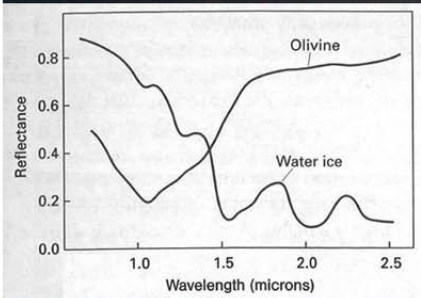
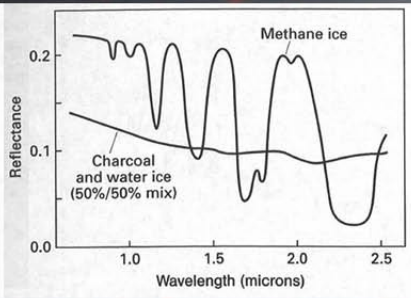




COMPOSITION AFFECTS REFLECTANCE SPECTRA

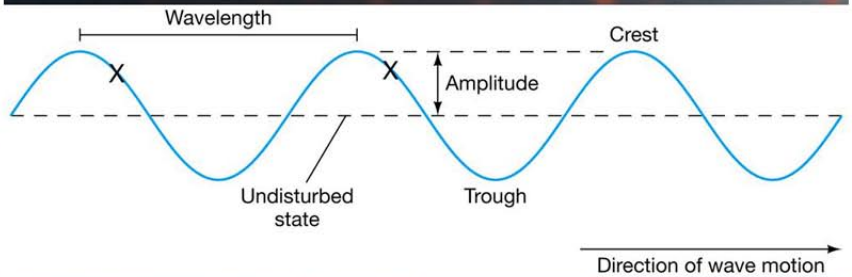




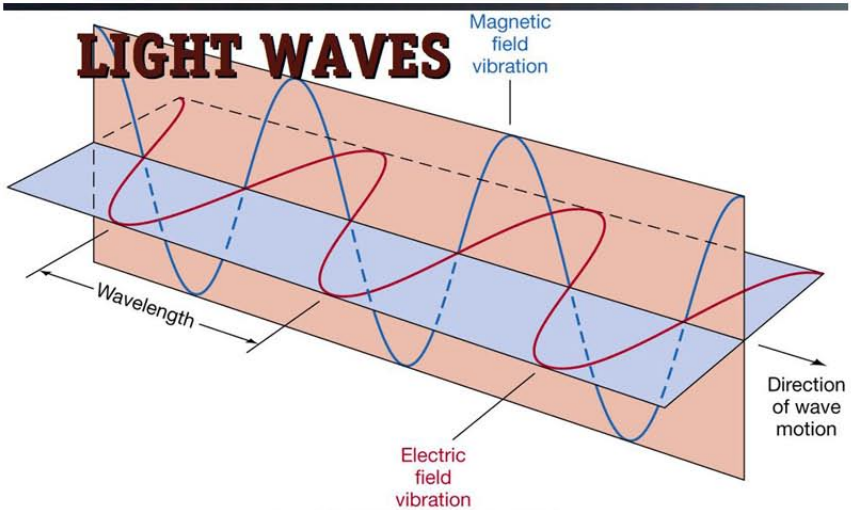
THE SPECTRUM

- white light can be broken up into colors
- Newton noticed this in the 1600s
- visible: 400–650 nm (4000–7000 Å)

WAVES



LIGHT WAVES



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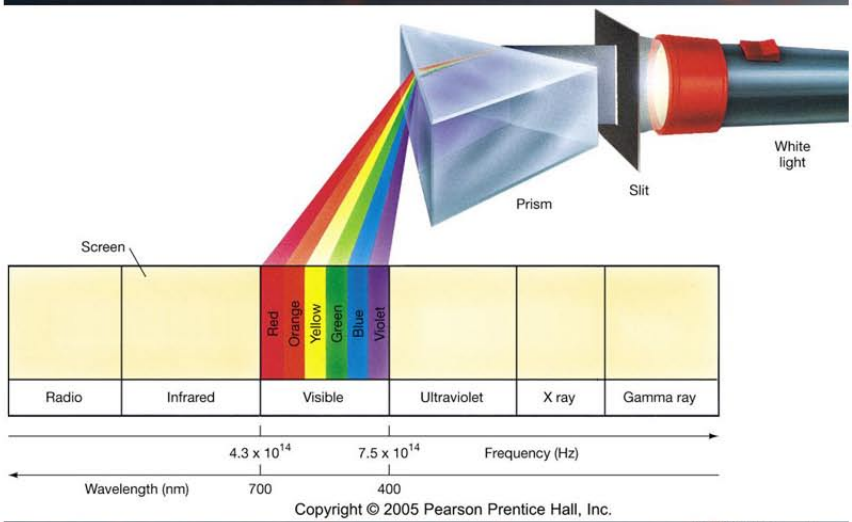
- $\lambda \nu = c$
- photon energy $E = h \nu = h c / \lambda$

THE SPECTRUM



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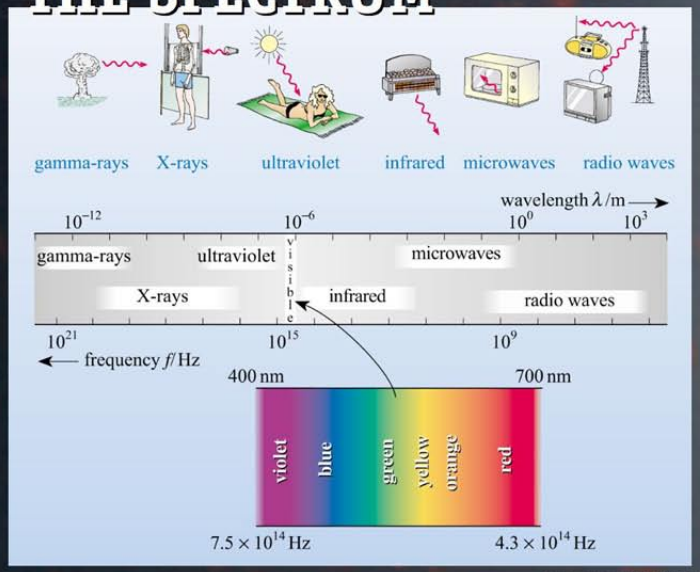
THE SPECTRUM



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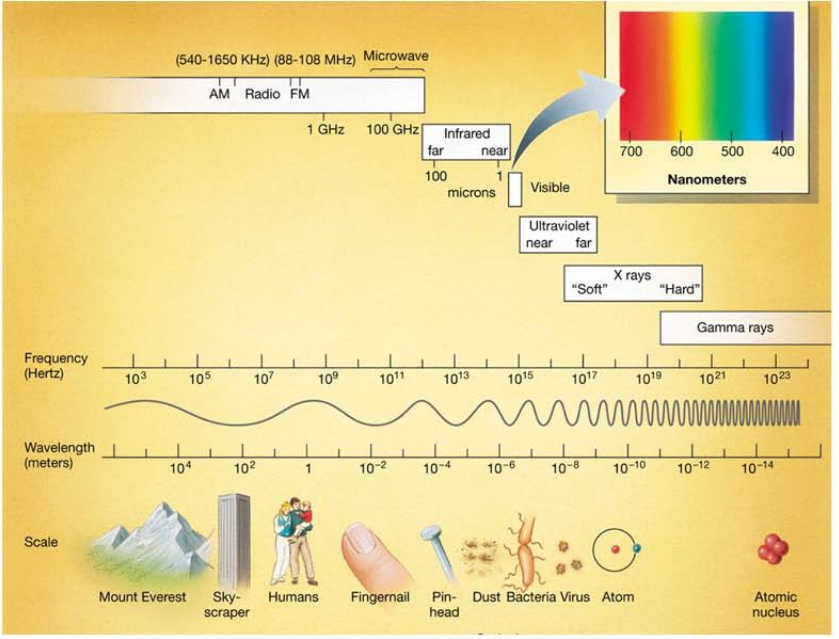
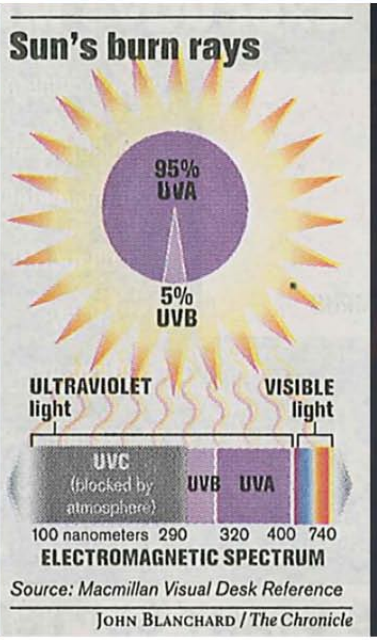


MENTAL EXERCISE

High-energy radiation (light) can damage DNA molecules in our body, causing damage such as cancer.

WHICH OF THESE TYPES OF LIGHT IS THE LEAST LIKELY TO CAUSE CANCER ?

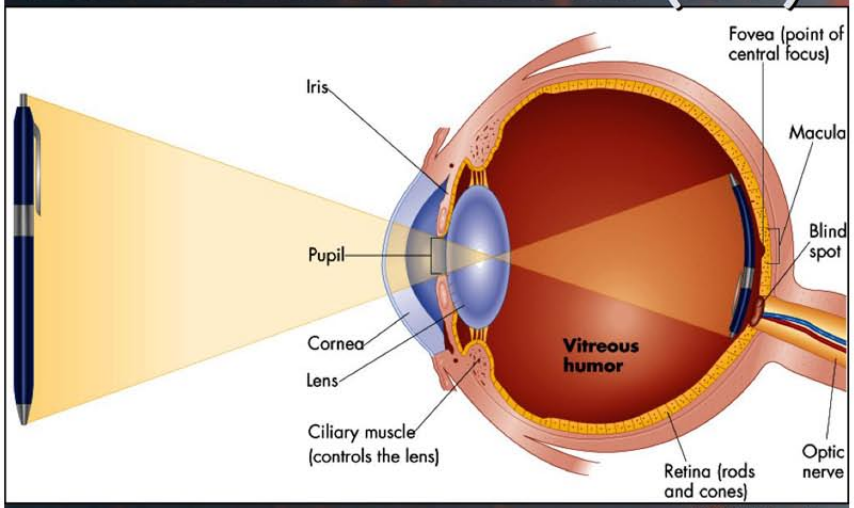
A. ultraviolet A (350 nm)
B. ultraviolet C (200 nm)
C. radio (100 cm)
D. x-ray (1 Å)



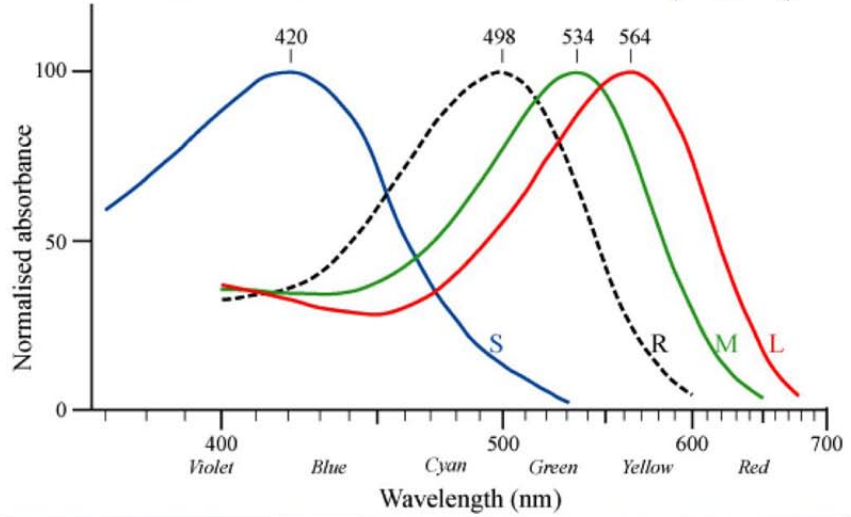
UV in the news

- ultraviolet is at shorter wavelengths than visible light
- UVC blocked by ozone layer

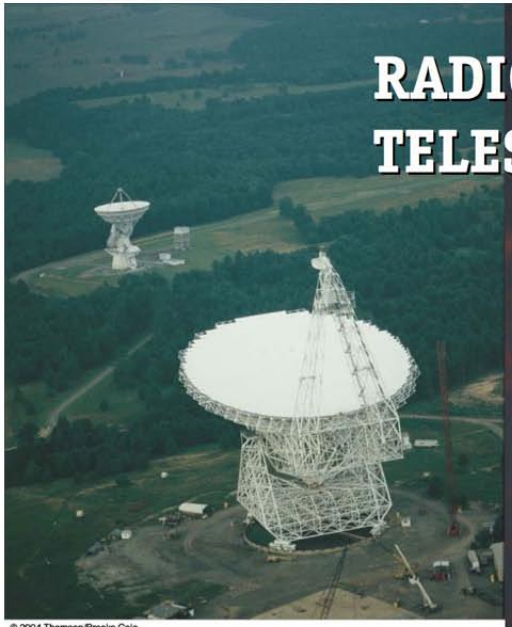
VISIBLE LIGHT SENSOR (EYE)



VISIBLE LIGHT SENSOR (EYE)



RADIO TELESCOPES



Green Bank WV

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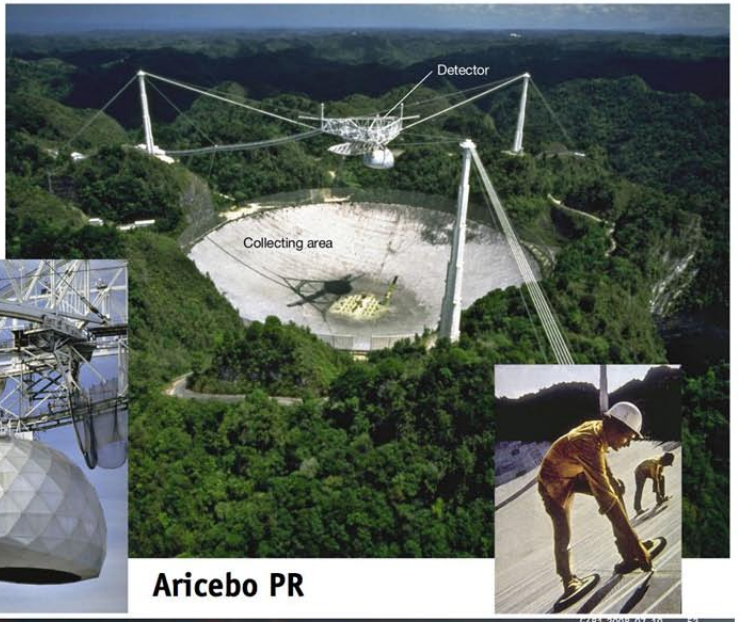


Aricebo PR

RADIO INTERFEROMETRY

Very Large Array (VLA) in NM

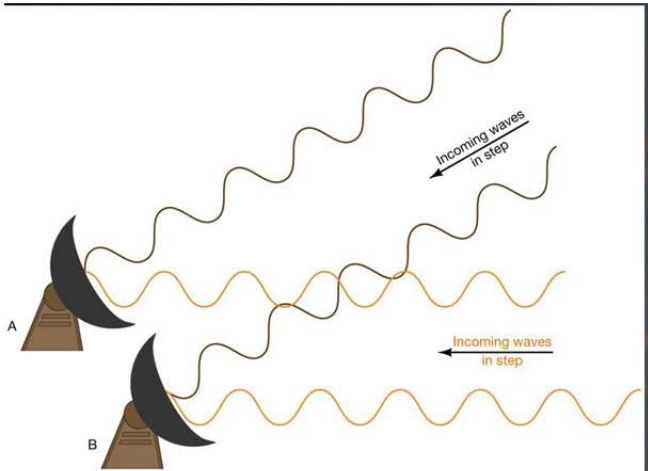
RADIO INTERFEROMETRY

ANGULAR RESOLUTION:

0.002 λ / D
(wavelength in Å, diameter in cm)

2000 λ / D
(wavelength in cm, diameter in m)

Very Large Baseline Array (VLBA)



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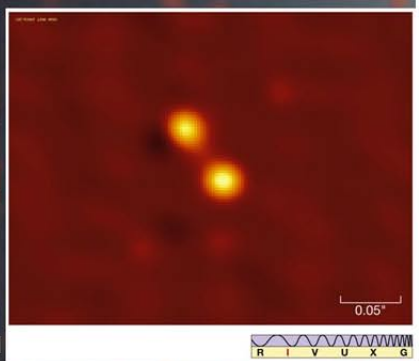
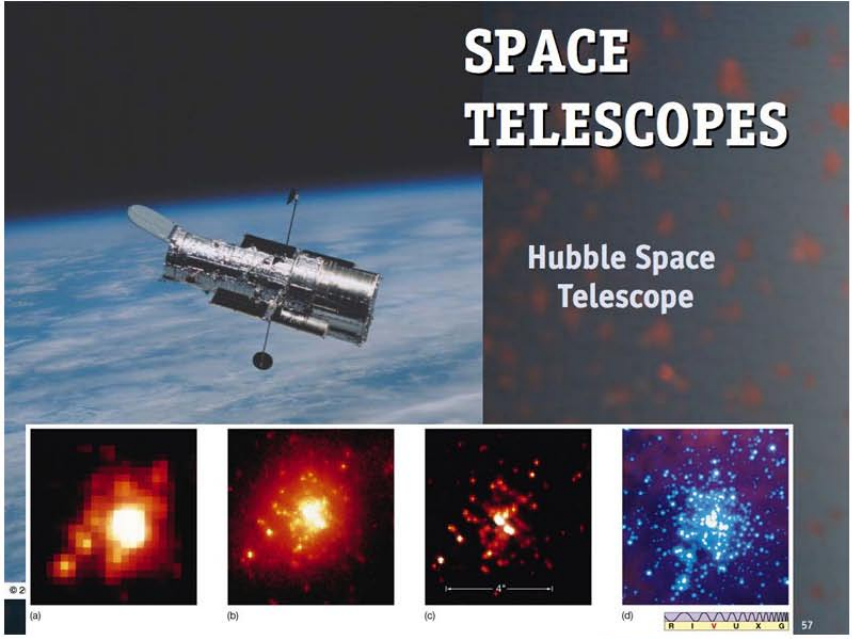
OPTICAL / IR INTERFEROMETRY

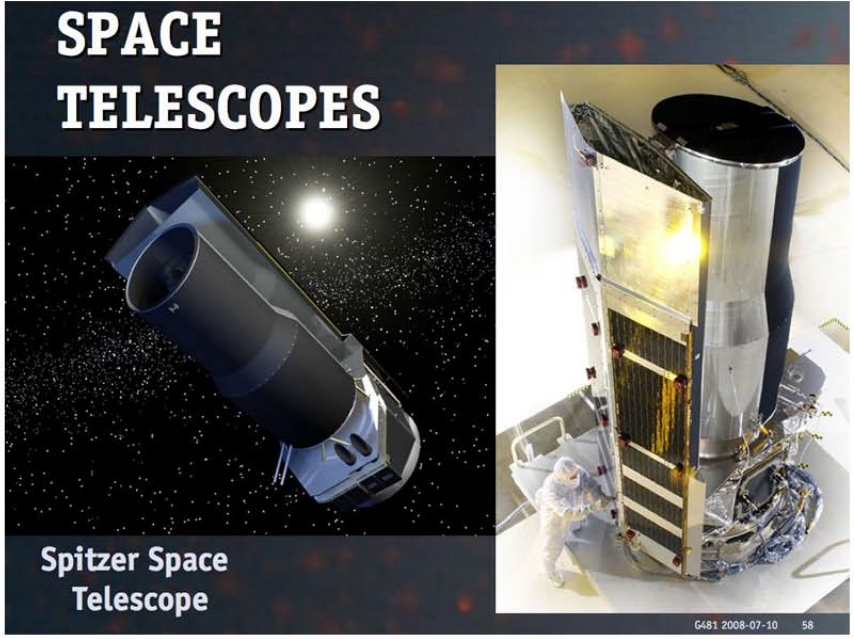


Very Large Telescope

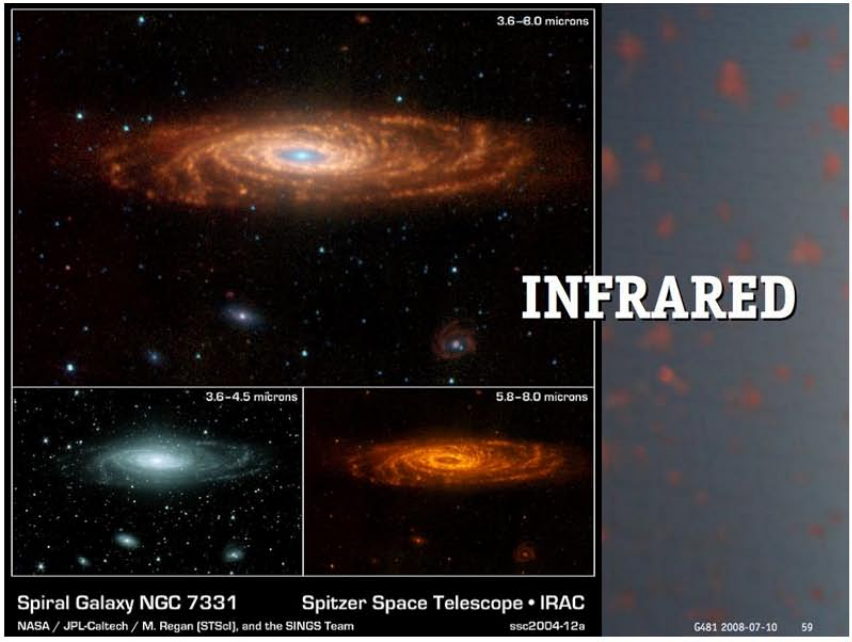
SPACE TELESCOPES



SPACE TELESCOPES



INFRARED



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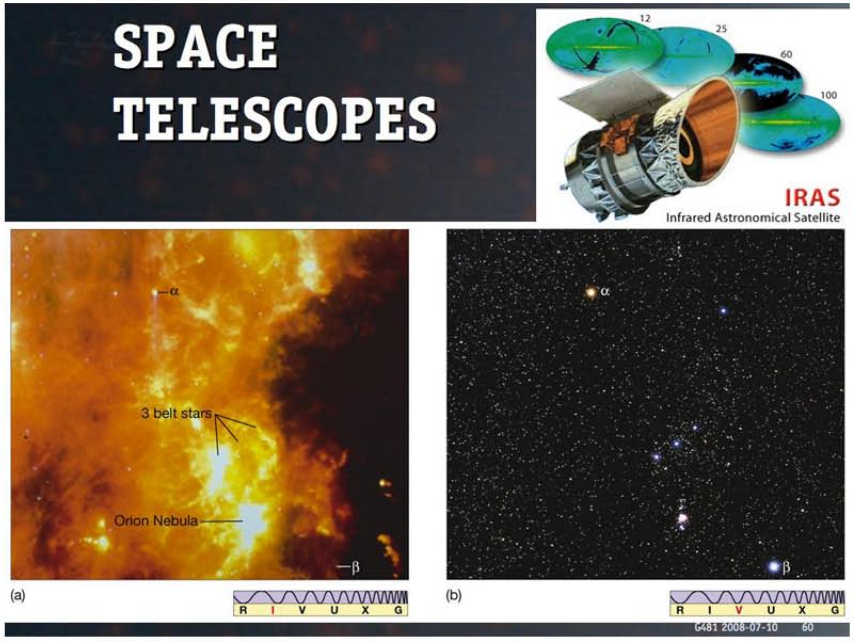
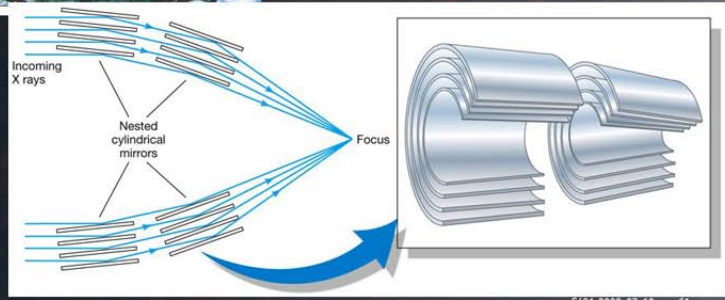


SPACE TELESCOPES

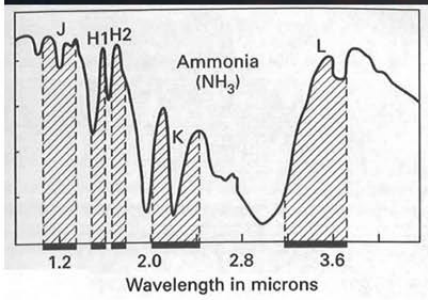
Chandra X-ray Observatory

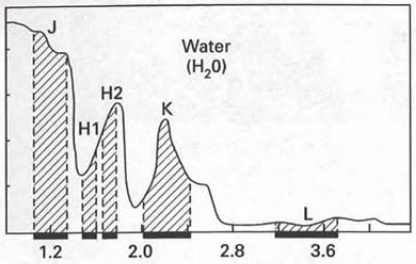


FILTERS

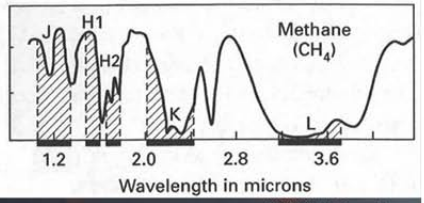
- filters for WFC3 camera to be installed on the final Hubble servicing mission, October 2008

FROST SPECTRA





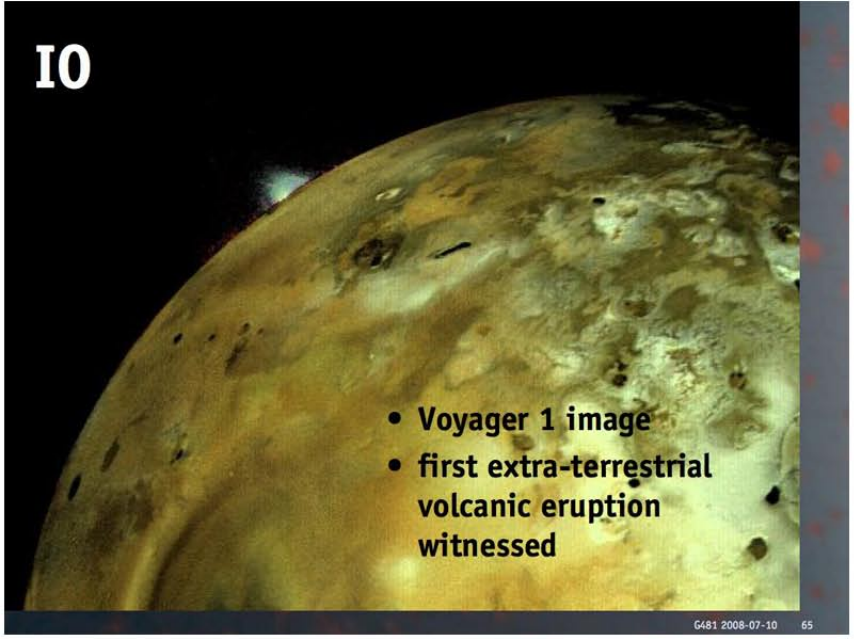
- when compared to Pluto's reflectivity, CH4 gave a good match



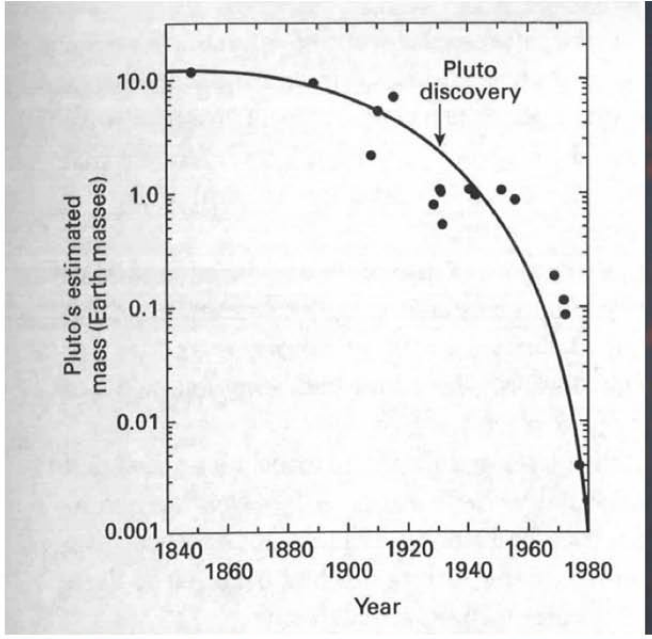
TITAN

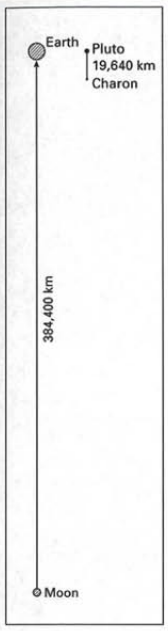
- Cassini/Huygens mission images
- Spectra obtained with infrared photographic film identified methane (CH_4) in 1944

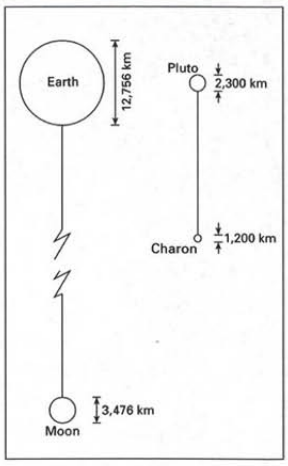
IO

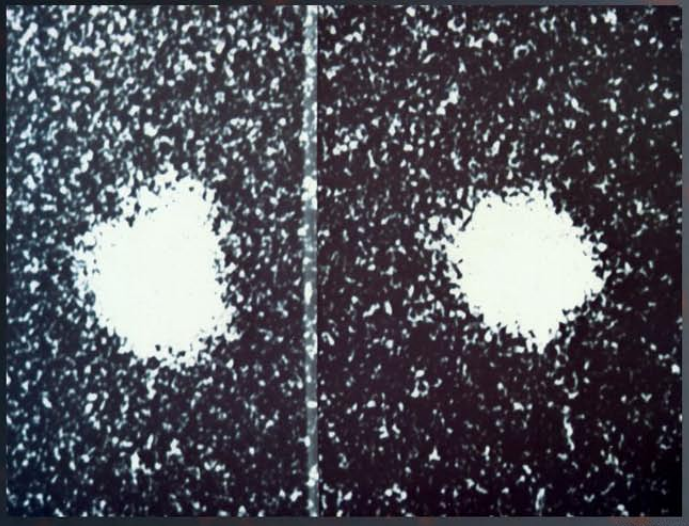


- Voyager 1 image
- first extra-terrestrial volcanic eruption witnessed







A "DOUBLE PLANET"

DISCOVERY OF CHARON