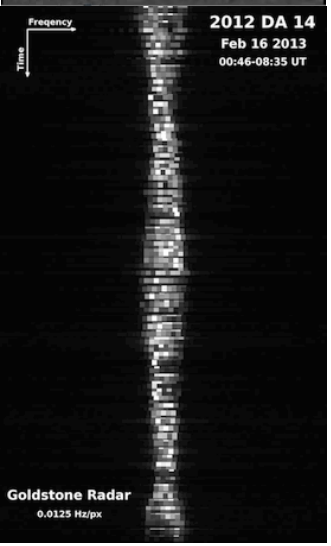
DSN as a Ground(-Space) Observatory



Solar System Radar

Unique solar system science; provides support to most planetary missions, Exploration, NEO Program

Radio Science

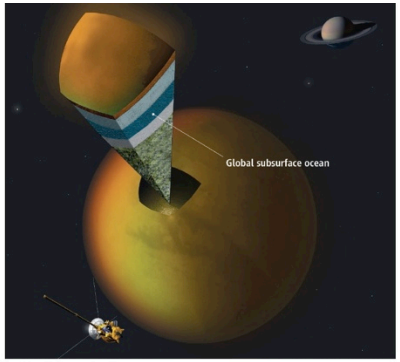
Science measurements on most planetary missions

Astronomy

Radio telescopes for mission science enhancement and international peer-reviewed proposals

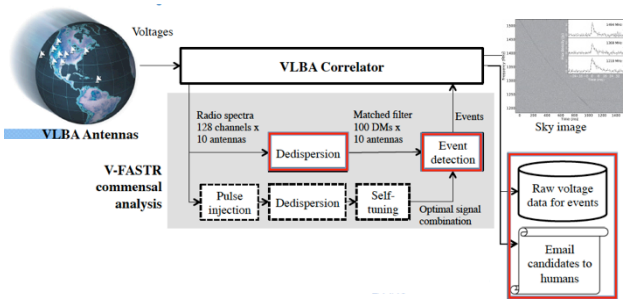
Education and Outreach

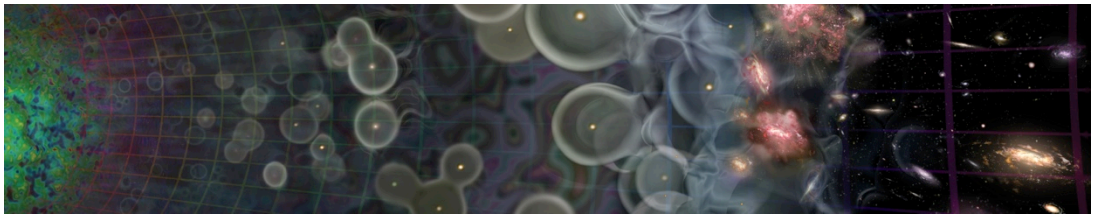
Scientists engaging with students and public



PLANETARY SCIENCE

Cassini Spies an Ocean Inside Saturn's Icy, Gassy Moon Titan



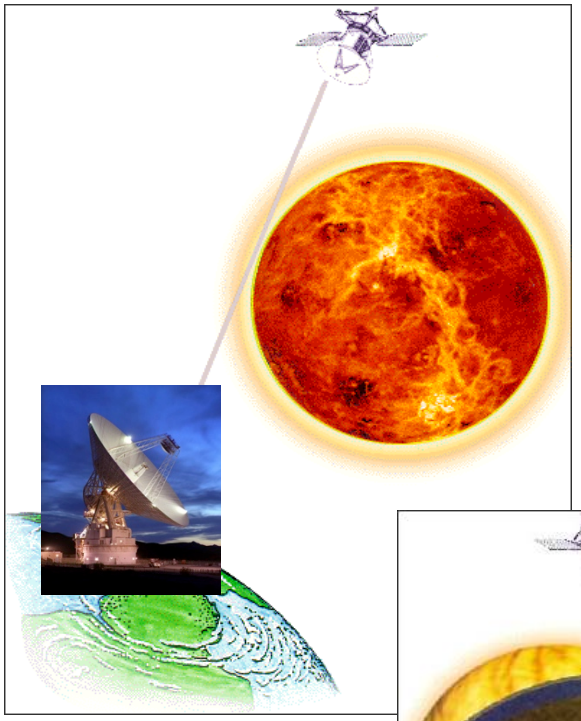


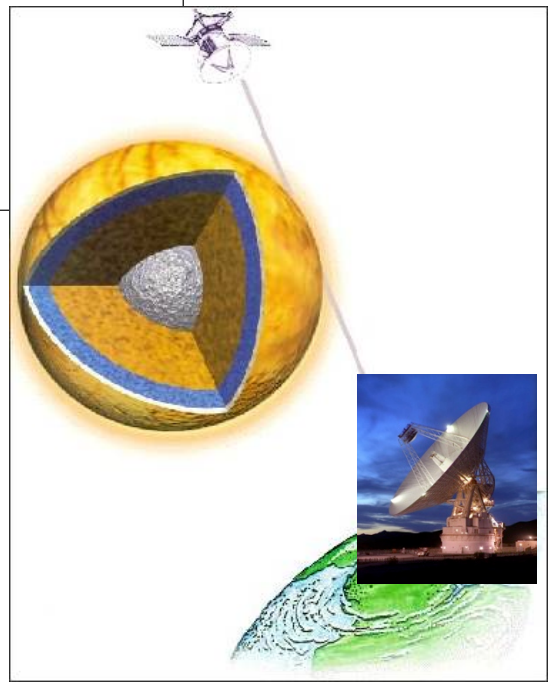
Radio Science

Apparent even with early missions that occultations by planetary atmospheres would affect the quality of radio communications

- **Mio dio! Tragedy!**
- **Or … one person's annoyance is another's data --- Study the atmospheric properties!**
- **Can also study planetary interior!**

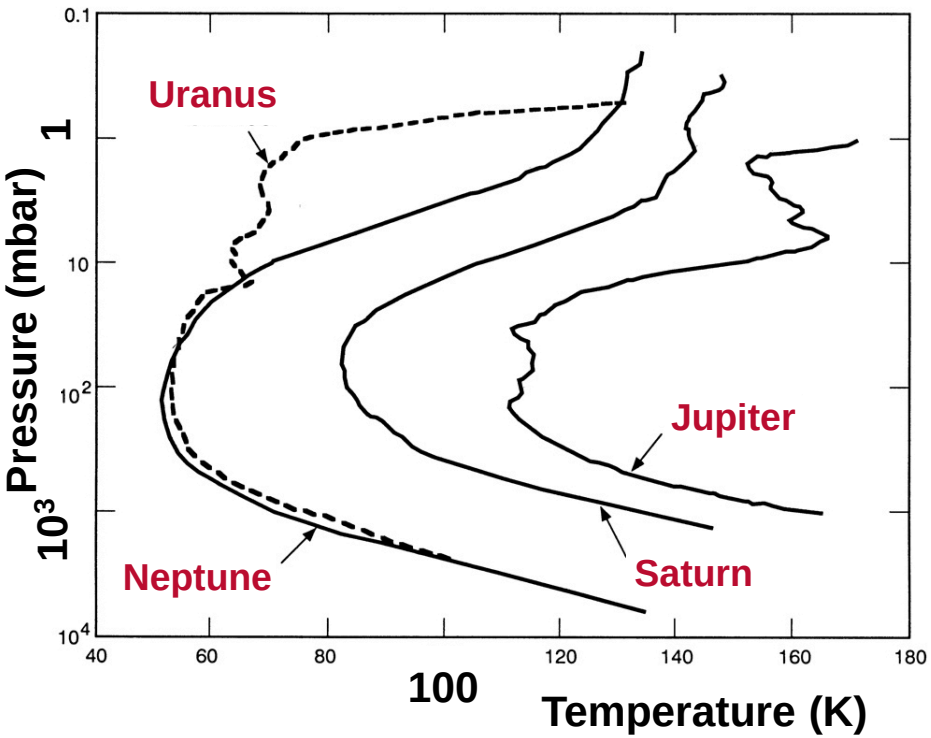
➢ **Turn the DSN+spacecraft into one giant science instrument**

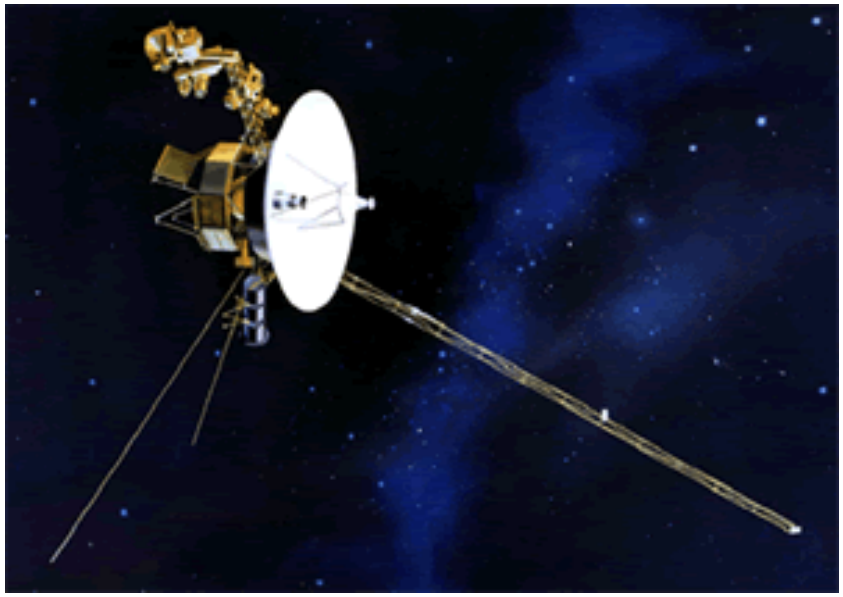




Radio Science

Giant Planet Atmospheres



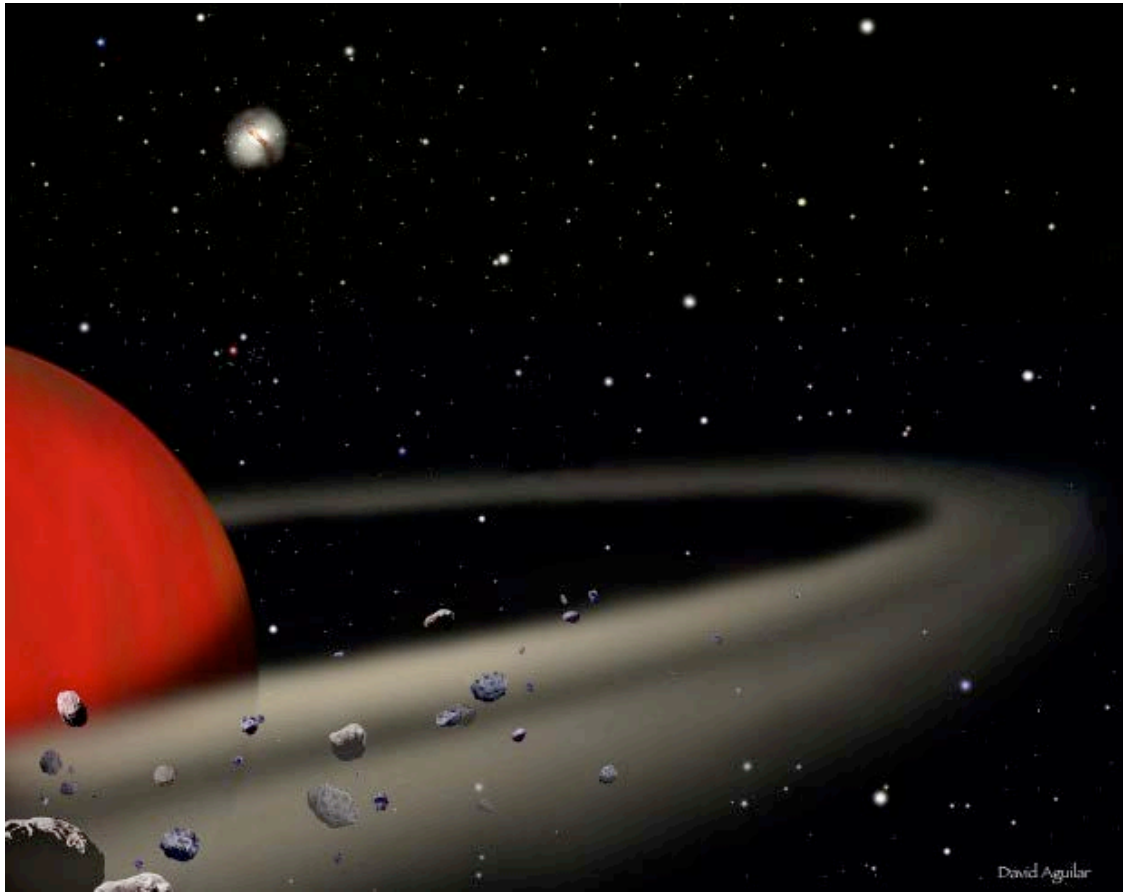


Temperature-Pressure profiles of the outer planets from Voyager single flybys

(Lindal 1992)

Radio Science

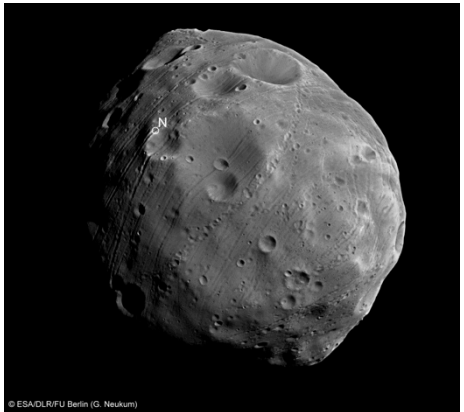
Interiors of Moons: Phobos



DSN-Mars Express radio science measurements

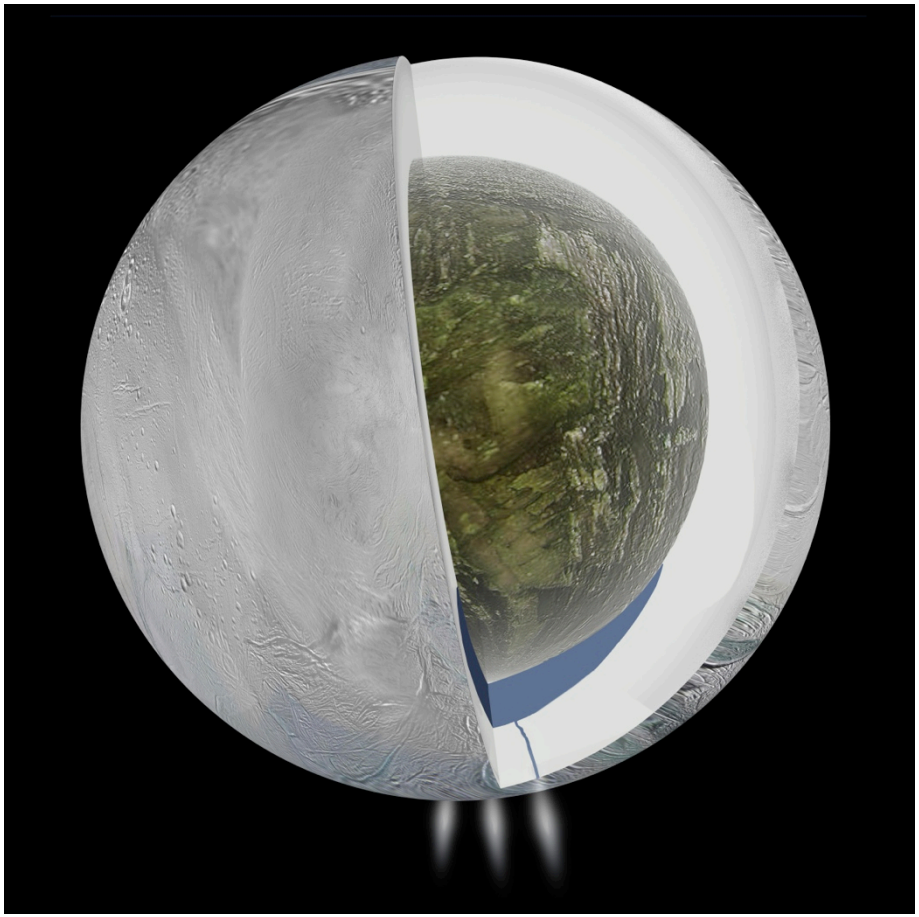
- **Bulk density (considerably) lower than "solid" bodies**
- **Lots of "gaps" inside (a.k.a. "high porosity")**

➢ **Phobos formed in place or captured?**



Radio Science

Interiors of Moons: Enceladus



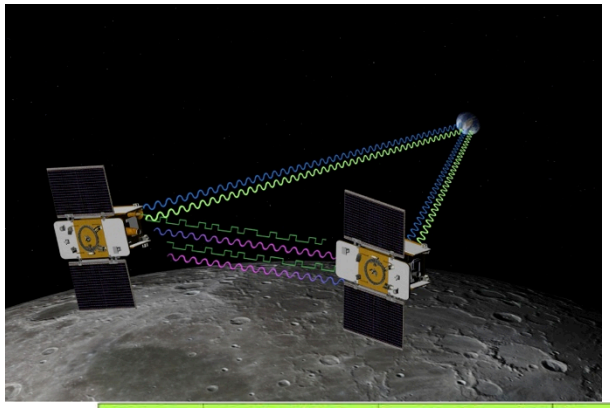
- ***Cassini*** **previously sampled jets of water spewing from south pole**
- **DSN-*Cassini* radio science measurements confirm sub-surface ocean**
  - **Another possible habitat in the solar system?**
    - **Viz. Europa**

Oceans of the Solar System

Europa, Enceladus, Titan, …

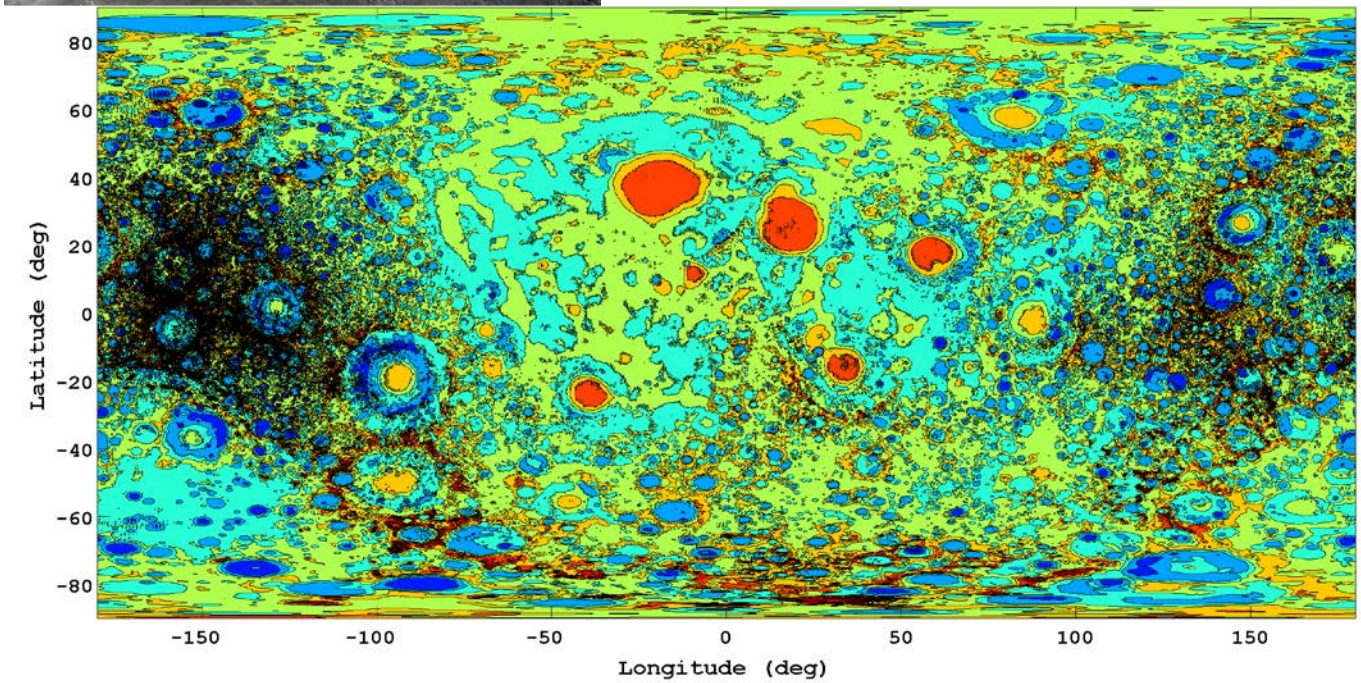
Radio Science

Interiors of Moons: Earth's Moon



GRAIL mission made precise measurements of separation between two spacecraft orbiting the Moon

- **Changes in separation due to acceleration of one of the spacecraft**

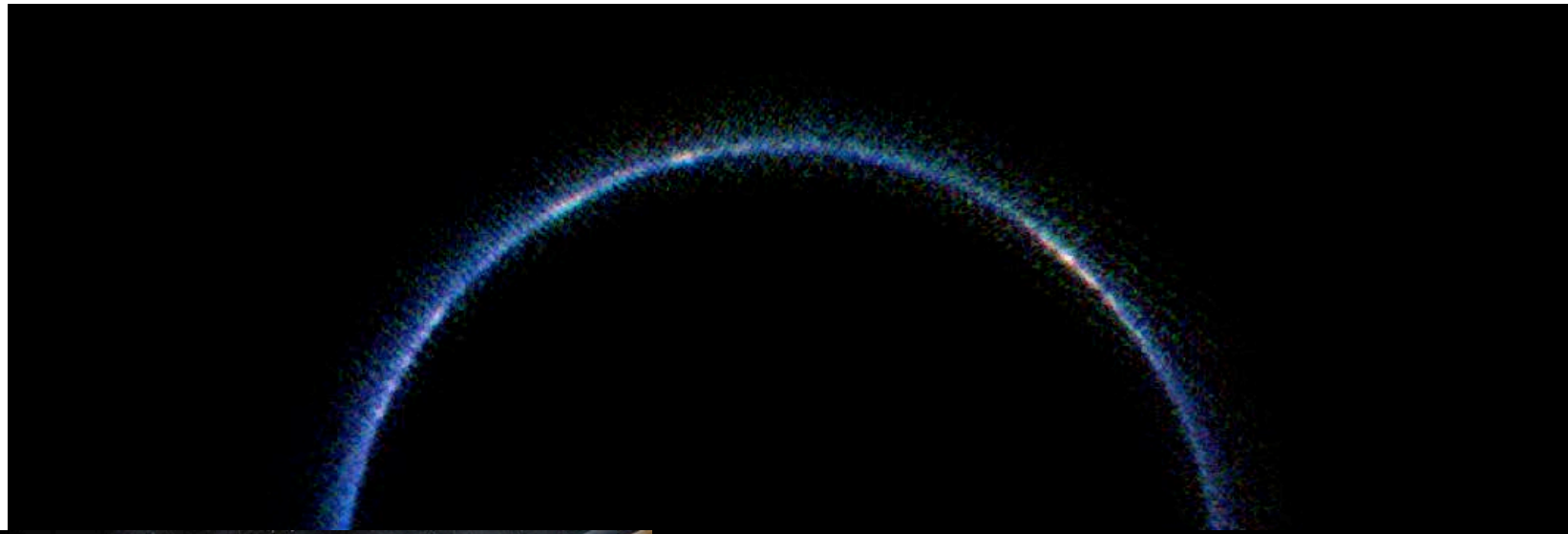


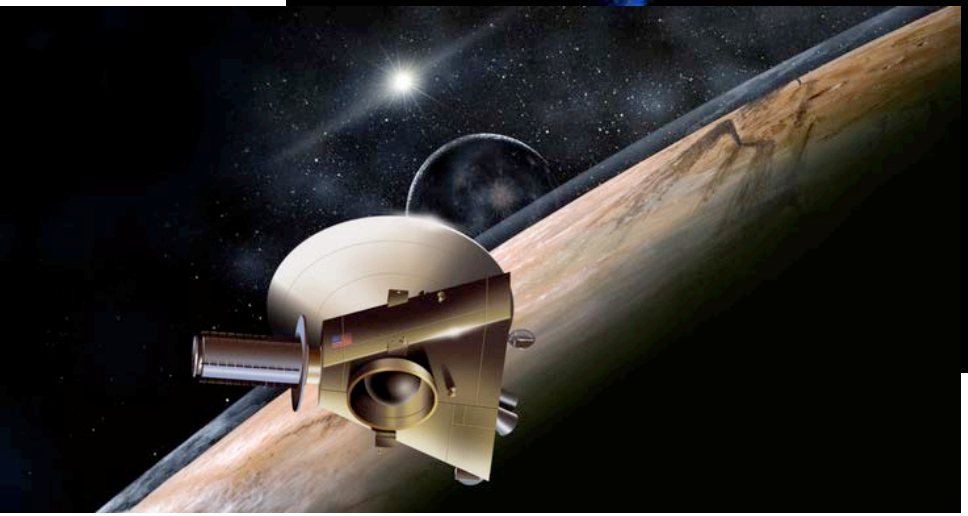
- **Changes in acceleration result from changes in mass along spacecraft trajectory …**

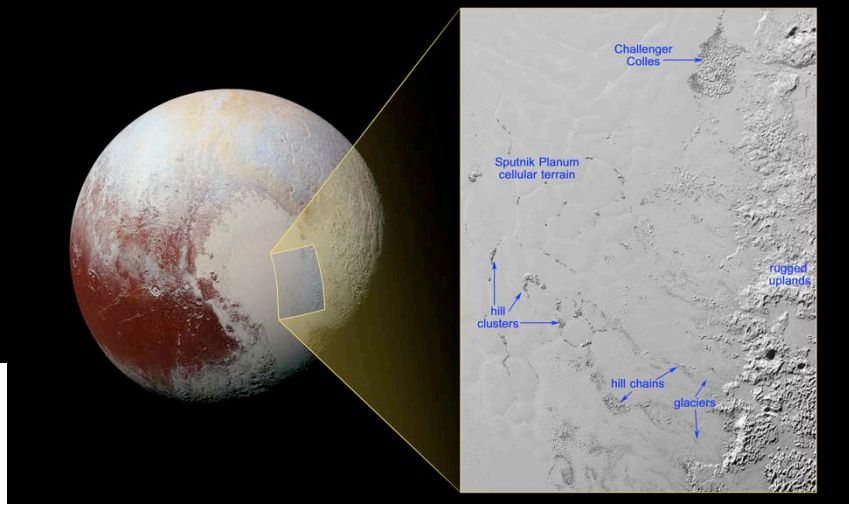
➢ **Radio Science between spacecraft, in addition to links to DSN**

DSN-REX

New Horizons

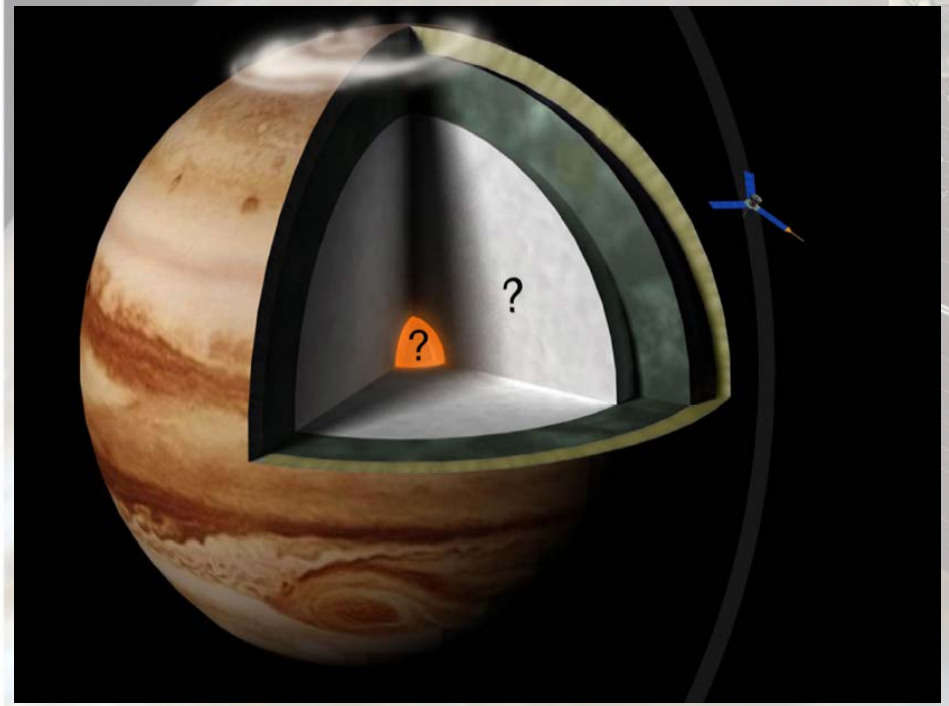






Radio Science

Giant Planet Interiors: Juno at Jupiter



Juno Gravity Science

- **Precise measurement of spacecraft motion (Doppler) measures gravity field**
- **Close-in Juno polar orbit maximizes sensitivity to gravity**
- **Distribution of mass reveals core and deep structure**
- **Higher degree harmonics reveal convective motion in deep atmosphere**