Planetary Science with SPICA

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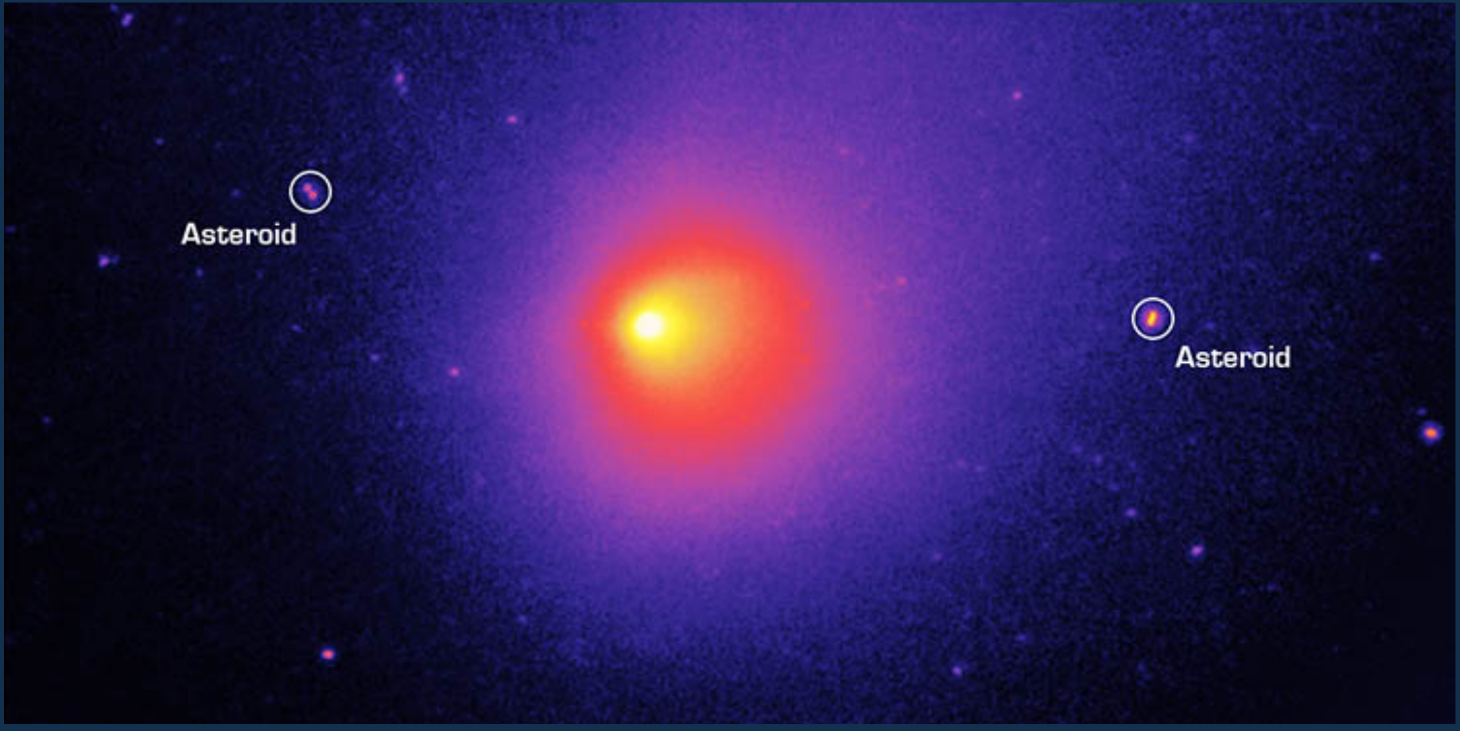
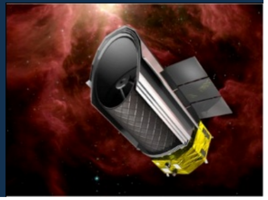


IR Space telescopes vs Planetary Science (1)

- For IR space telescopes such as ISO, Spitzer, Hubble Space Telescope, Herschel, Planetary science issues are usually a secondary goal
- Usually large main belt asteroids are observed as “photometric calibrators”
- Nevertheless, high number of publication in high impact factor Journals (1988-2012: 420 papers)
- Many outstanding results were obtained

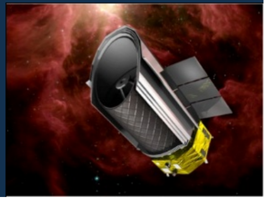
SPICA
Space Infrared Telescope for Cosmology and Astrophysics



IR Space telescopes vs Planetary Science (2)

- MB asteroids, Centaurs and Trans neptunians science
  - Spitzer 51, HST 62, Herschel 15, ISO 17
- Comets study
  - Spitzer 33, HST 82, Herschel 7, ISO 13
- Dust ring discoveries and analysis
  - Spitzer 1, HST 14
- Giant planet Atmospheres study
  - Spitzer 1, HST 110, Herschel 5, ISO 10

Space Infrared Telescope for Cosmology and Astrophysics

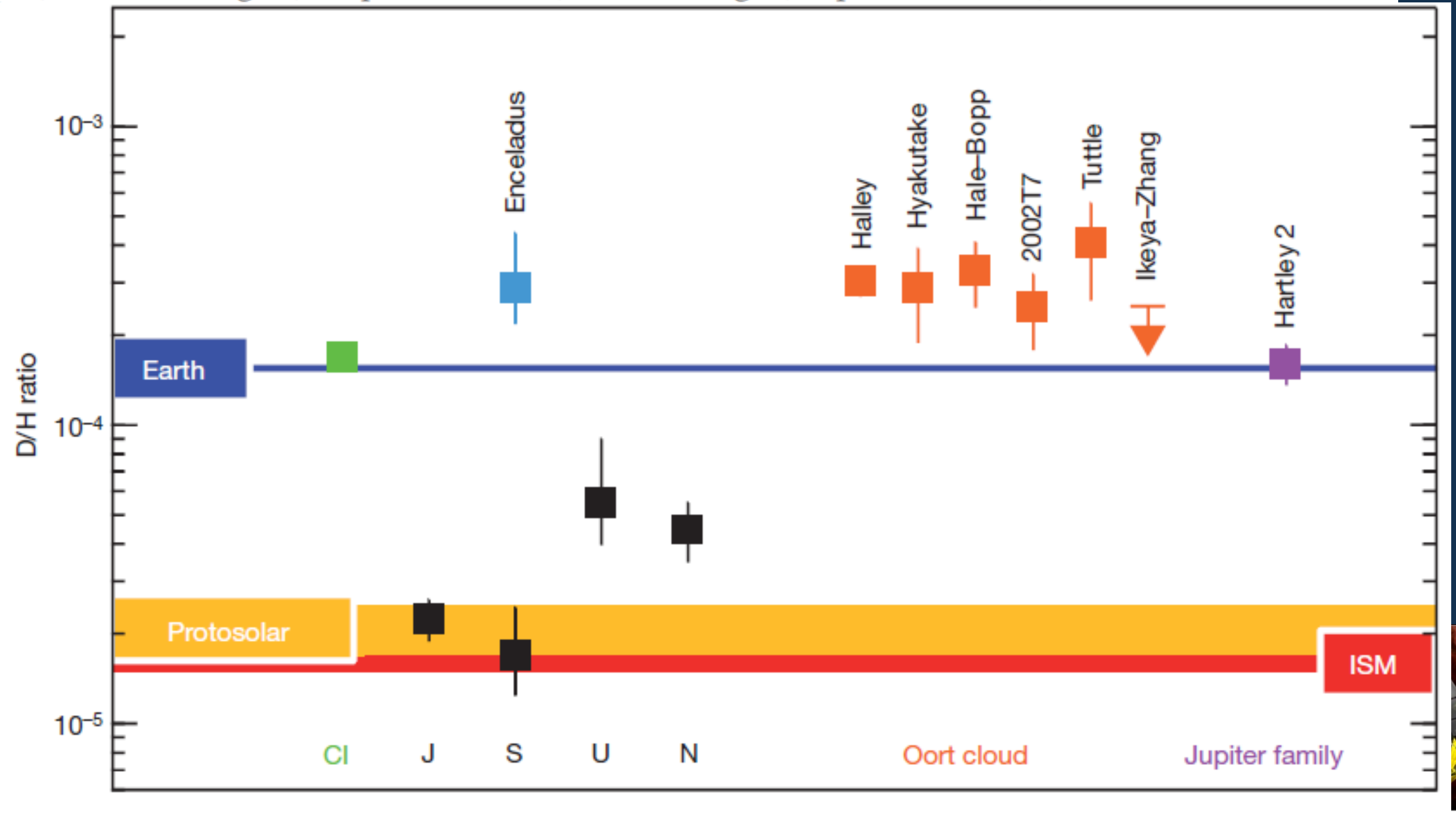


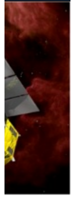
LETTER Nature 2011 41 citations

doi:10.1038/nature1

Ocean-like water in the Jupiter-family comet 103P/Hartley 2

Paul Hartogh[1], Dariusz C. Lis[2], Dominique Bockelée-Morvan[3], Miguel de Val-Borro[1], Nicolas Biver[3], Michael Küppers[4], Martin Emprechtinger[2], Edwin A. Bergin[5], Jacques Crovisier[3], Miriam Rengel[1], Raphael Moreno[3], Slawomira Szutowicz[6] & Geoffrey A. Blake





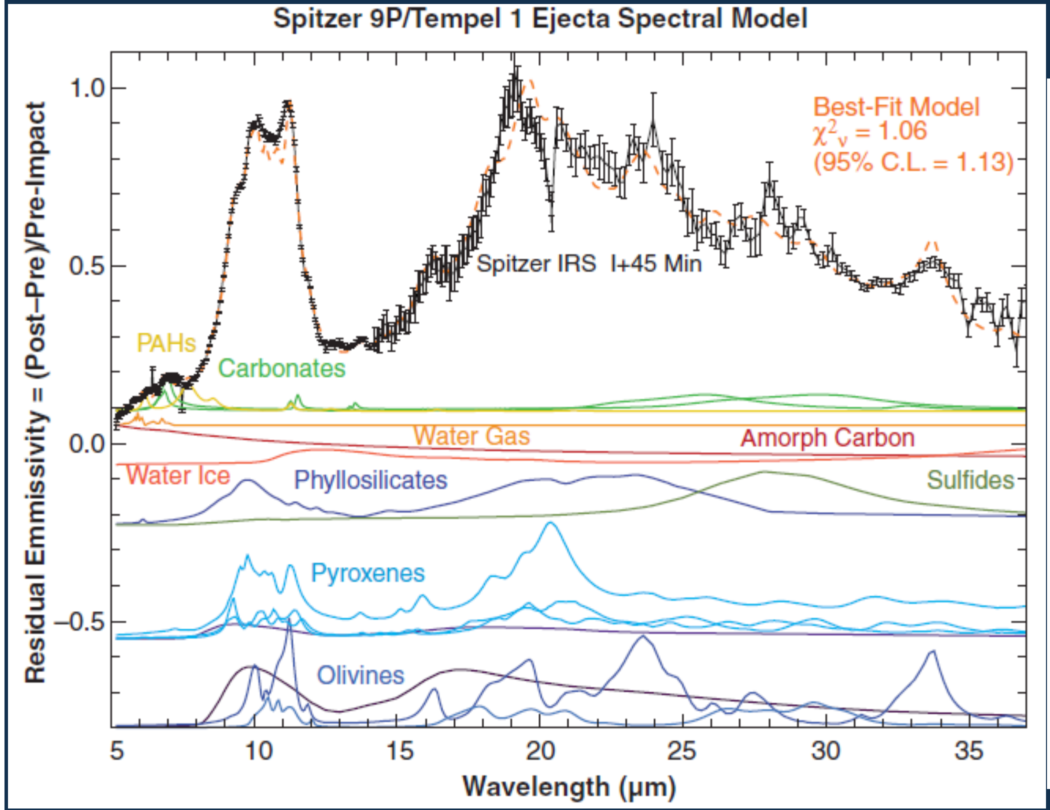
Space Infrared Telescope for Cosmology and Astrophys

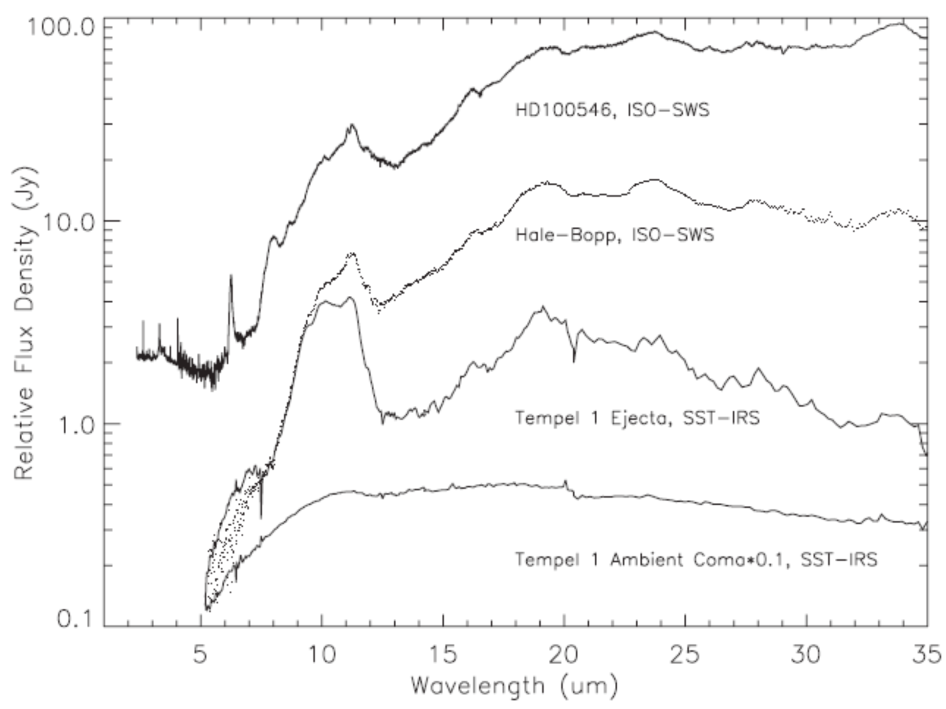
Spitzer Spectral Observations of the Deep Impact Ejecta

Science 2006

146 citations

C. M. Lisse,[1,2]* J. VanCleve,[3] A. C. Adams,[3] M. F. A'Hearn,[2] Y. R. Fernández,[4] T. L. Farnham,[2]
L. Armus,[5] C. J. Grillmair,[5] J. Ingalls,[5] M. J. S. Belton,[6] O. Groussin,[2] L. A. McFadden,[2]
K. J. Meech,[7] P. H. Schultz,[8] B. C. Clark,[9] L. M. Feaga,[2] J. M. Sunshine[2]

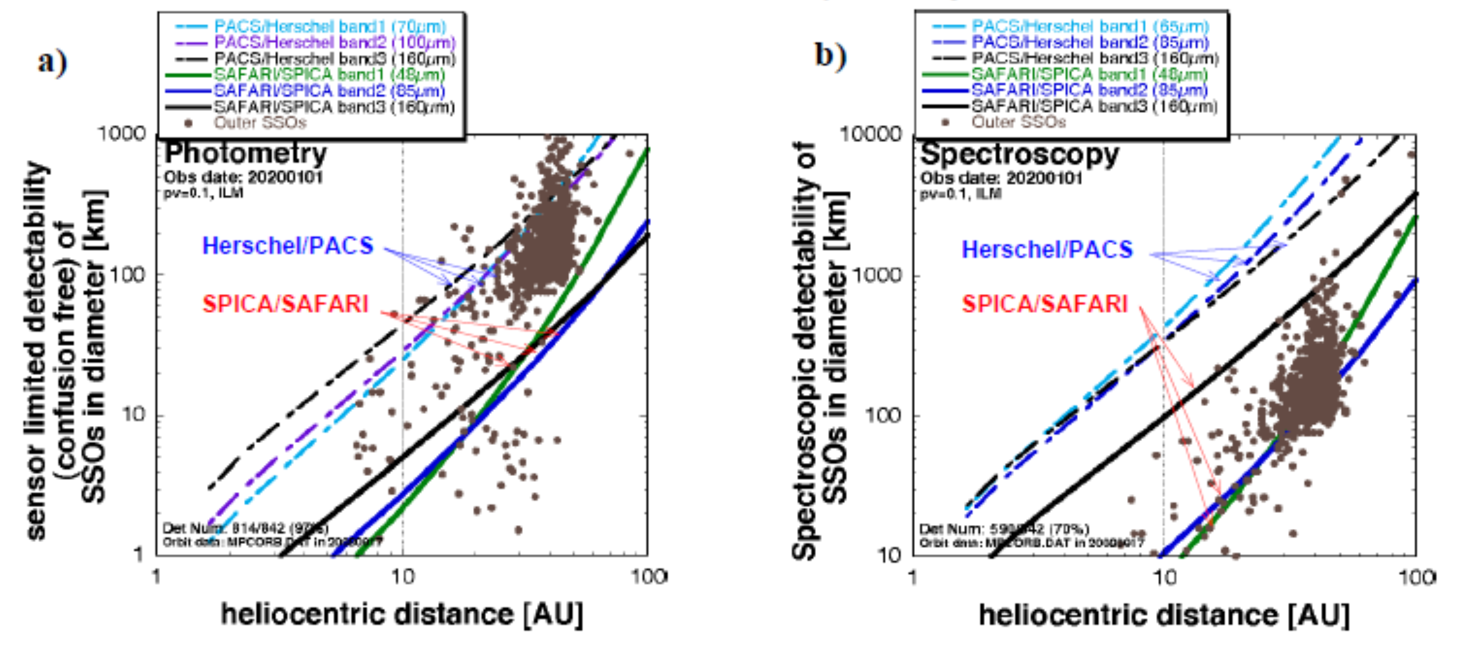




Spica vs Planetary Science (1)

Planetary science is a primary science goal especially the Kuper Belt Object investigation

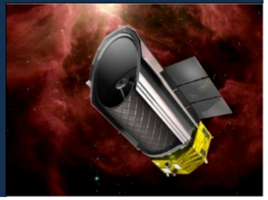
- Detection of almost all known KBOs (those with diameters > 100 km) in only ~ 50 hr
- Detection of bodies as small as ~ 10 km
- KBO Spectroscopy



Spica vs Planetary Science (2) Scientific objectives improvement

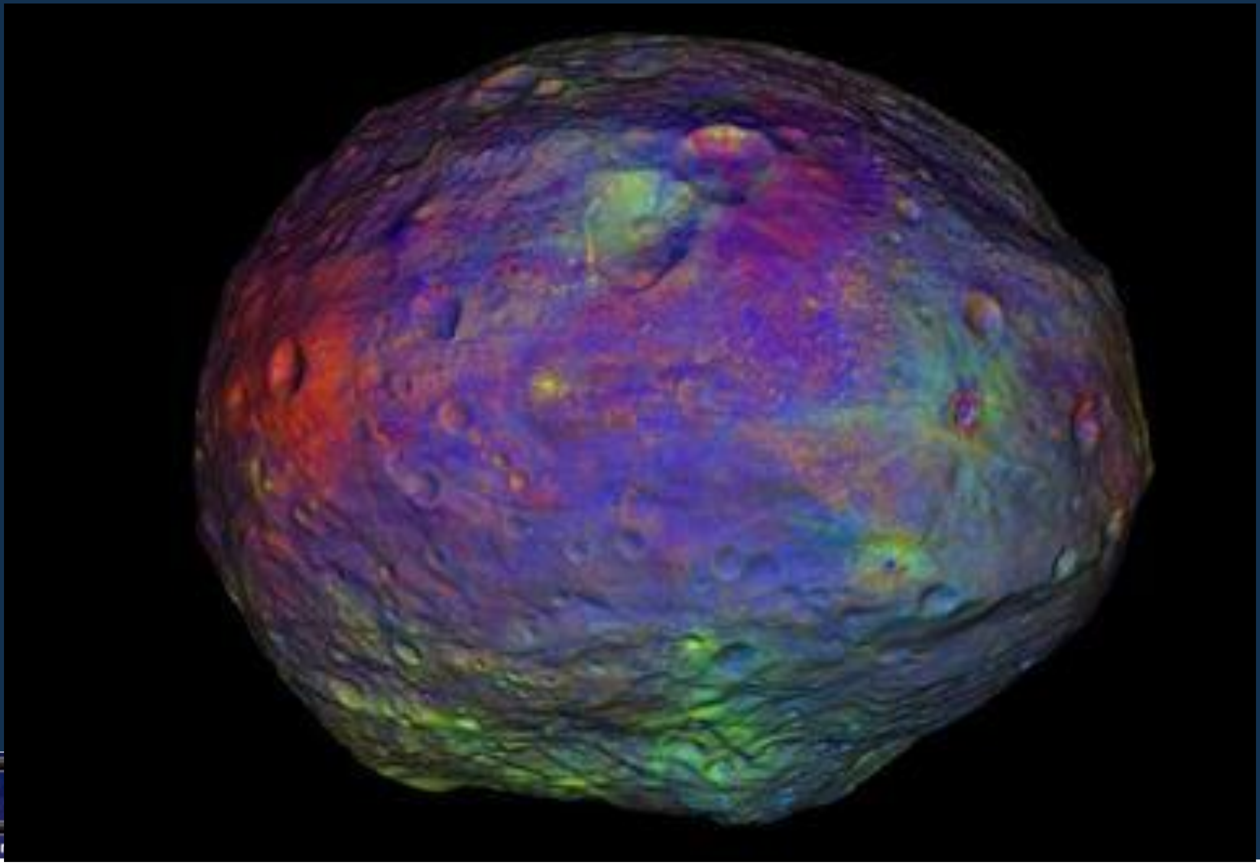
- MB asteroids, Centaurs and Trans neptunian science
  - Surface mineral composition, physical (e.g. size, mass, orbital parameters, albedo) and thermal properties (inertia, beaming factor)
- Comets study
  - Coma, tail, nucleus and ejecta investigations
  - dust mineral composition
  - Volatiles degassing rate
  - Gas isotopic ratios
- Dust ring discoveries and analysis
  - Saturn and Jupiter ring, discovery of new dust ring/torus (e.g. Mars)
- Giant planet Atmospheres study
  - Search for minor organic species (Uranus, Neptune)

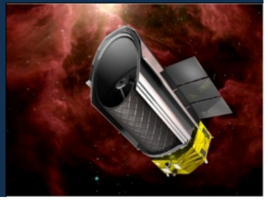
Space Infrared Telescope for Cosmology and Astrophysics



SPICA future observations: three examples

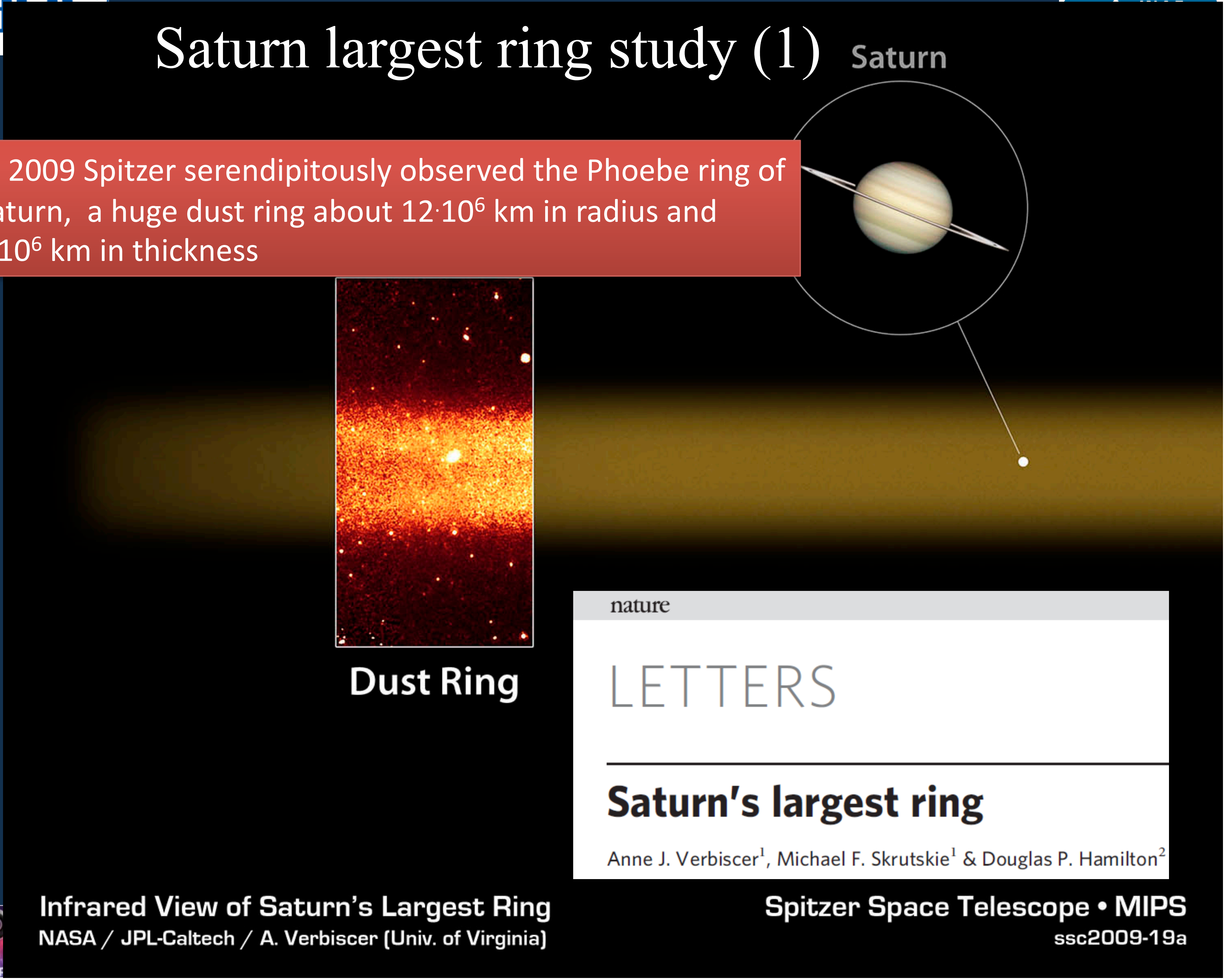
1. Saturn largest ring study
2. Vesta investigations
3. Martian dust torus detection & study





Saturn largest ring study (1)

In 2009 Spitzer serendipitously observed the Phoebe ring of Saturn, a huge dust ring about $12 \cdot 10^6$ km in radius and $3 \cdot 10^6$ km in thickness



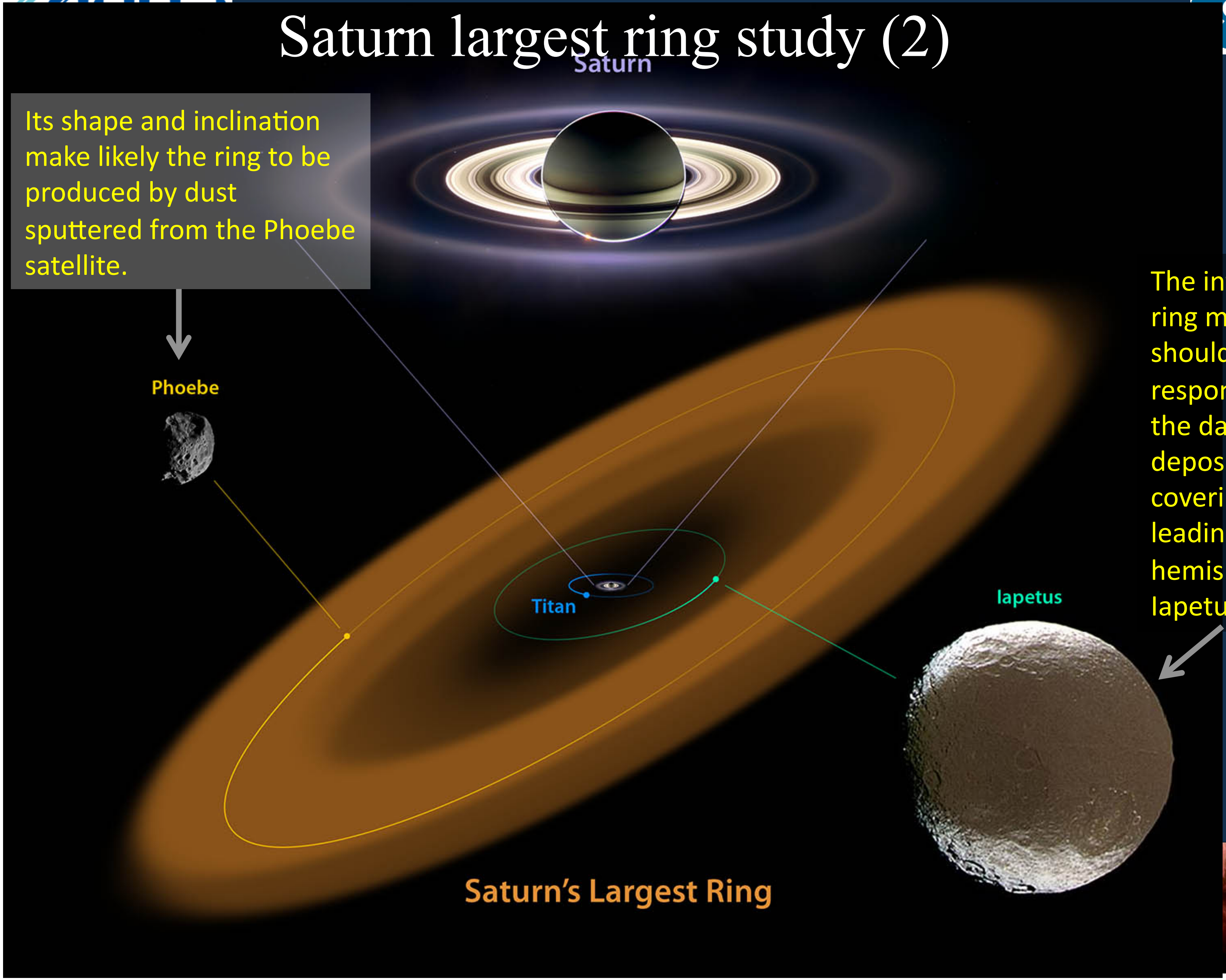
nature

LETTERS

Saturn's largest ring

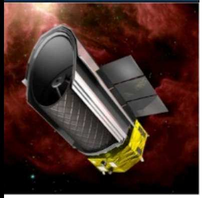
Anne J. Verbiscer[1], Michael F. Skrutskie[1] & Douglas P. Hamilton[2]

Saturn largest ring study (2)

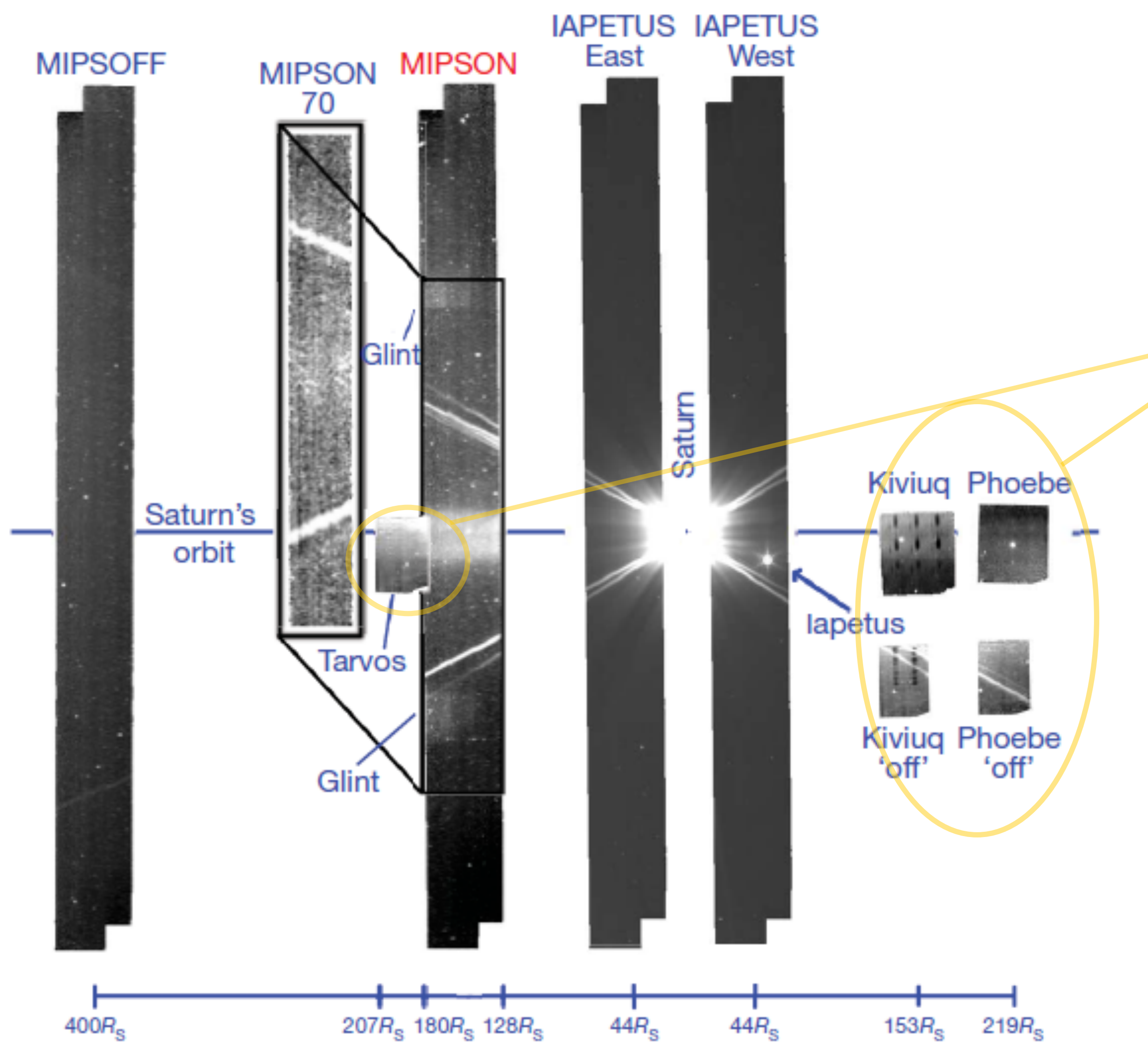


Its shape and inclination make likely the ring to be produced by dust sputtered from the Phoebe satellite.

The infall of ring material should be responsible of the dark deposits covering the leading hemisphere of Iapetus.



Saturn largest ring study (3)



MIPS indipendent observations

Saturn largest ring study (4)

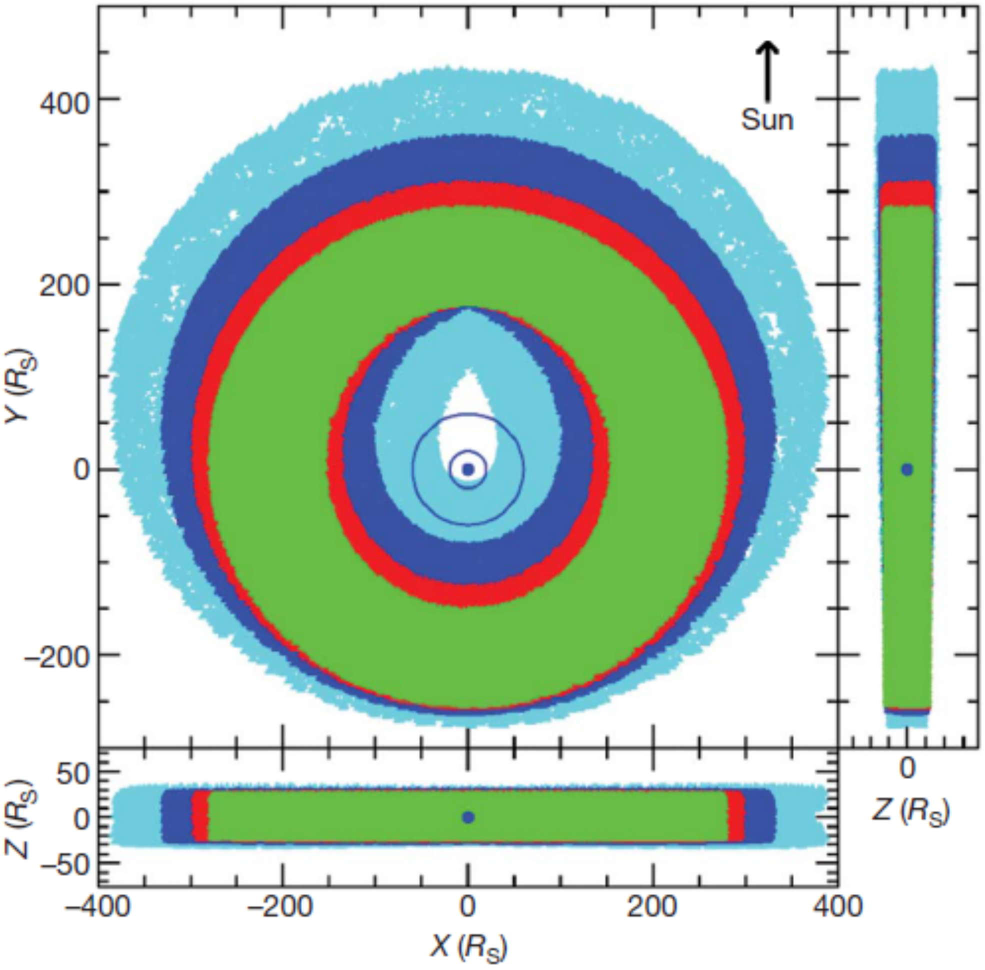
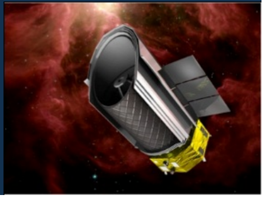
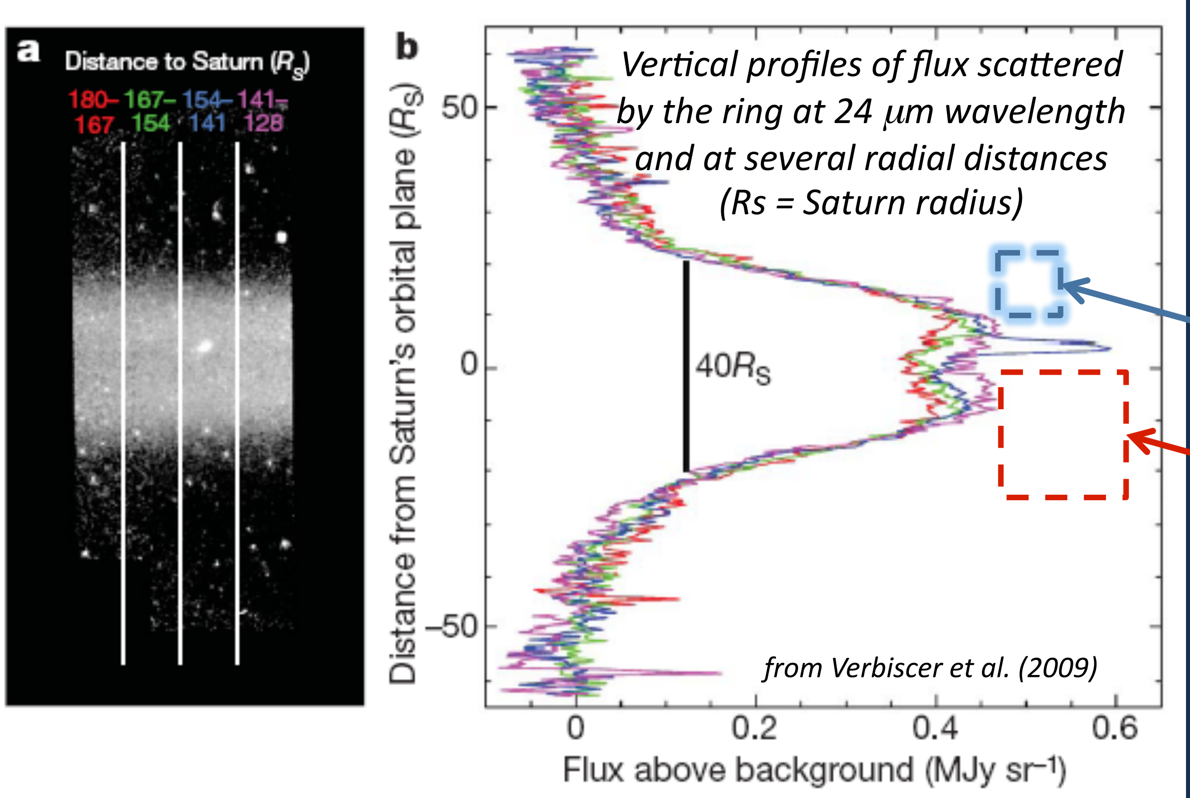


Figure 4 | The orbital distribution of dust grains launched from Phoebe followed for 2,000 years. Colours indicate particle radii in micrometres: 5 (cyan), 10 (blue), 20 (red), and 40 (green). The reference frame is centred on

The X–Y plane is Saturn's orbital plane. Circles at 20RS and 60RS denote the orbits of Titan and Iapetus, respectively. Solar radiation pressure, the dominant perturbation for small particles, forces the distribution of small grains to be azimuthally asymmetric and offset towards the Sun. Conversely, grains 40 μm and larger form a symmetric torus around Saturn. Within 15 years (half a Saturn orbit), particles smaller than 3.5 μm will strike Saturn or its rings, while those smaller than 1.5 μm will be rapidly ejected from the Saturnian system.



Saturn largest ring study (5)



Vertical profiles of flux scattered by the ring at 24 μm wavelength and at several radial distances (Rs = Saturn radius)

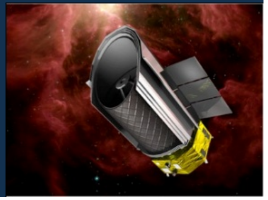
from Verbiscer et al. (2009)

SAFARI FoV: 120 arcsec ~ 14Rs

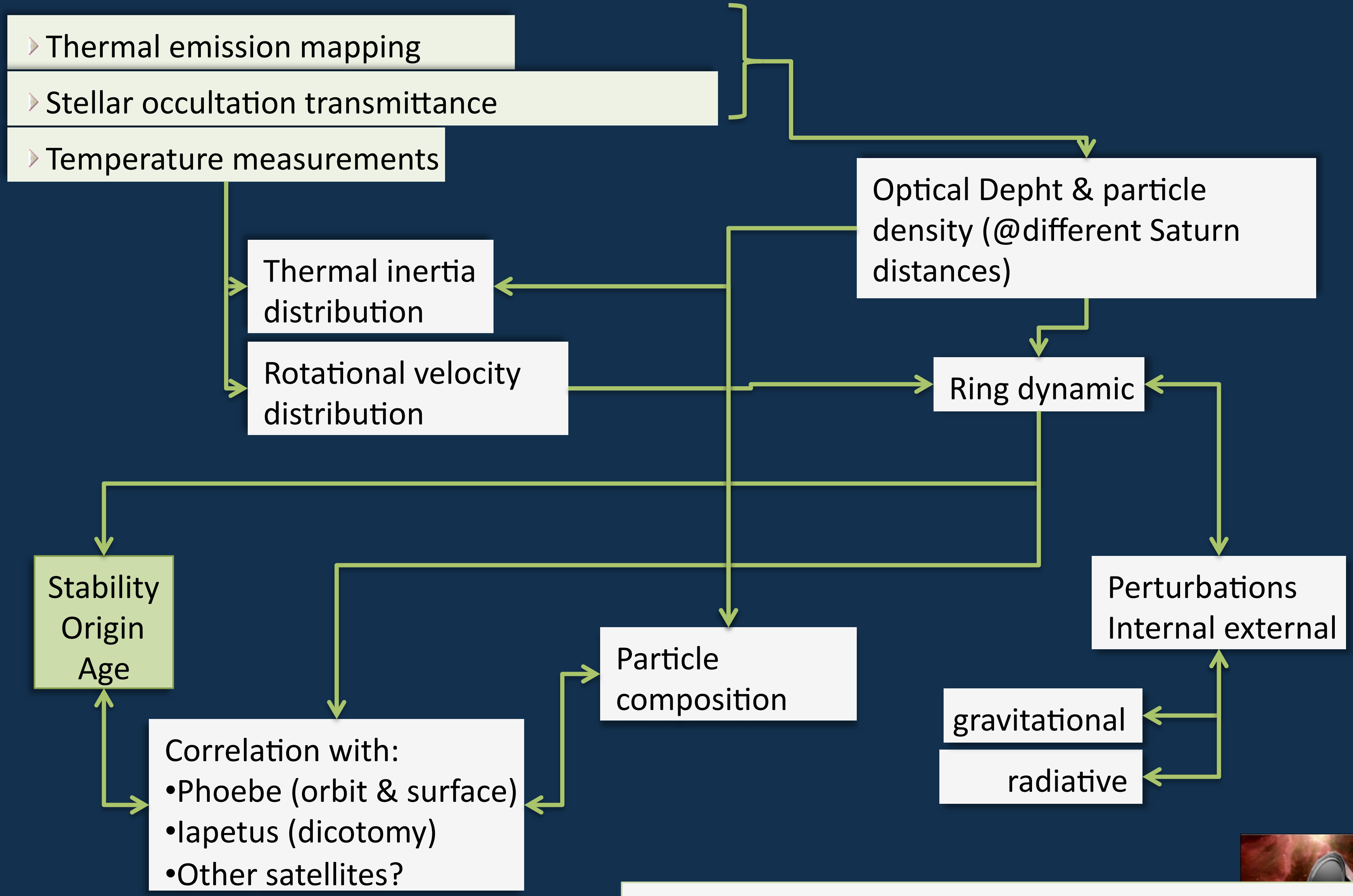
Cameras FoV: 300 arcsec ~ 34 Rs

The imager instruments proposed for SPICA should be able to sample the Phoebe ring at high resolution in its full extension…

…casting light on the grain size distribution of the ring particles and their thermal properties, better constraining their origin, their dynamical behaviour and the age of the system.



Saturn largest ring study (6)



- Thermal emission mapping
- Stellar occultation transmittance
- Temperature measurements

Optical Depht & particle density (@different Saturn distances)

Thermal inertia distribution

Rotational velocity distribution

Ring dynamic

Stability
Origin
Age

Perturbations
Internal external

gravitational

radiative

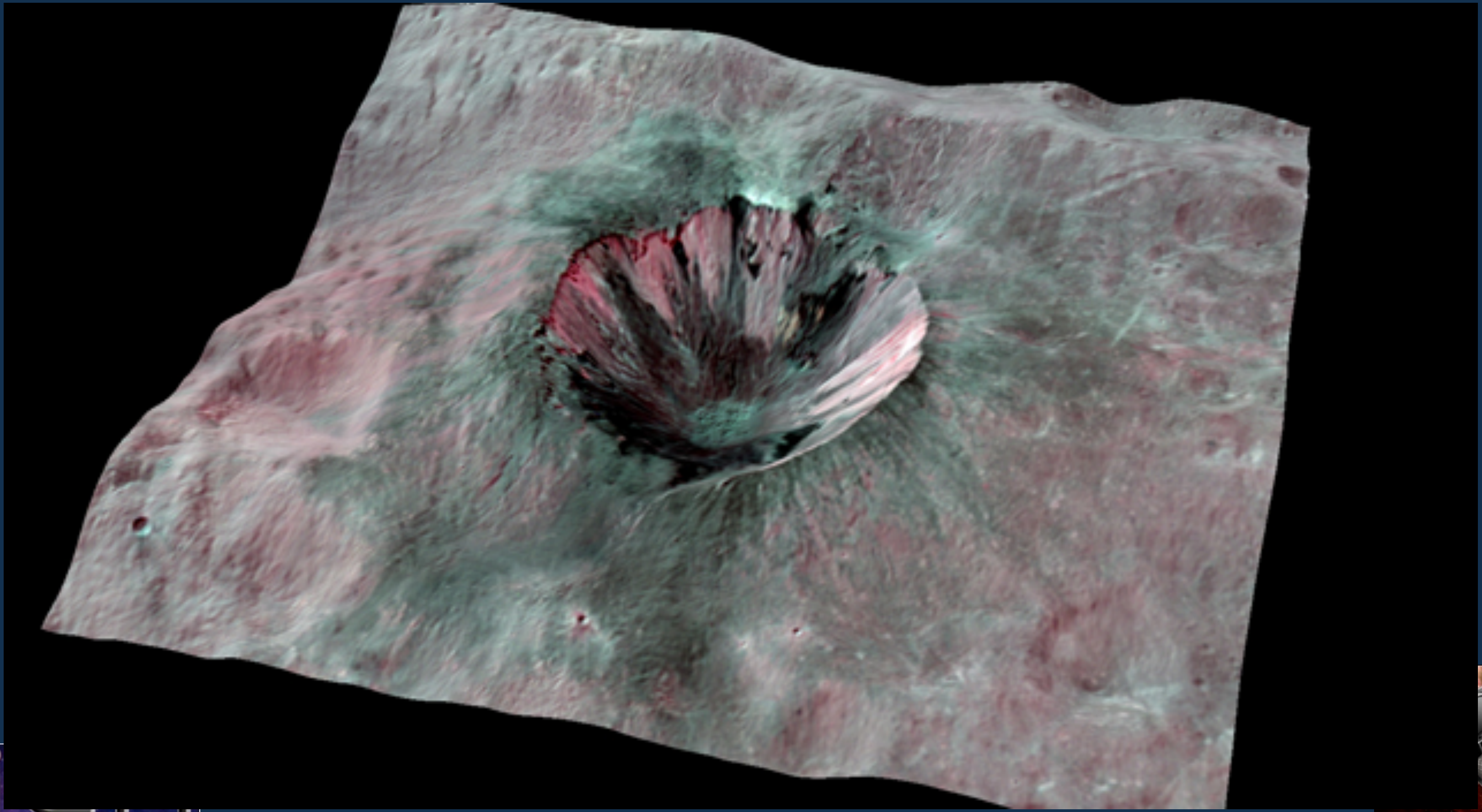
Particle composition

Correlation with:
•Phoebe (orbit & surface)
•Iapetus (dicotomy)
•Other satellites?

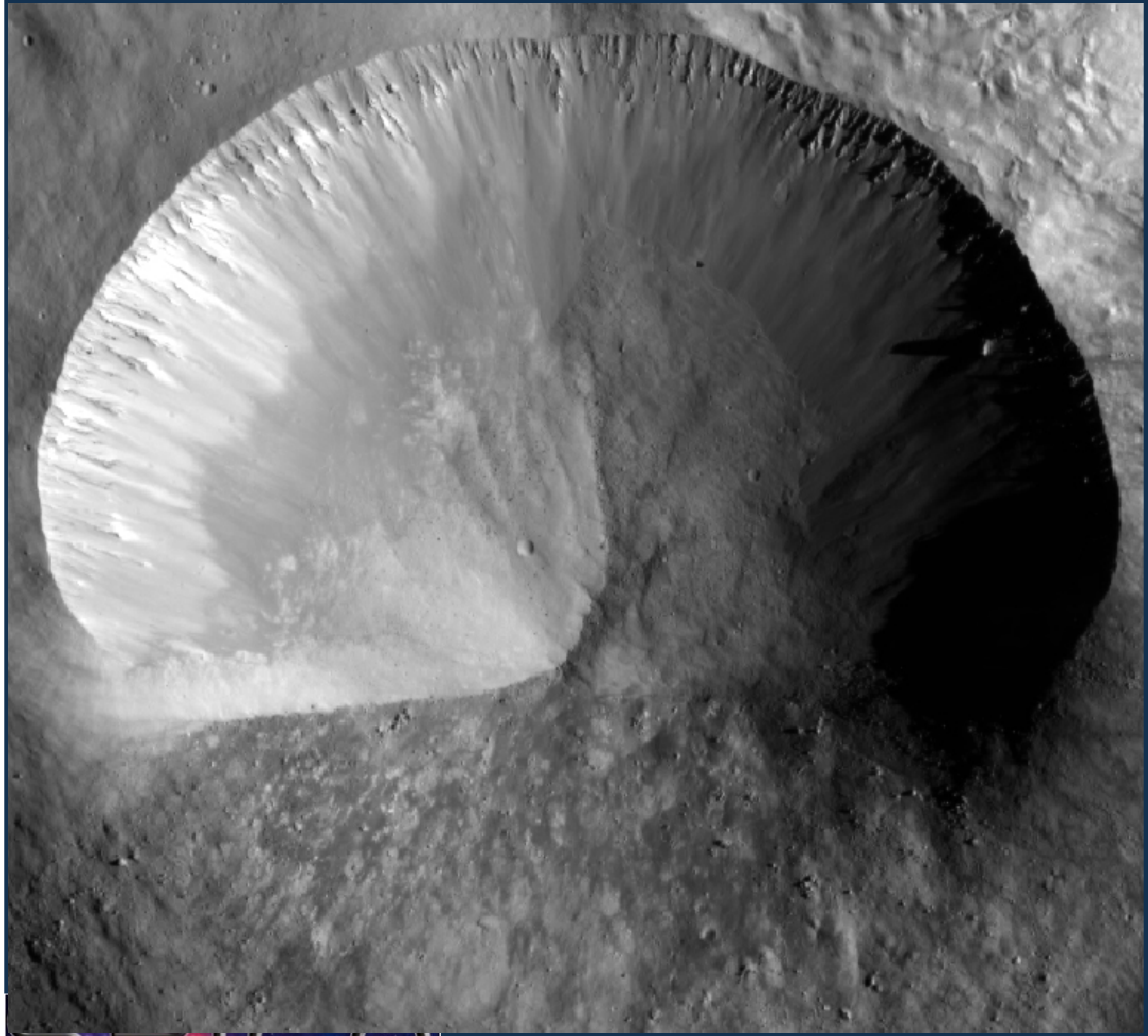
Morishima et al. 2011,Icarus,215,107
Spilker et al. 2006, Planet. Space Science 54, 1167–1176

Vesta Investigations (1)

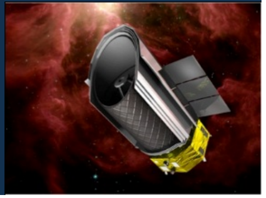
The DAWN mission that has been in orbit around Vesta for approximately 1 year and was able to discover bright and dark regions, showing that the variation in the geometric albedo is the largest ever observed so far *(Reddy et al, Science, 2012)*



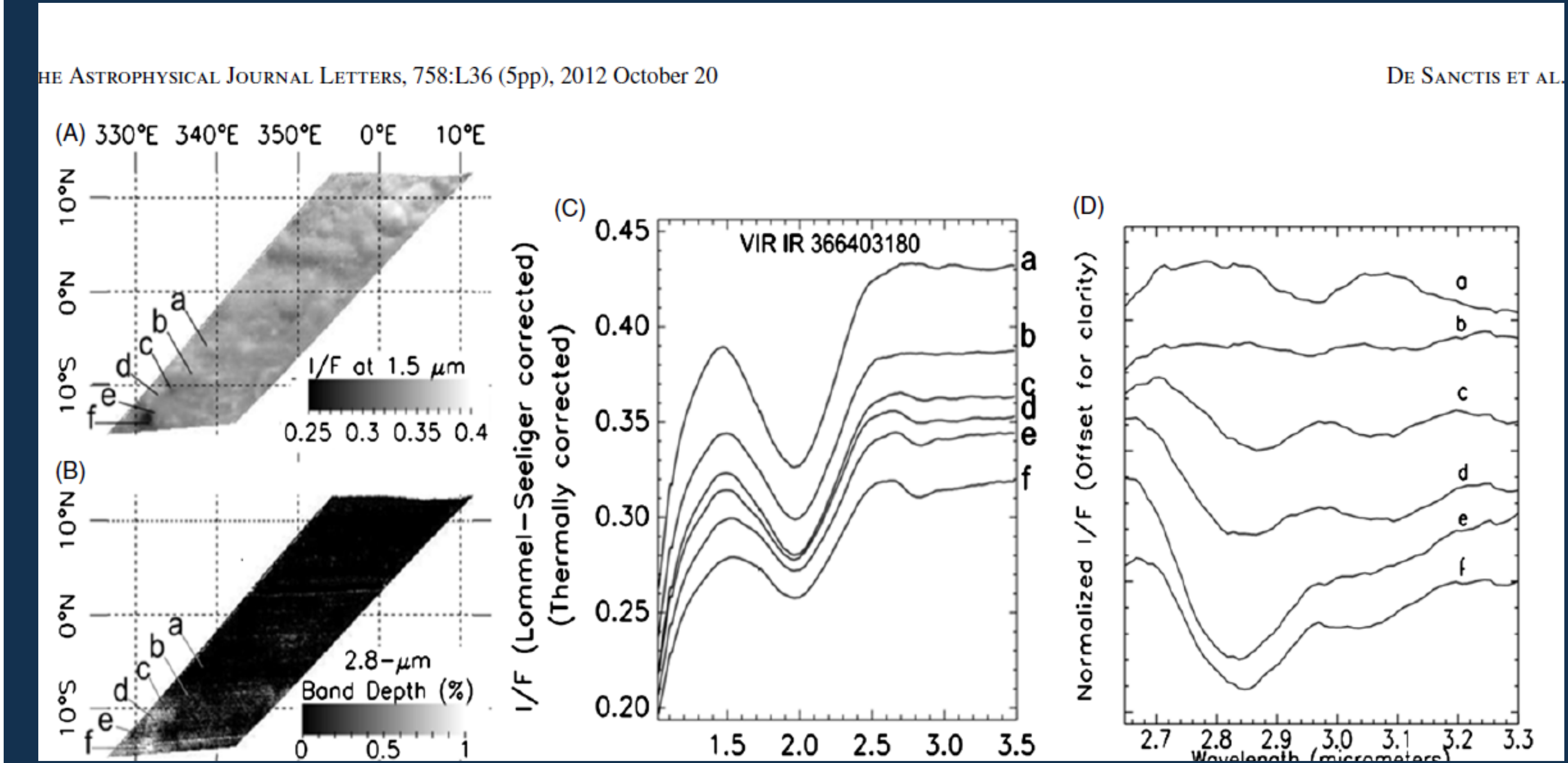
Vesta Investigations (2)



Dark regions are a mixture of original Vestan material and Carbonaceous Chondritic exogenous component. Dark regions were found to be enriched in hydrated materials *(McCord et al., Nature, 2012)*



Vesta Investigations (3)



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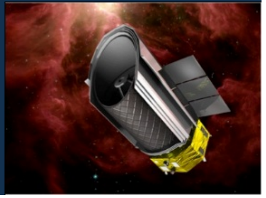


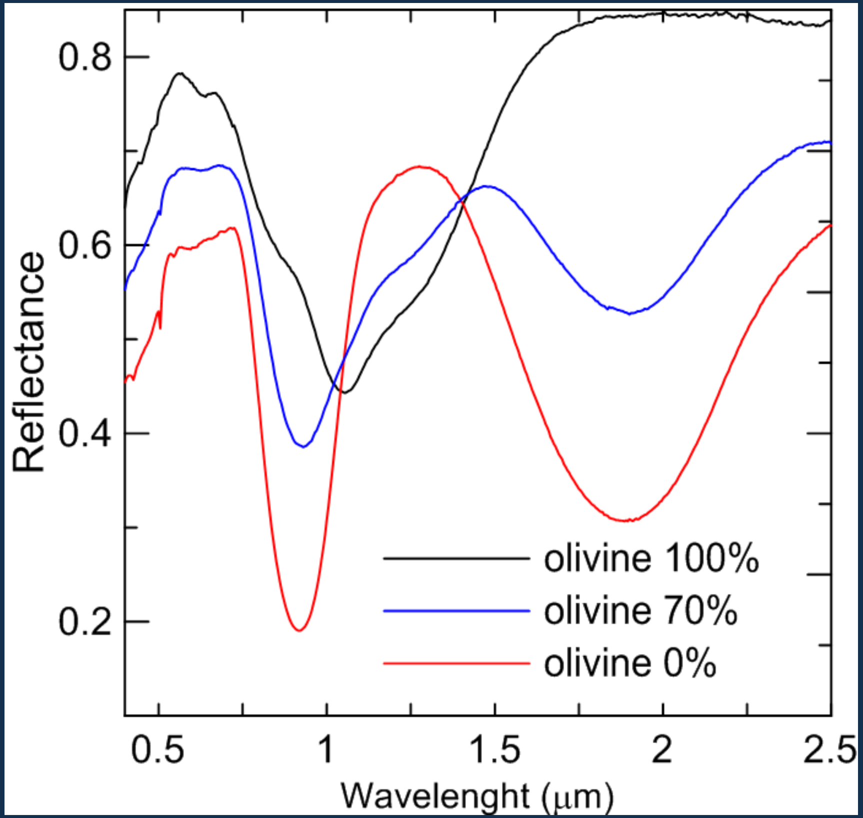
Space Infrared Telescope for Cosmology and Astrophysics

Vis to IR sources of spectral features

- Two basic types of processes from 0.4 - 50 µm
  - **Electronic** (~0.4 to 2 µm)
    - High-energy photons absorbed by bound electrons
    - Energy states/wavelength controlled by atom and crystal structure
    - Primarily interactions with transition metals (e.g., Fe)
      - Not all minerals contain these
  - **Vibrational** (>~6 µm)
    - Excitation of fundamental vibrational motions of atoms
      - stretching and bending
      - Frequencies related to strength and length of bonds
    - ~1.5 - ~6 µm are weaker overtones and combination bands
      - Complex transitional region between reflection & emission

NIR vs MIR spectra

NIR



MIR