

Deep into the Solar System

..some ideas for SPICA

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Why this mission?

- **build from where previous FIR missions stopped**
- **far greater sensitivity**
- **focus on science with spectroscopy at moderate resolution (spatial & spectral)**

SPICA Science Workshop, May 21-23, 2014, Leiden, The Netherlands

SPICA Mission

SPICA (Space Infrared Telescope for Cosmology and Astrophysics) is a space mission optimized for mid- and far-infrared astronomy with a cryogenically cooled (<6 Kelvin) 3.2 m telescope. SPICA will be launched in 2025 and provides an extremely low background level environment and unprecedented sensitivity in far-infrared wavelength regions, enabling us to address a number of key questions in the pre-sent-day astronomy ranging from the starformation history of the universe to the formation of planets. In order to reduce the weight of the whole spacecraft, the SPICA telescope is launched at ambient temperature and cooled down after reaching space by using mechanical coolers with an efficient radiative cooling system: the combination of them allows us to have a mid class cooled telescope in space with moderate total weight (3.7 tons). SPICA is thrown into an L2 Halo orbit around the Sun-Earth system.

SPICA Specifications

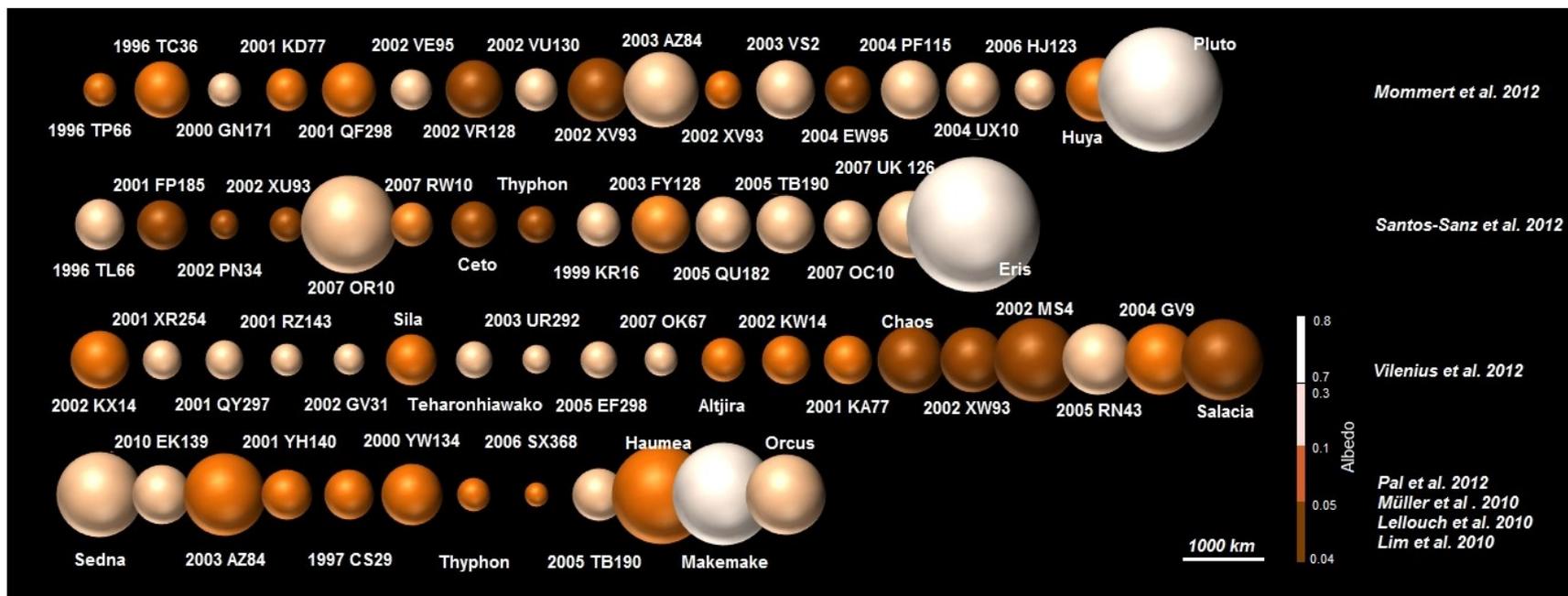
- Telescope diameter: 3.2m
- Telescope temperature: <6K
- Wavelength: 20-210 μ m
- Total mass: 3.7t
- Orbit: Halo orbit around libration point S-E L2
- Launch: FY2025

SPICA now enters the open competition in the ESA Cosmic Vision program (4th M-class mission, M4). An international science task force has been established in order to sharpen the science goal of SPICA, and with the outcome of the task force activity the design of the focal plane instrument suite is under revision. All-Japan consortium is in charge of the mid-infrared instrument covering 20--37 μ m, while the European consortium led by SRON is in charge of the far-infrared instrument covering 34--210 μ m. Korea and Taiwan are also important partners for SPICA, currently contributing on the refinement of the science cases.

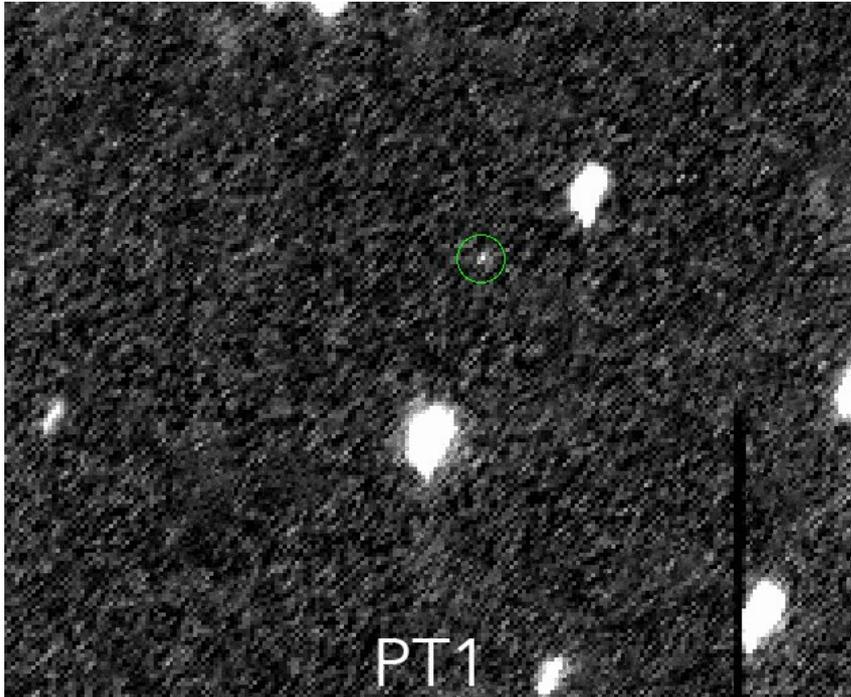
@JAXA
Background image @ESA/PACS/NASA/JPL-Caltec/IRAM

distant solar system

- **size and albedo of trans-neptunian objects** \Rightarrow **clues to origins of planets**
 - with deeper photometry: light curves, composition differences, companions...



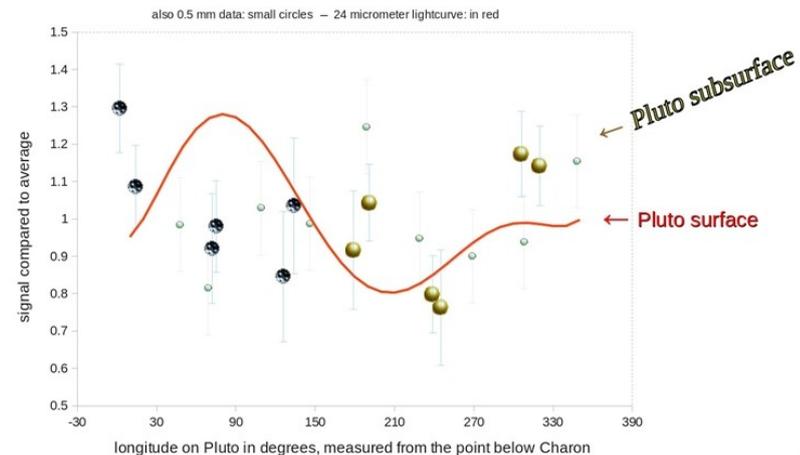
distant solar system



Herschel & SCUBA view of rotation of Pluto (Greaves et al. 2014)

- Herschel surveyed TNOs ≥ 150 km in diameter
- clues from populations of smaller objects? e.g the 2019 target for New Horizons, $d \sim 30-45$ km

Pluto at 0.85 mm (dark and light points - nightside and dayside during 2015 flyby)



let it snow...

- **tenuous atmosphere on Pluto (& other large TNOs?)**
 - T_{Pluto} is around the phase transition point of α and β N_2 ices \Rightarrow uncertain how the surface/atmosphere exchange works...
- **... as Pluto recedes from the Sun, may catch snowfall??**

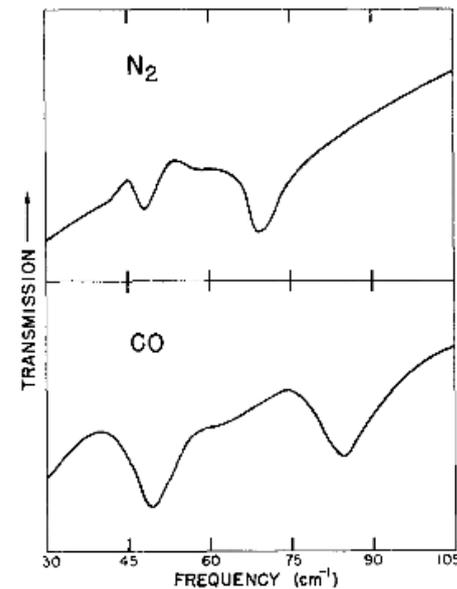
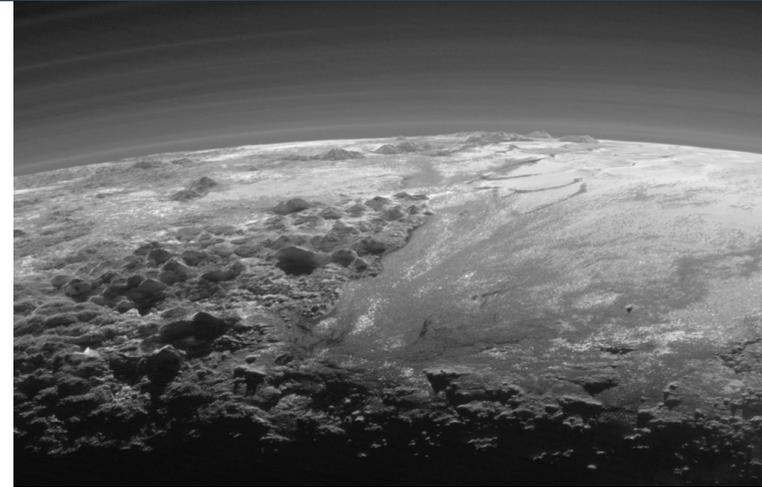


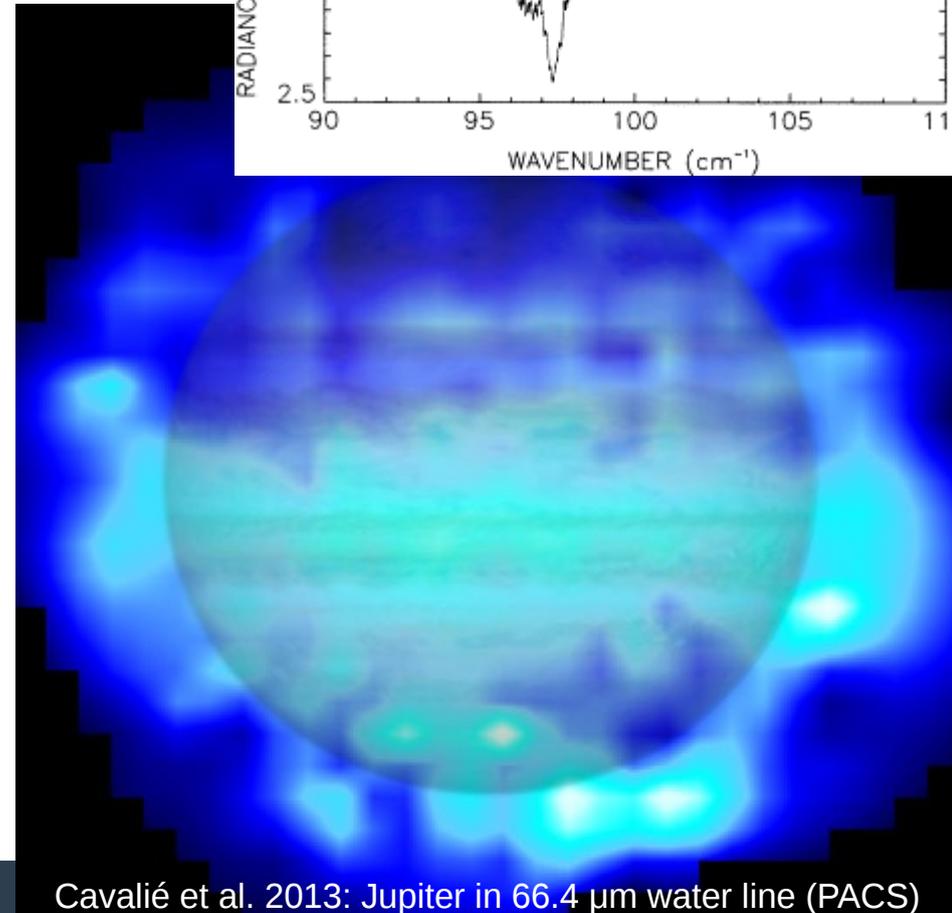
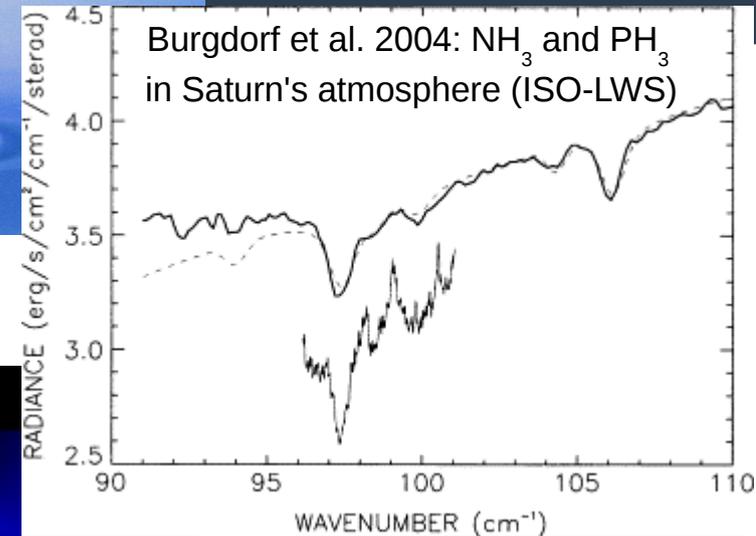
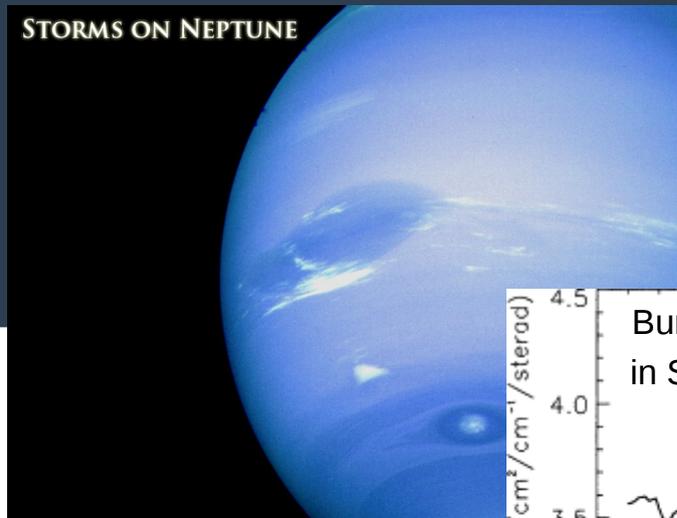
FIG. 1. Single-beam far-infrared absorption spectra of nitrogen (upper) and carbon monoxide (lower) at 10°K.
Anderson & Leroi 1966



weather

- **seasons on the giant planets**
 - + comet impacts
 - + solar activity
- **perfect time to re-observe Saturn!**
 - 1 orbit (29 years) on from ISO: late-2020s

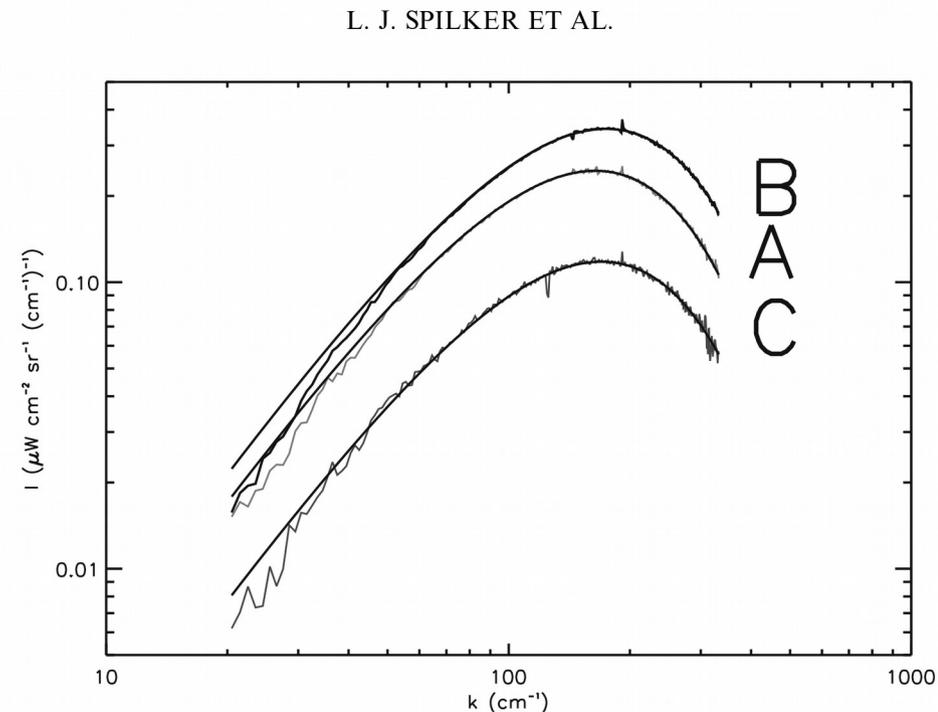
STORMS ON NEPTUNE



Cavalié et al. 2013: Jupiter in 66.4 μm water line (PACS)

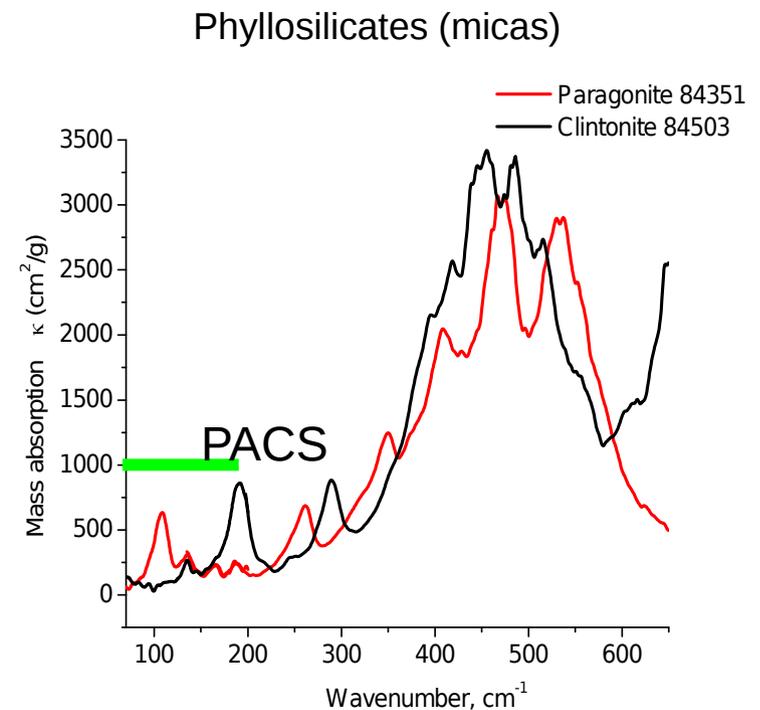
rings (what binds them?)

- **deep FIR spectra \Rightarrow composition of ring grains**
 - in-situ Cassini data show water ice dominates Saturn's rings (stripped from a major icy moon?)
- **what is the mineral composition of the rings of the 4 giant planets? (clues to origins?)**



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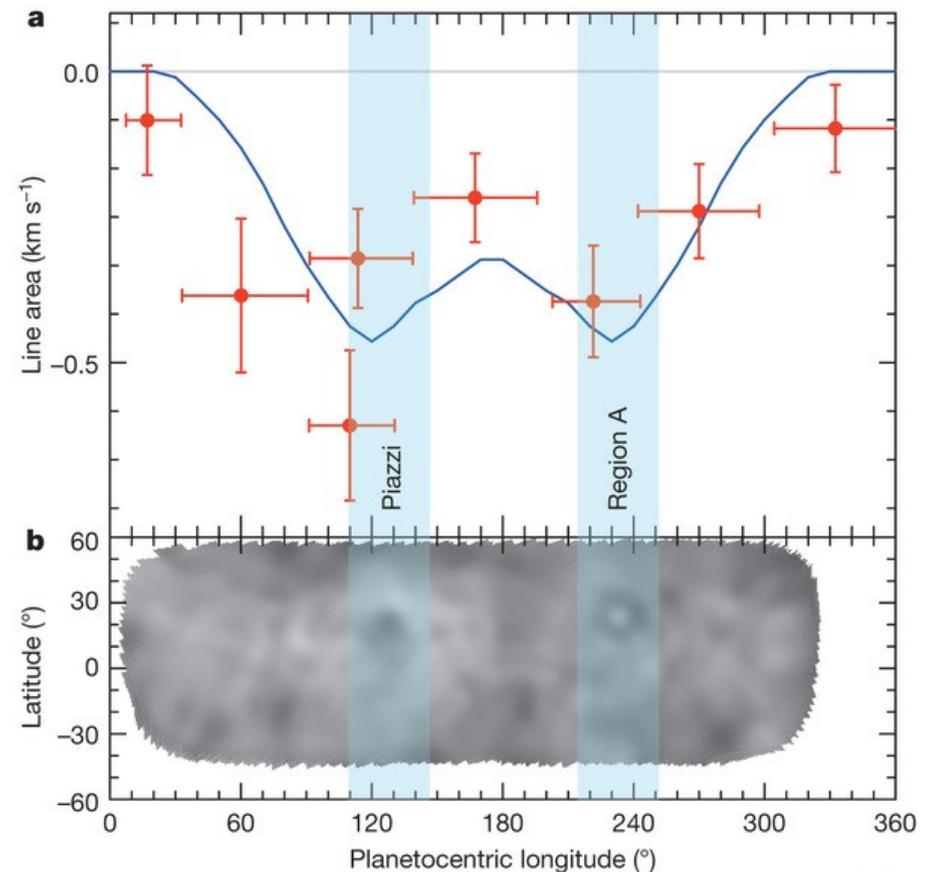
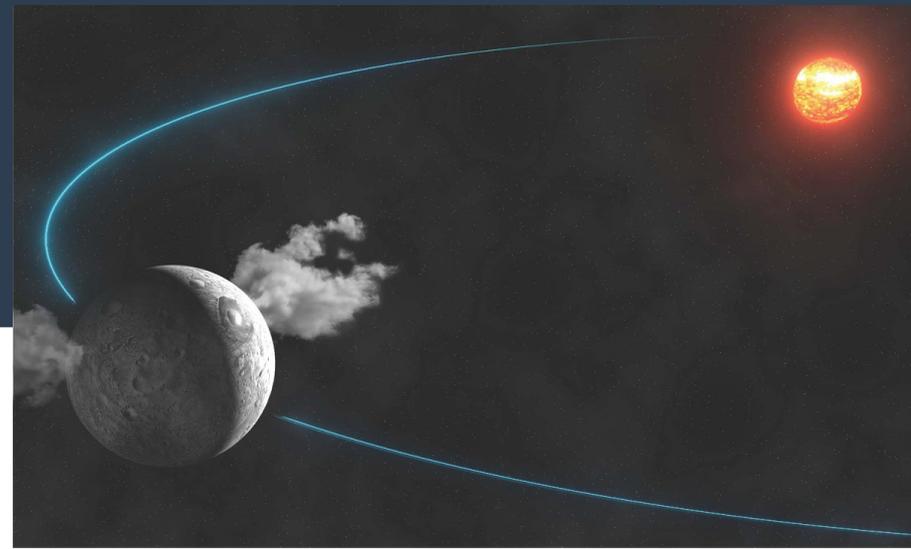


(Brusentsova et al. 2010)
FIR signature of rock-water interaction?



water

- **outgassing water is seen for Enceladus, Europa?, Ceres**
 - not a constant flow, unclear what drives the vents
 - monitoring essential to understanding
- **potential *habitats* beyond the Earth?**

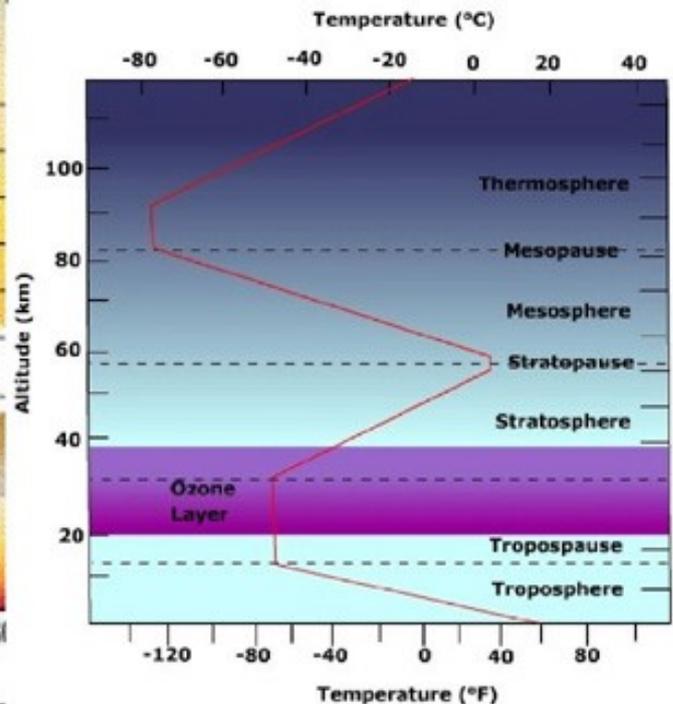
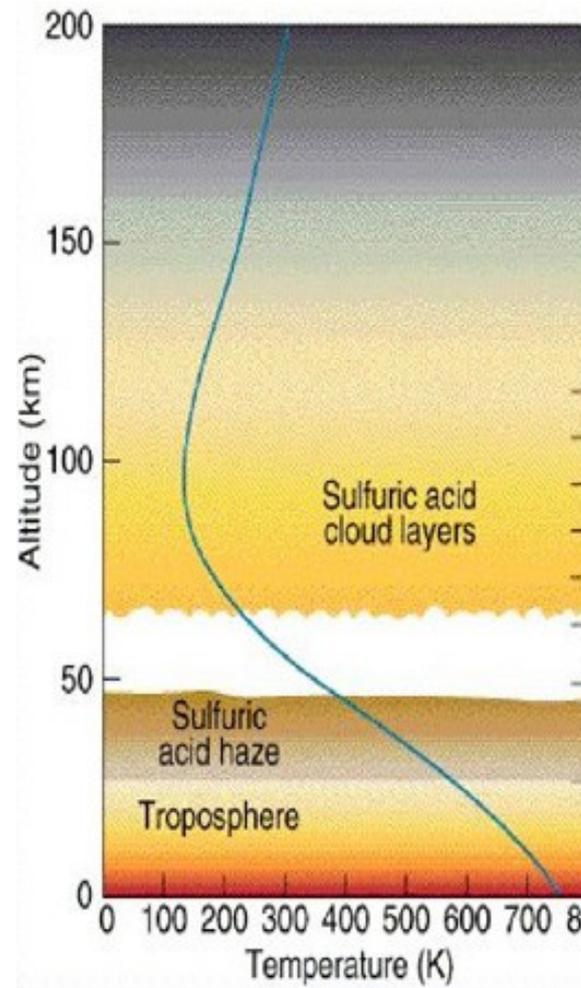


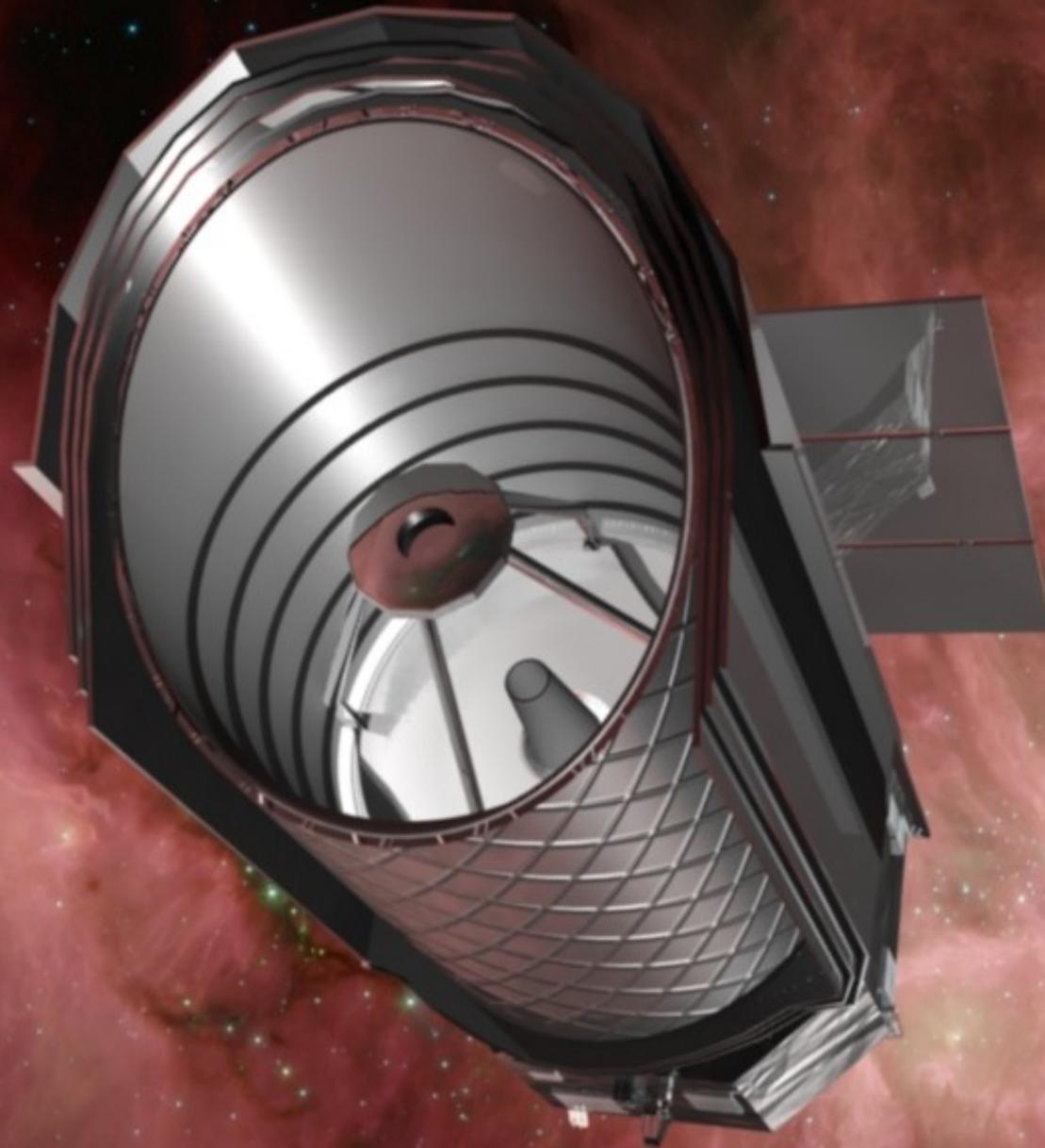
Ceres with Herschel-HIFI: Küppers et al. 2014



biosigns

- incidentally, phosphine (PH_3) can be a biomarker of anaerobic bacteria, so could search for it in the cool clouds decks of Venus...?





...science begun by ISO, Spitzer, Herschel... lots to do!!!

see also: <https://www.ucl.ac.uk/fisica-london-workshop/pdfs/PPT-Fletcher>