Deep into the Solar System

..some ideas for SPICA

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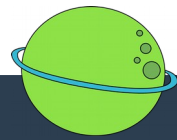
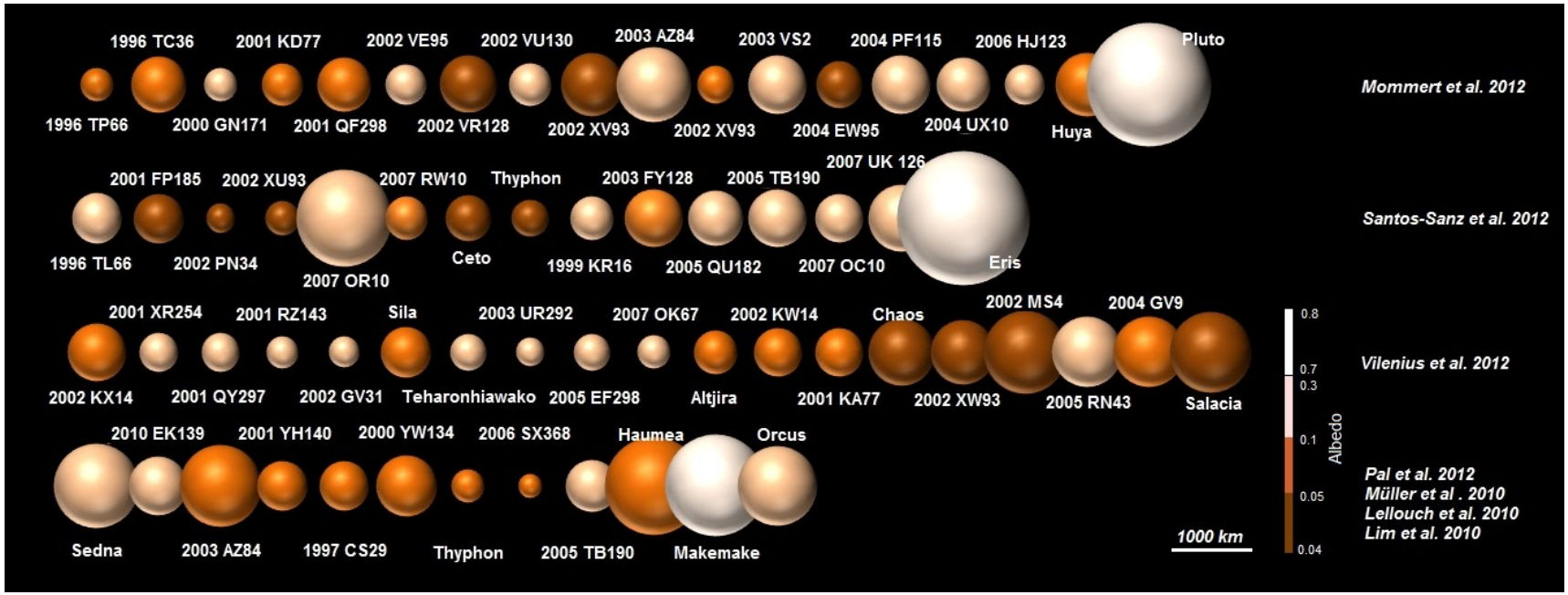


Why this mission?

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

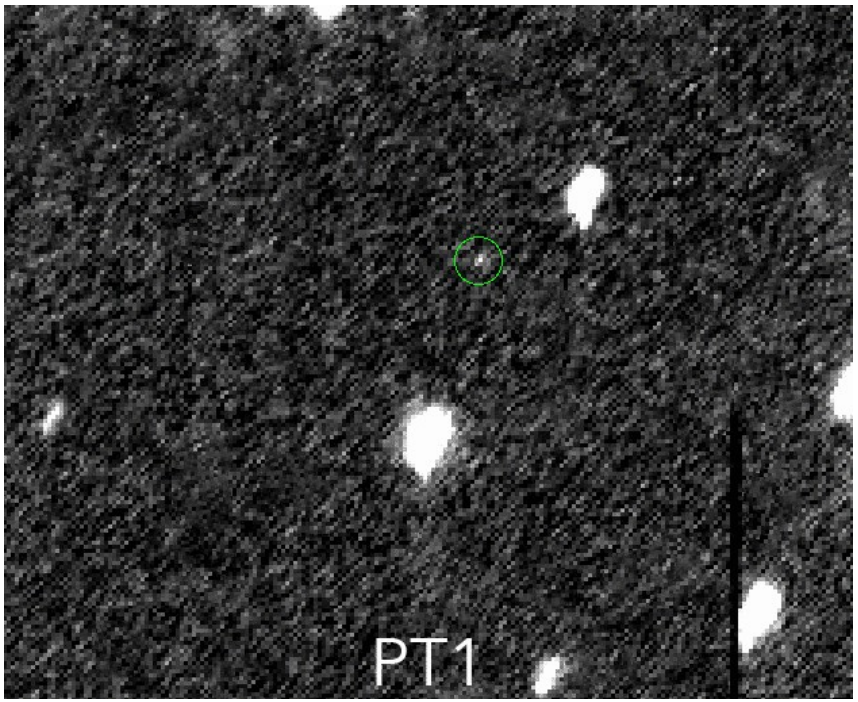
distant solar system

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



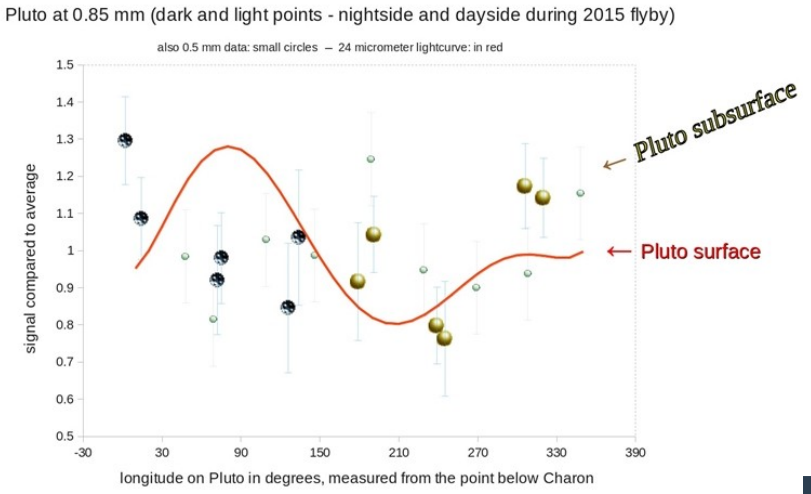
Herschel Key Project: “TNOs are cool”, Müller et al.

distant solar system



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

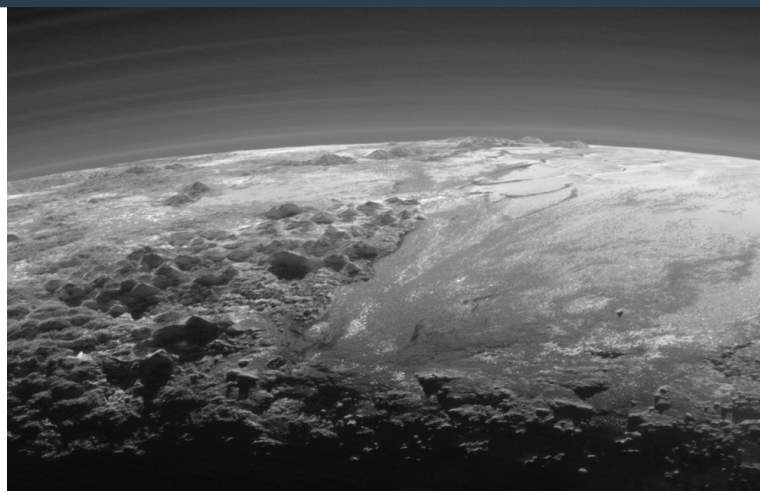
- Herschel surveyed TNOs ≥150 km in diameter
- clues from populations of smaller objects? e.g the 2019 target for New Horizons, d ~ 30-45 km



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 ⇒ uncertain how the surface/atmosphere exchange works...

... as Pluto recedes from the Sun, may catch snowfall??



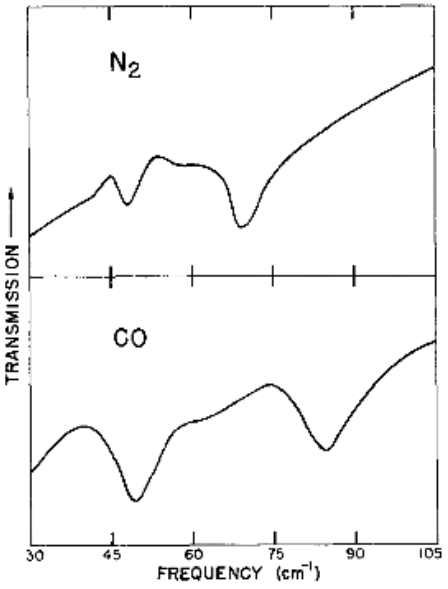
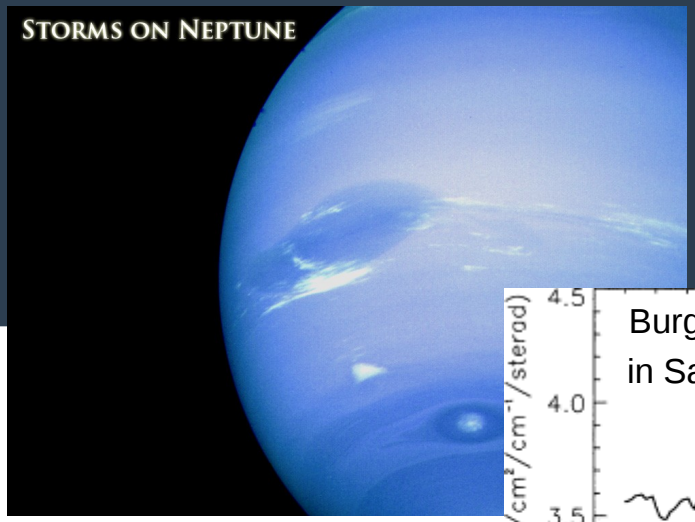
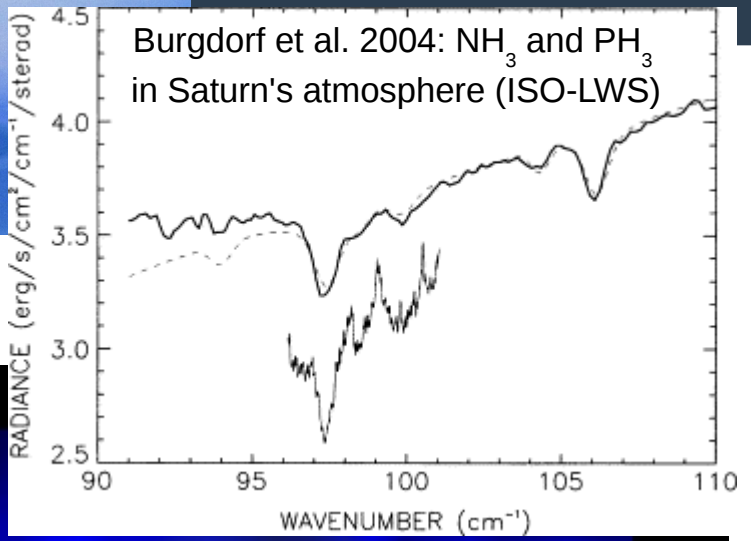


FIG. 1. Single-beam far-infrared absorption spectra of nitrogen (upper) and carbon monoxide (lower) at 10°K.

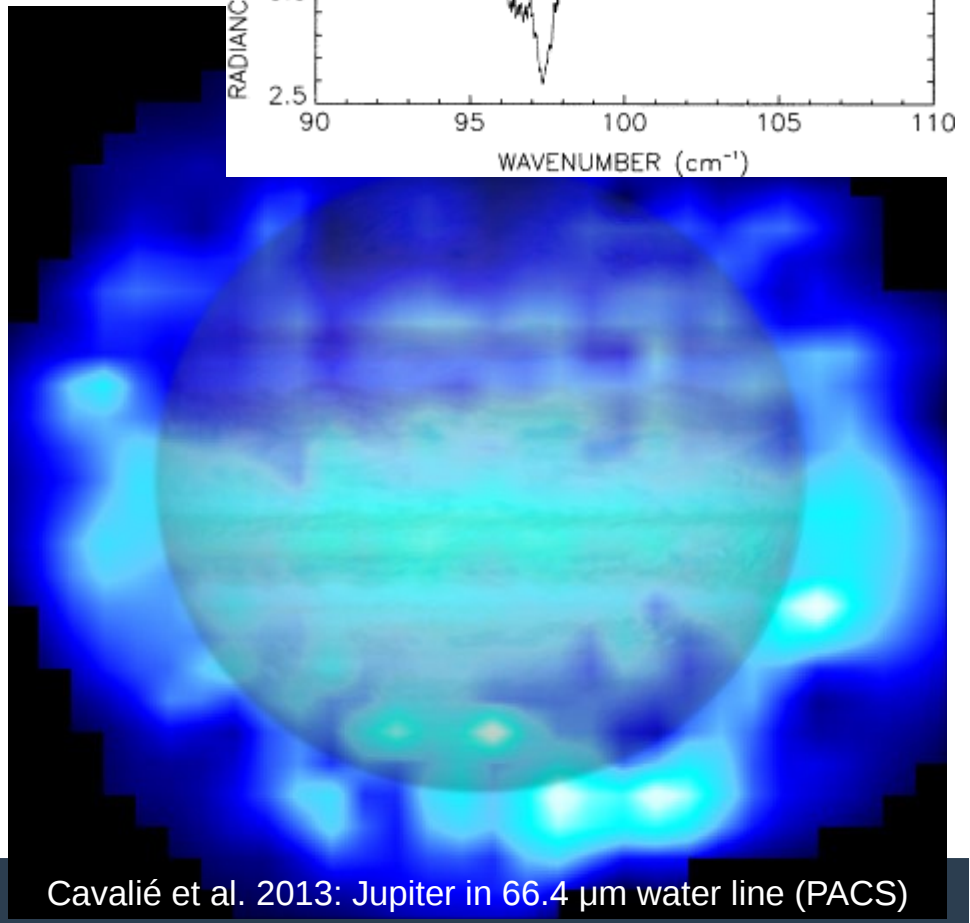
Anderson & Leroi 1966

weather



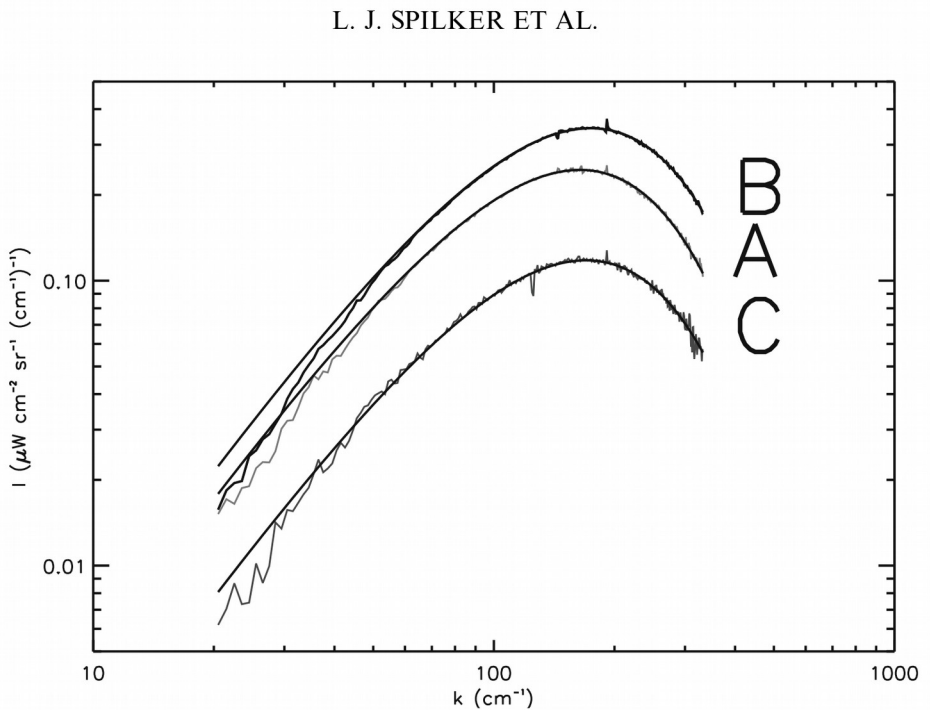


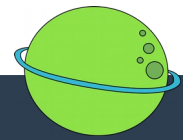
- **seasons on the giant planets**
  - + comet impacts
  - + solar activity
- **perfect time to re-observe Saturn!**
  - 1 orbit (29 years) on from ISO: late-2020s



rings (what binds them?)

- **deep FIR spectra ⇒ 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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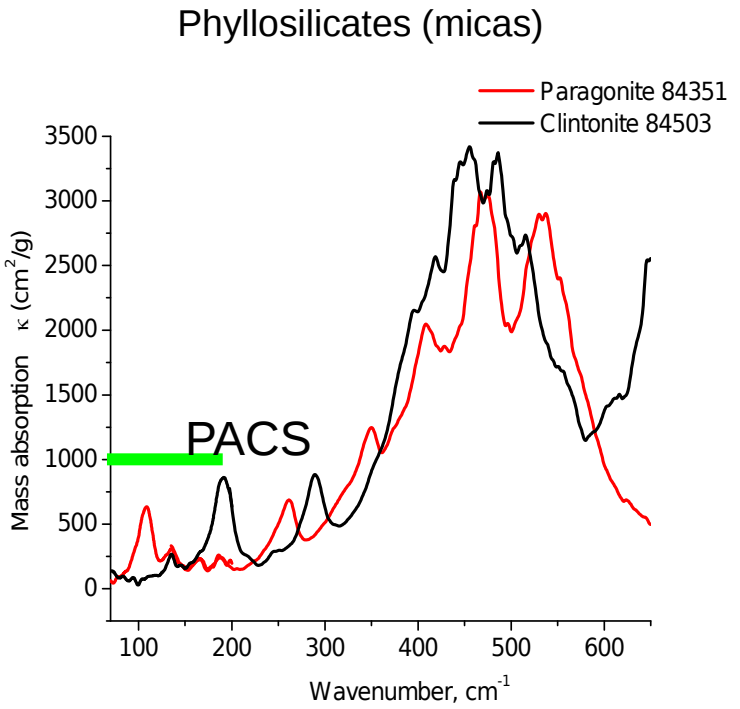
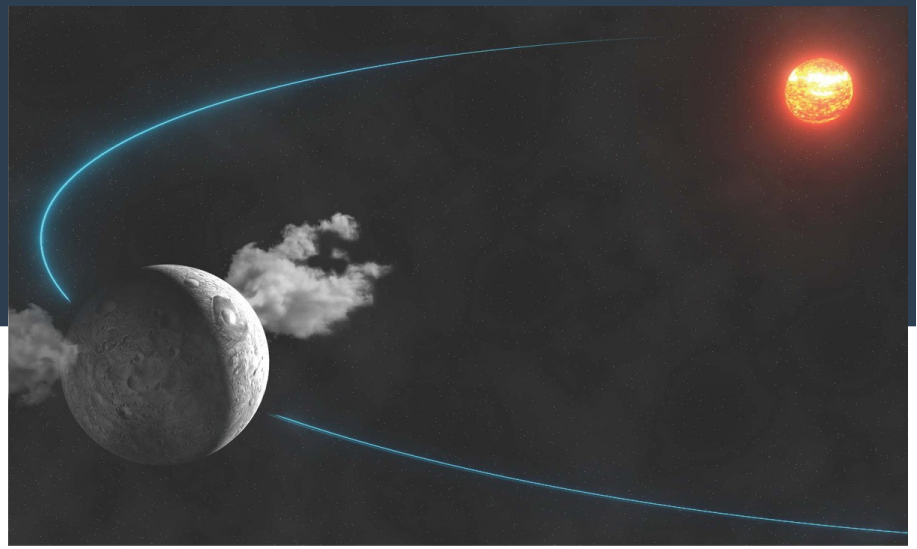
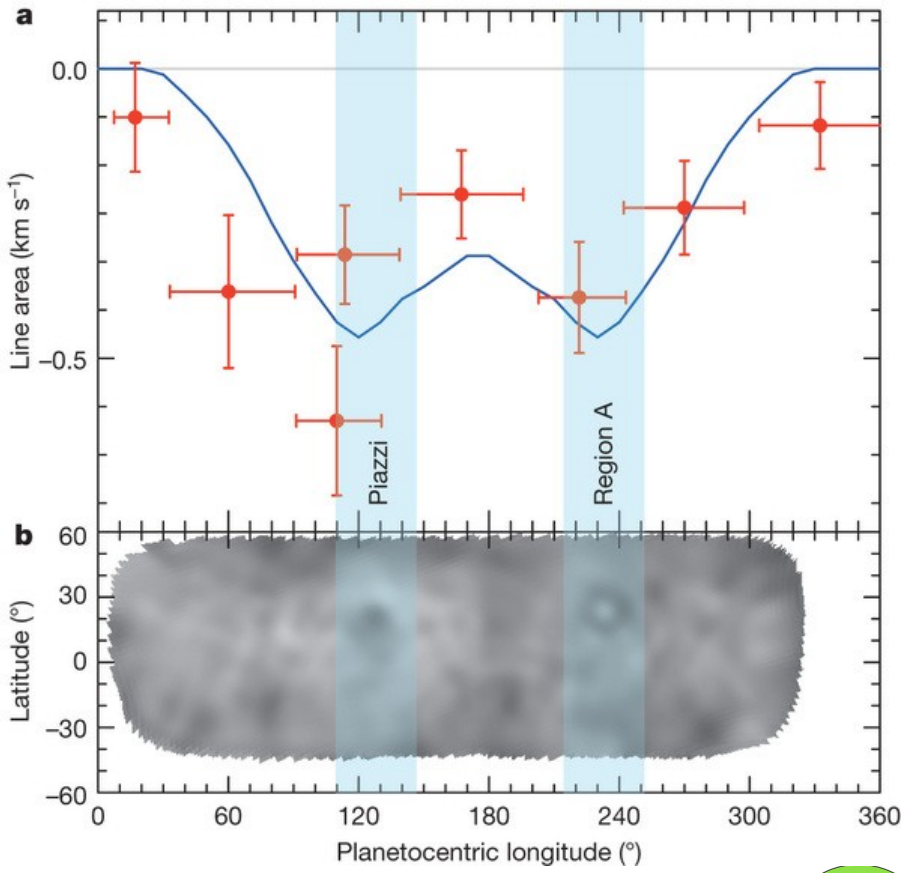


(Brusentsova et al. 2010)
FIR signature of rock-water interaction?

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?**

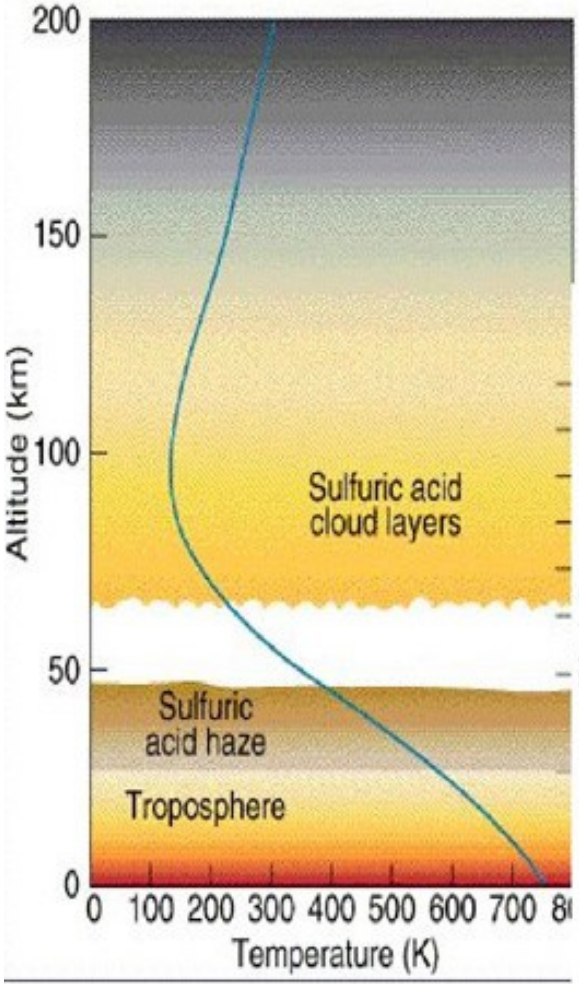


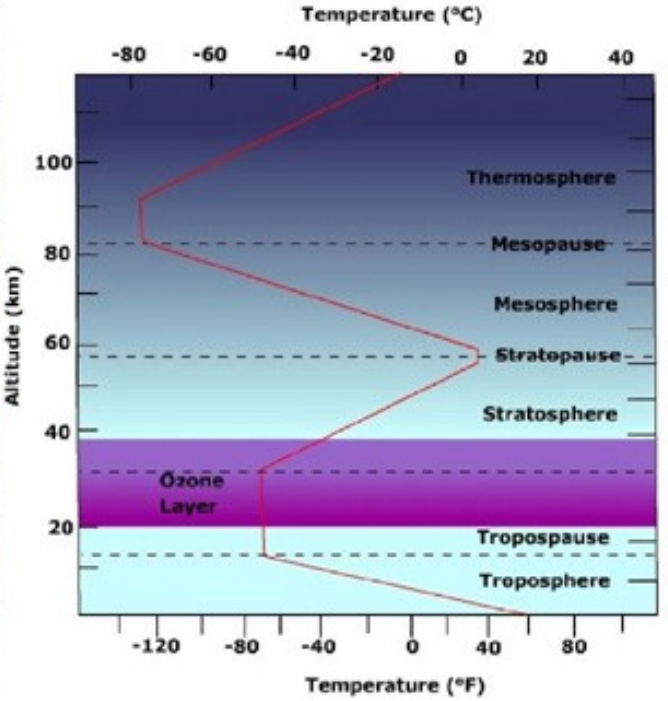


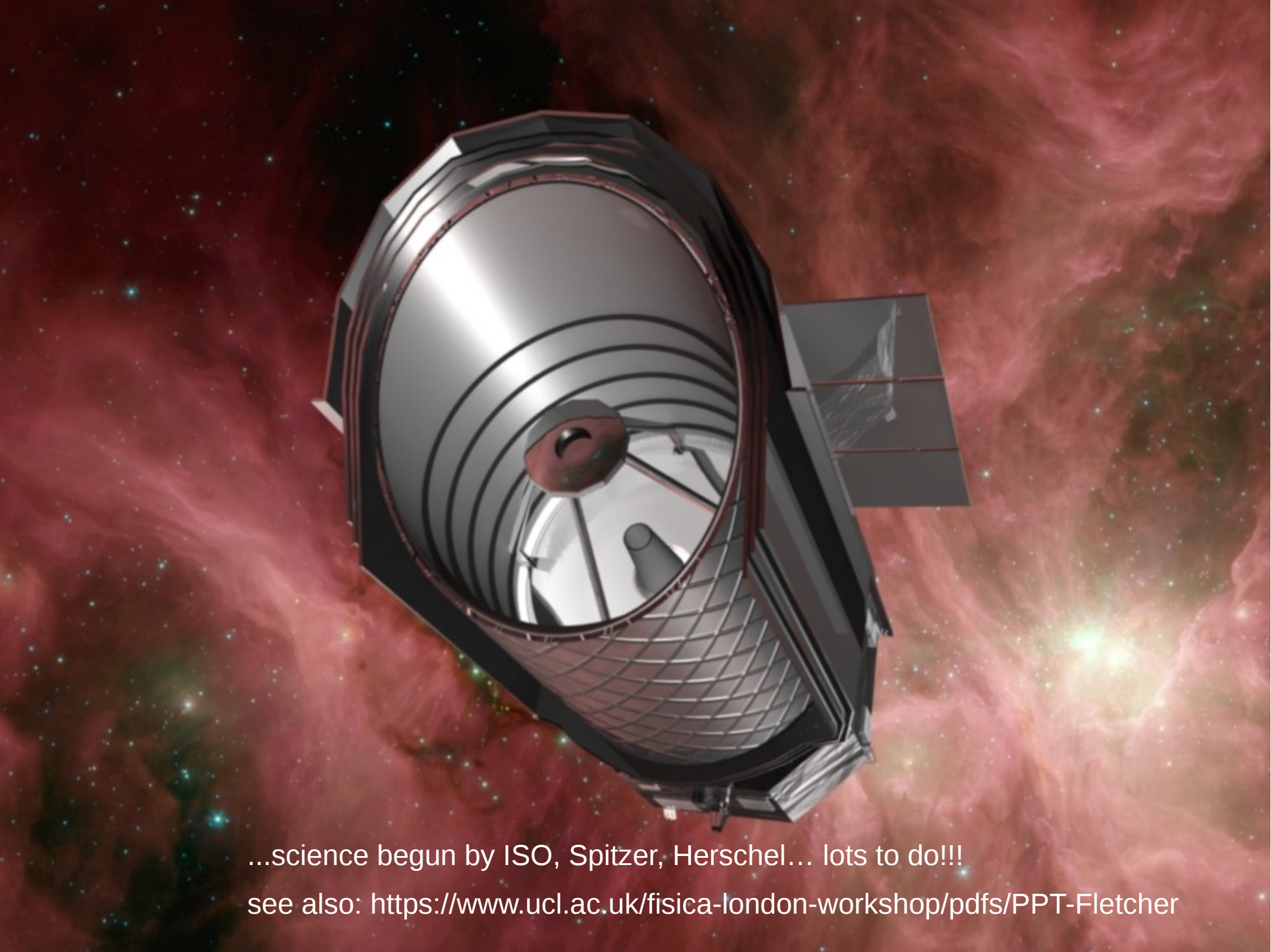
Ceres with Herschel-HIFI: Küppers et al. 2014

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