Jovian irregular satellites: Scientific status and potential contribution of MAJIS

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High level objectives (1)

- Irregular satellites are unique solar system laboratories for studying:
    - Collisional processes
    - Outer planet formation (planetesimals formed Jupiter’s core)
    - Understanding their origin sheds light into the conditions of the solar nebula
- If there is a link between irregular satellites and other small bodies in the SS, how does this constrain gas giant formation/migration?
    - Giant planet instability favors irregulars as captured TNOs – a testable prediction

High level objectives (2)

- How do irregulars relate to other classes of small bodies?
  - Comparisons to main belt asteroids, Trojans, TNOs/comets (MBOSS color families, spectral species)
  - Do differences in VNIR spectra represent evolutionary processing or an intrinsic difference by formation?
  - Key to trace formation region, an important constraint on giant planet instability models

Measurements:
VNIR spectra of irregular families by MAJIS
and ground-based telescopes (LBT, VLT, IRTF, E-ELT, ...)

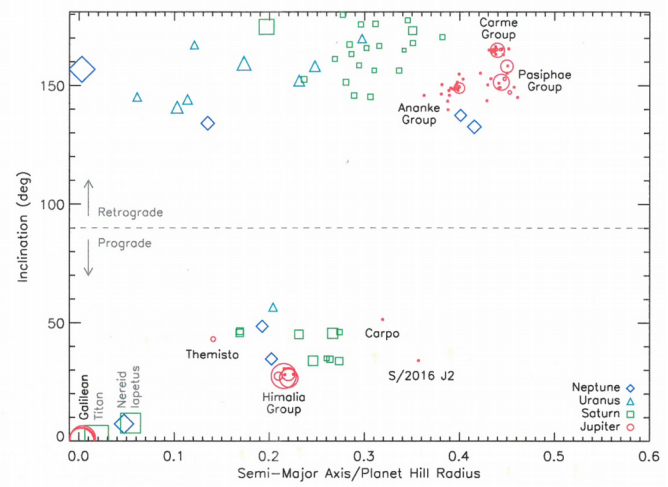
High level objectives (3)

- How did the irregulars' high collisional environment (Bottke et al. 2010) shape them?
  - Do irregulars represent interior material of icy planetesimals? Is there a difference between surface and internal material?
  - Are P- and D-type irregulars similar to Trojans? If so, despite a dramatically different collisional environments?

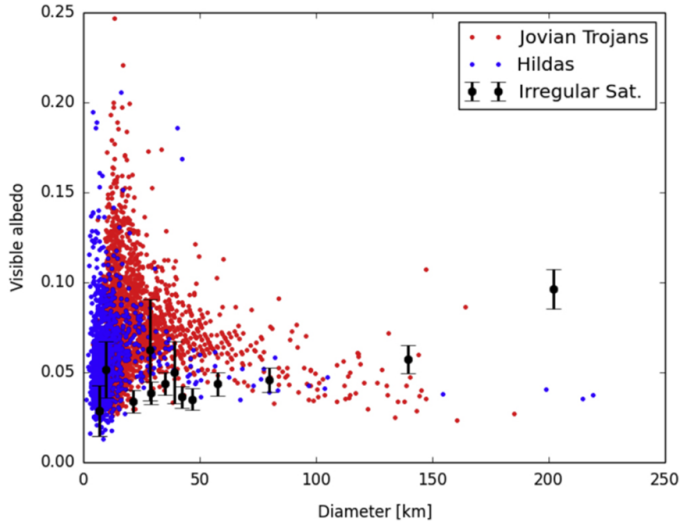
Measurements:
VNIR spectra of several members of a single family by MAJIS and ground-based telescopes

What do we know?

- Jupiter has 79 satellites (most of them are irregulars)
- Irregulars are in prograde and retrograde orbits
- Irregulars cluster in dynamical families (Jupiter has at least 5 families)
- Colors in each family are homogeneous (common parent body?)
- Irregular satellites are dark (darker than most Hildas and Trojans, more like comets&TNOs)



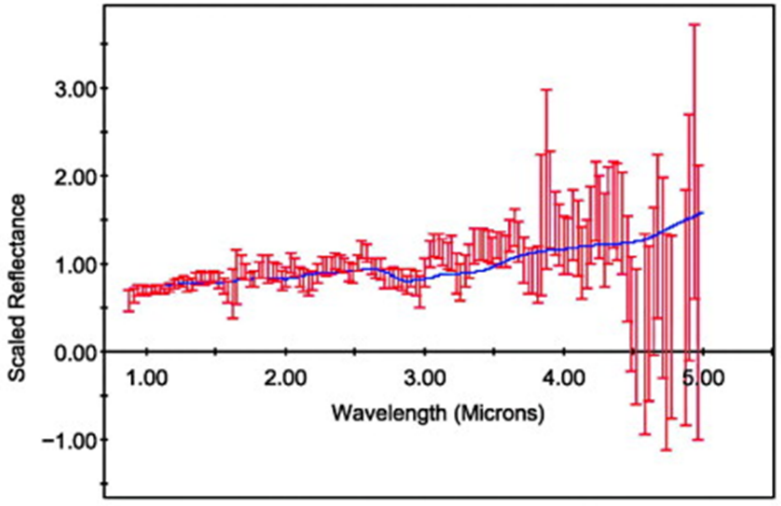
Dynamical clusters of Jovian irregulars (Sheppard et al. 2018)



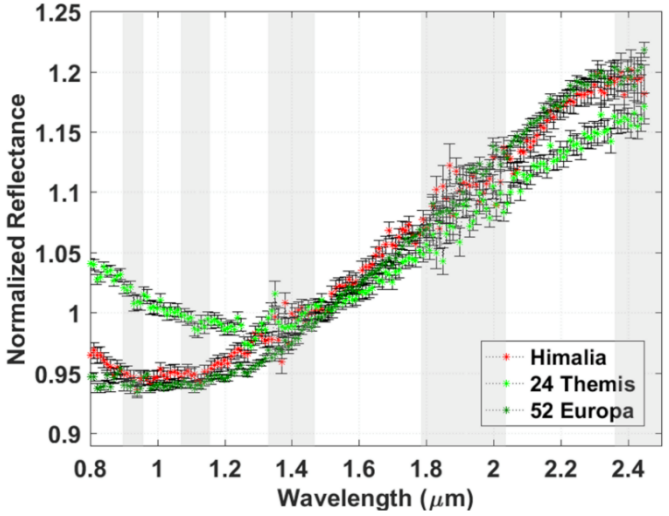
NEOWISE albedo of many objects (Grav et al., 2015)

VNIR studies performed

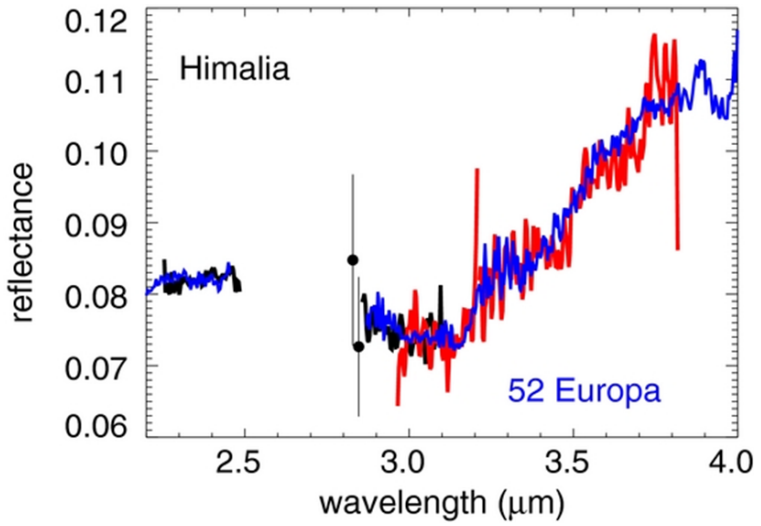
- Several irregulars have been investigated by spectroscopy or color photometry:
  1. Himalia, Elara, Carne (Bhatt et al., 2017) – Spectra (0.8 - 2.4 μm)
  2. Himalia (Brown et al., 2014; Dumas et al., 1998) – Spectra (2.2 - 2.5 μm and 2.8 - 4.0 μm)
  3. Lysithea, Elara, Leda, Himalia, Lacadiera, Carme, Sinope, Callirhoe, Thermisto, Ananke, Pasiphae (Grav et al., 2004) – 7 color data (0.4 - 2.4 μm)
  4. Himalia, Elara, Pasaphae (Brown, 2000) – Spectra (1.2 - 2.4 μm)
  5. Himalia, Elara, Lysiteha, Pasiphae, Sinope, Carne (Tholen & Zellner, 1984) – 8 color data (0.4 - 1.0 μm)



Himalia by Cassini (Brown et al. 2003). Is there a 3-μm absorption feature?



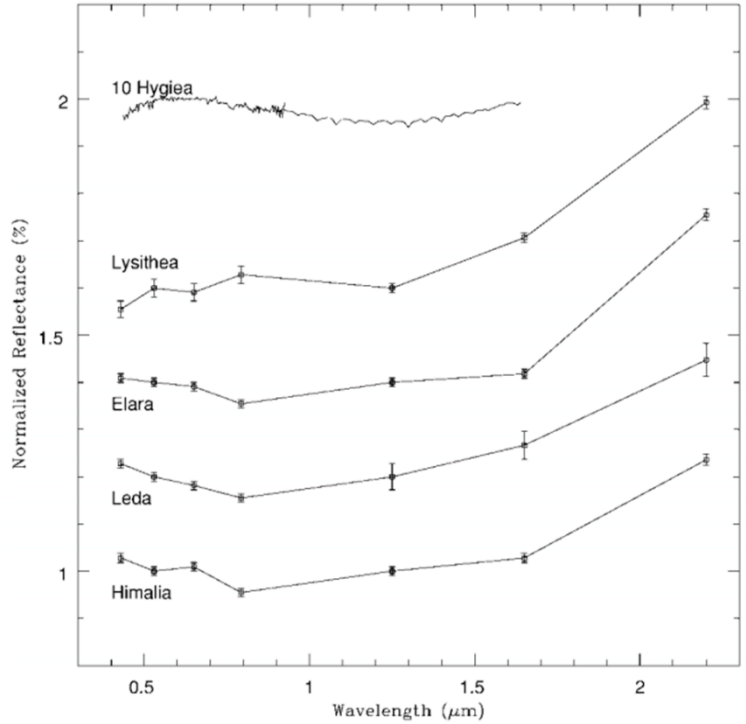
Himalia and 52 Europa show similar spectra (Bhatt et al., 2017). Himalia a captured main-belt asteroid?



(Brown & Rhoden, 2014), Main belt origin of Himalia?

What is missing?

- High quality spectra of Jovian irregulars:
  1. By JUICE spacecraft with increased wavelength coverage (IR), improved SNR (at terrestrial atmosphere bands)
  2. By ground-based telescopes (increase number of irregulars with known spectra)
     ➔ Work by B. Sharkey (LPL) starting soon, MPS initiative for LBT & other observatories, compositional analysis to constrain their nature.



Himalia family members (Grav et al., 2004)

JUICE – MAJIS Opportunities

- Distant fly-bys at 6 (outer) irregulars: Themisto, Himalia, Leda, Elara, 55066, Carpo (info thanks to F. Tosi)

- All irregulars at < 1 pixel MAJIS resolution

  ➔ characterization on global scale

- Irregulars could be measured by MAJIS at wavelengths never covered before!

  ➔ improved composition analysis feasible

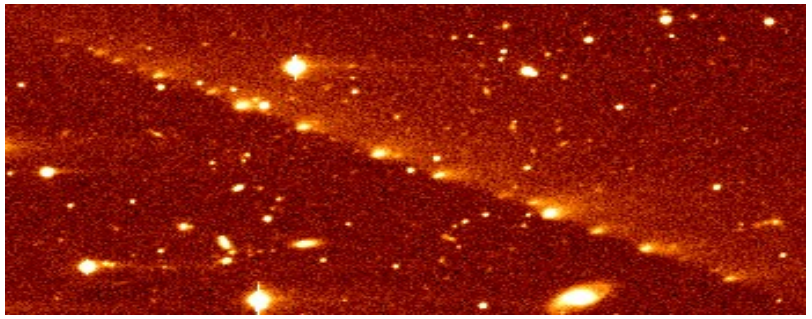
To-do list

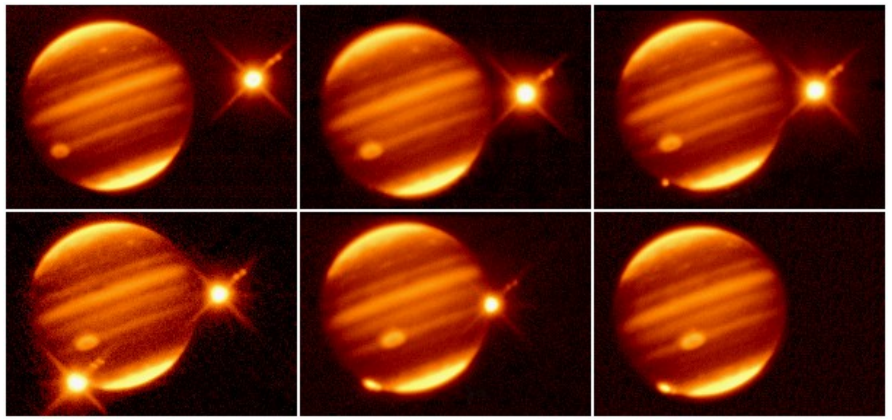
- Prepare observing proposals for irregulars on ground-based telescopes (in collaboration with V. Reddy’s group at LPL).
- Check observability of irregulars with the latest JUICE SPICE information.
- Define detection limits and expected SNRs by MAJIS

Suggestions

- Optimization of trajectories in Jovian system to allow more observations of irregular satellites – if possible

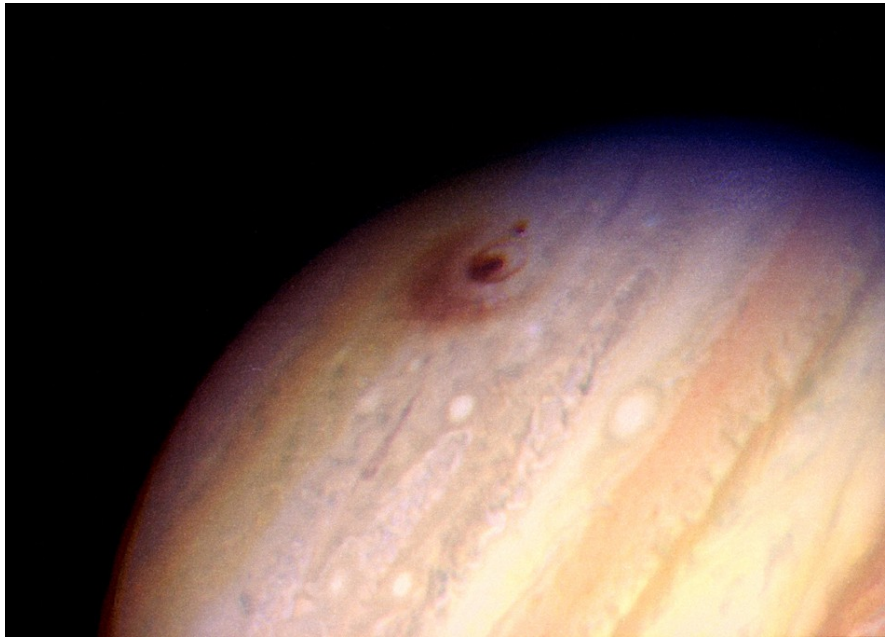
- Think of ToO observations of a surprising event caused by irregular satellites ==> see images on next page

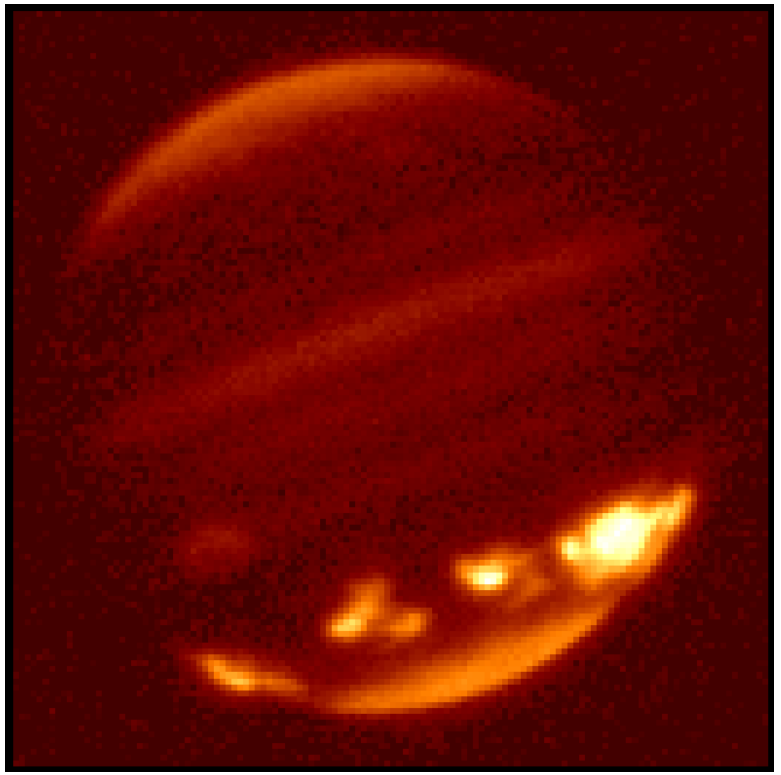




Surprises caused by irregular satellites

1994: Comet D/Shoemaker-Levy 9 at Jupiter





... and in 2009: An unknown asteroid or comet at Jupiter