Planetary Defense Use of the SPHEREx Solar System Object Catalog

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What is this paper?

- SPHEREx:
  - Spectro-Photometer for the History of the Universe, Epoch of Reionization, and Ices Explorer
  - NASA Mission launching latest April 2025
  - Main target: Stars and Galaxies
- Authors argue:
  - This satellite is well-equipped for planetary defense

What is planetary defense?

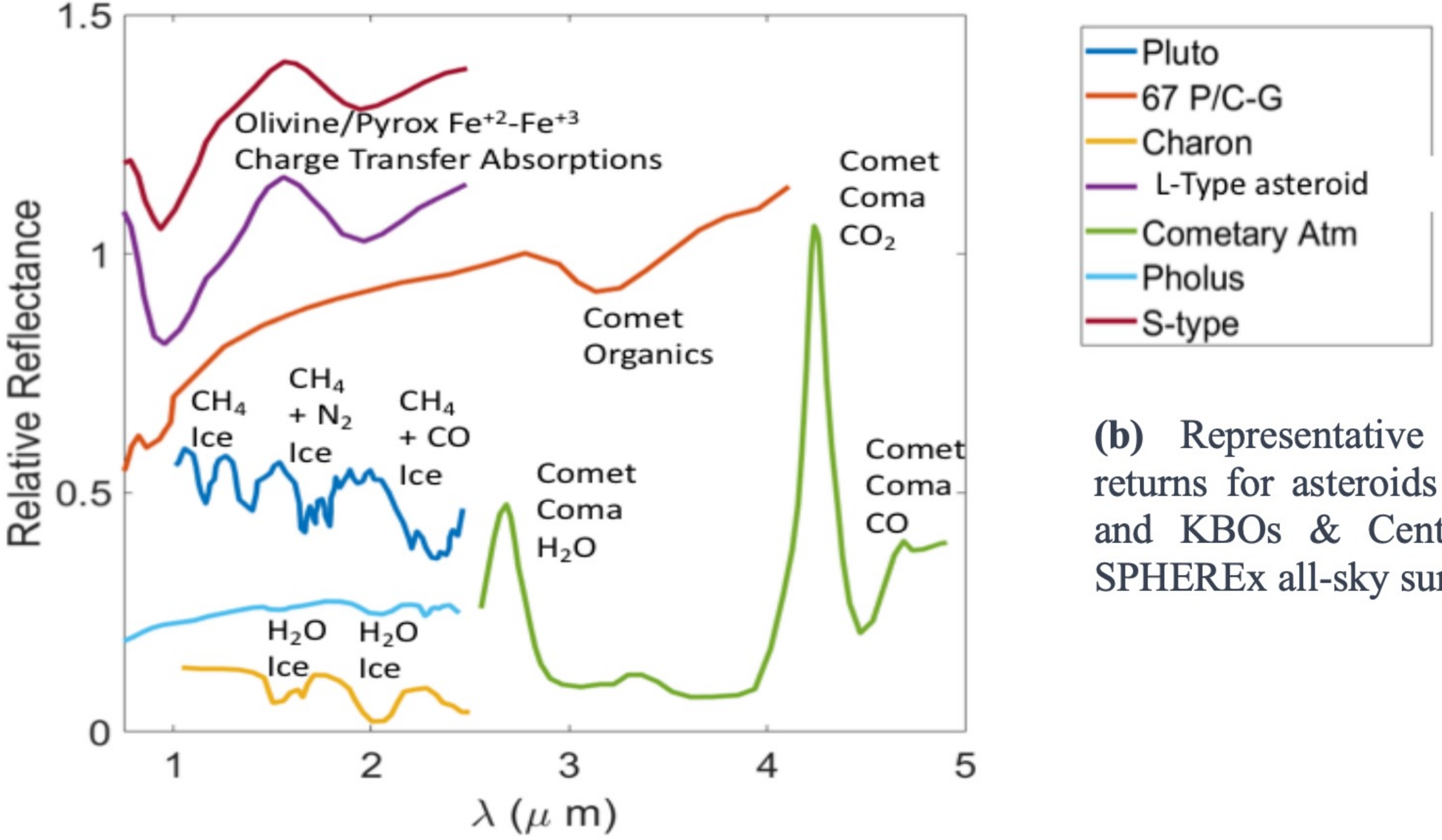
- Space stuff hitting the Earth is really bad
  - Just ask the dinosaurs LOL
- Potentially Hazardous Objects (PHOs)
  - “objects that are known to come close enough to Earth”
  - “their size is large enough that the impact could have catastrophic effects”
- NASA tasked with finding 90% of PHOs by congressional mandate
  - Should be accomplished in next 10 yr

What do we want to know about PHOs?

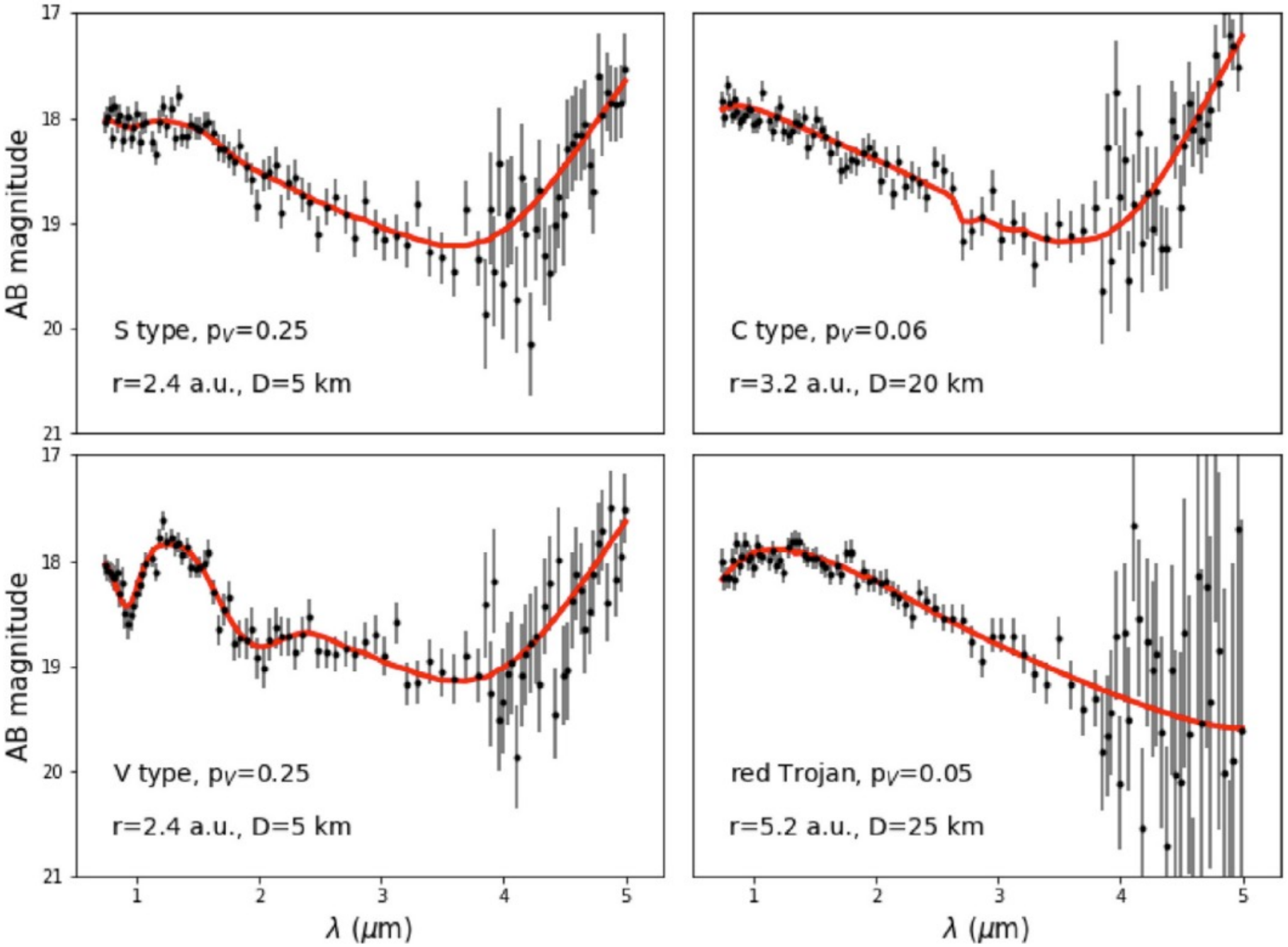
- Done with other instruments:
  - Where they are
  - How big they are
- Importance of SPHEREx:
  - Spectral Classification
    - Material changes how we approach dealing with the hazard
    - “know thy impactor”
    - Specifically, 0.8-1.2 μm silicate absorption, 3 μm water absorption, and VISNIR broadband
    - Be able to distinguish between rock, metal, or icy organic mix

What is SPHEREx good for?

- Limiting mag of 19 → not good for object *discovery*
- But very good for object *classification*
- Wide field of view
- Spectroscopic
- Space → stable/precise observing for improving orbit estimates
- Assist with other observations
- Planned companions: NEO Surveyor and LSST/Rubin Observatory
  - These all combined will provide fast, accurate compositional determination for ~10^5 asteroids



(b) Representative expected spectral science returns for asteroids (upper left), comets (right), and KBOs & Centaurs (lower left) from the SPHEREx all-sky survey.



(c) Calculated SPHEREx spectra for 3 different kinds of **small** asteroids and Jovian Trojan, including realistic error bars. The taxonomic type, visual albedo p_v, heliocentric distance r and object diameter D are listed in each panel. Object sizes are chosen to approximately reproduce a signal-to-noise ratio of 5 at the wavelength of 2.4 μm. Note the small but significant water absorption feature at ~2.7 um for the C-type asteroid, the pronounced 1-2 um silicate absorption features for the V-type asteroid, and that for main-belt asteroids at 2 – 3 au from the Sun, thermal emission dominates past ~4 μm, while it is negligible for Trojans at 5.2 a.u. (After Ivezić *et al.* 2022.)

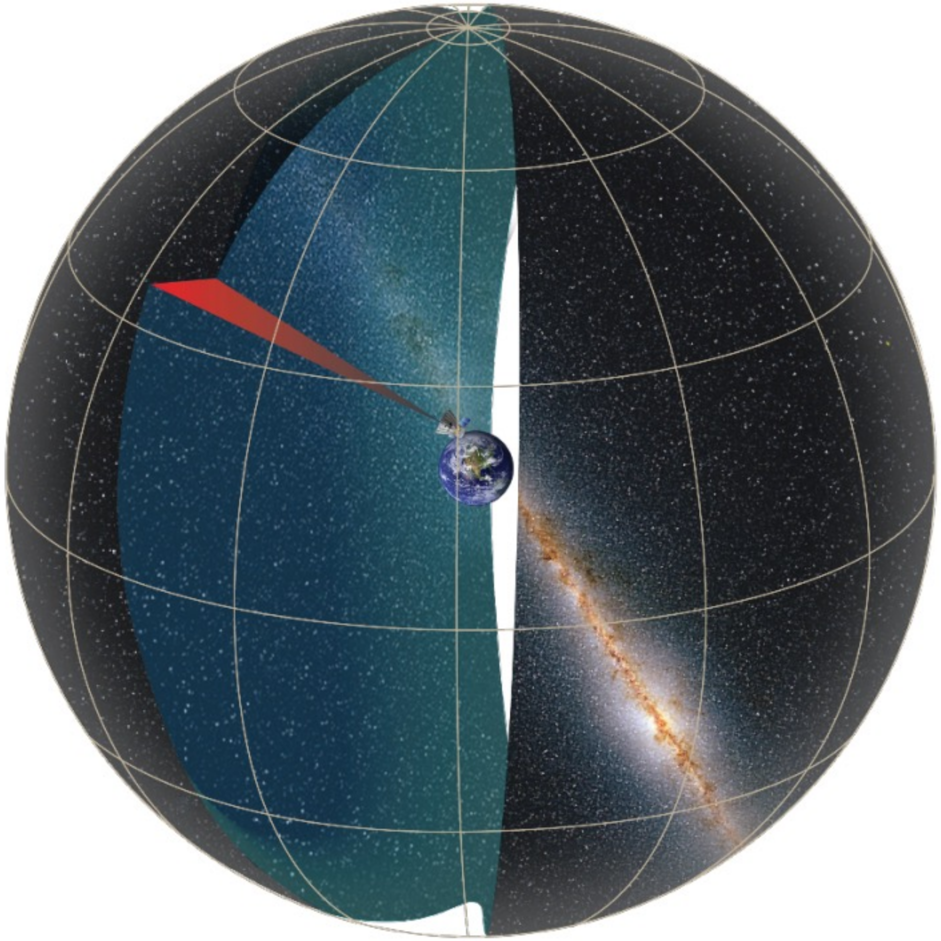


Figure 1: (*left*) SPHEREx all-sky near-infrared mapping. Utilizing a sun-synchronous NEOWISE-like polar orbit, objects in the sky at ~90 deg elongation will be observed in each great circle. The Earth's motion around the Sun advances the great circle's longitude ~1 deg/day; taking data in both the leading/trailing (forward/ behind) directions means that the entire sky's range of longitudes is covered in 6 months, with the ecliptic poles observed

Example

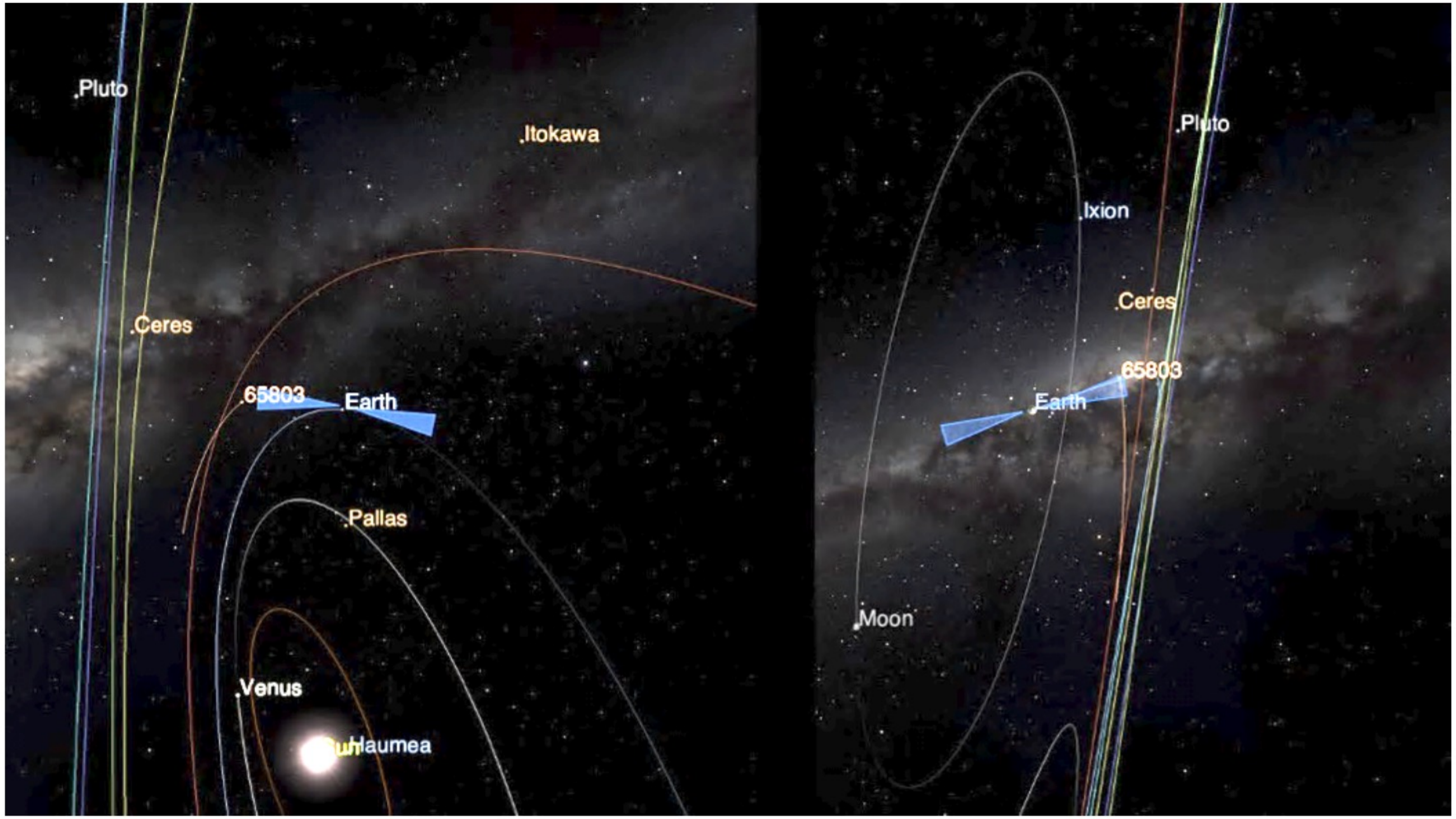


Figure 5 – A new, dangerous PHO is announced, termed "65803". Worldwide, observatories will slew to detect it, further measure its apparent sky motion and orbit solutions, and characterize its nature. SPHEREx, with its all-sky survey, will be able to quickly mine its dataset to extract any already extant observations of it in the SSOC, as well as forward-predicting when the s/c will observe it next.

Example cont.

- Data compared with other spectra and cleaned
- Compared to a database to classify into
  - S-type (rocky)
  - M-type (metal)
  - C-type (carbonaceous)
- Typical albedos assumed → effective size estimated and light curve produced
- From other sources, astrometry will find orbital solutions
- Quick, rough estimates for dimensions, spin, shape, mass emission, etc.