The Mission Accessible Near-Earth Objects Survey (MANOS): photometric results

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What is MANOS?

- Multi-year survey awarded by NOAO: 2013B-2016B, and funded through NASA NEOO (PI: N. Moskovitz).
- Goal: Catalog physical properties of several hundred of sub-km Near-Earth Objects (NEOs).
- Two techniques: **spectroscopy** for composition, taxonomic class and albedo and **photometry** for astrometry (refine orbit), and lightcurve: rotational properties, morphology $\Rightarrow$ object fully characterized, observed with both techniques.
- Target selection: NEO has to be mission accessible, focus on small objects (diameter $<$1 km).
- Main facilities: 8.1 m Gemini Telescopes (north and south), 4.3 m Discovery Channel Telescope (DCT), 4.1 m Southern Astrophysical Research telescope (SOAR), 4 m Mayall Telescope, and 1.3 m SMARTS telescope.

The case of 2016 RB_1

Multi-facility study of asteroid 2016 RB_1 during its near-Earth encounter

The asteroid 2016 RB_1 was discovered on 5 Sept 2016 by the Catalina Sky Survey. Two days later around UTC 17:15 the object flew by Earth at a **distance comparable to the orbit of geosynchronous satellites.**

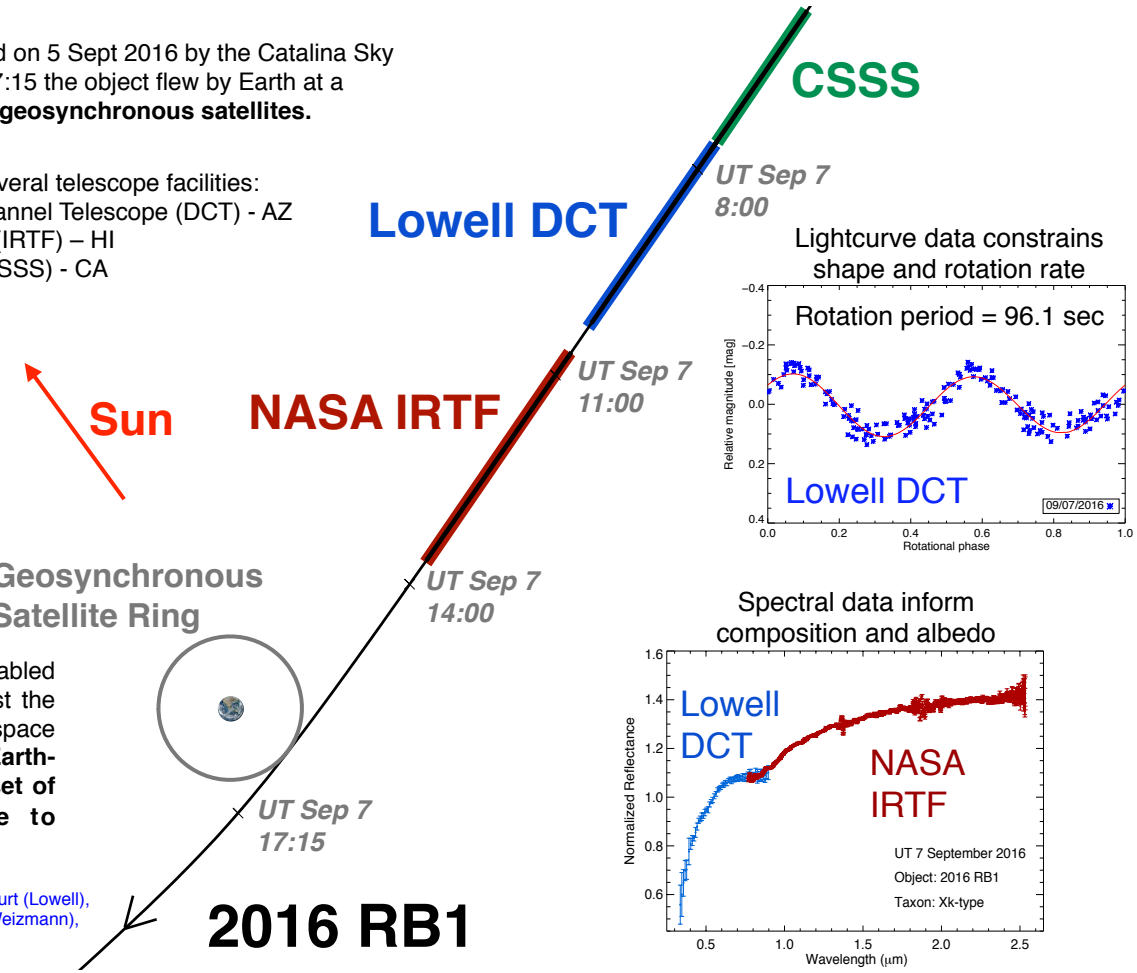
Observations were conducted from several telescope facilities:
- Lowell Observatory's Discovery Channel Telescope (DCT) - AZ
- NASA's Infrared Telescope Facility (IRTF) – HI
- Center for Solar System Studies (CSSS) - CA

Spectral data from DCT and IRTF constrain **composition** and **albedo**. Inferred **size of object is 3-9 meters**. Data suggest a **metal-rich** composition

Lightcurve observations from DCT, IRTF, and CSSS suggest a **rapid rotation period = 96 seconds.**

Target-of-opportunity observations enabled study of this object, which is amongst the smallest observable in near-Earth space and is **representative of both the Earth-impacting population and the subset of asteroids that are accessible to spacecraft exploration.**

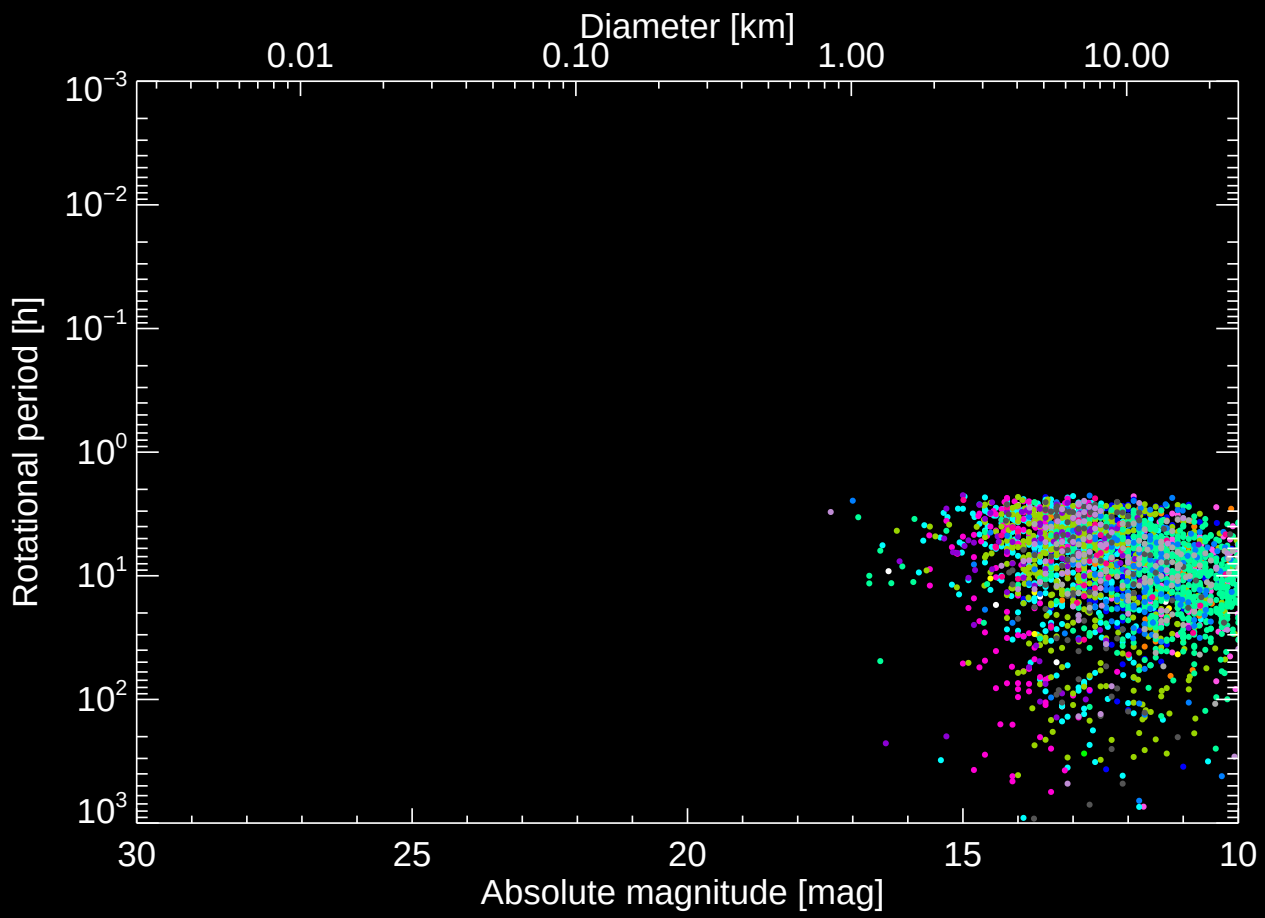
Observations & analysis: N. Moskovitz (Lowell), B. Burt (Lowell), T. Burt (Lowell), A. Thirouin (Lowell), D. Polishook (Weizmann), B. Warner (CSSS), V. Reddy (LPL)



Lightcurve data constrains shape and rotation rate

Spectral data inform composition and albedo

Rotational properties



- Rotational period versus size: asteroid with a diameter $>$1 km.
- Spin barrier at $\sim$2.2 h $\Rightarrow$ An object made to spin faster would shed material, or break apart.
- Information about the object's structure.
- Some large objects can rotate faster than the spin barrier.
- Small objects are able to rotate down to few minutes.
- Rubble-pile versus Monolithic asteroid.

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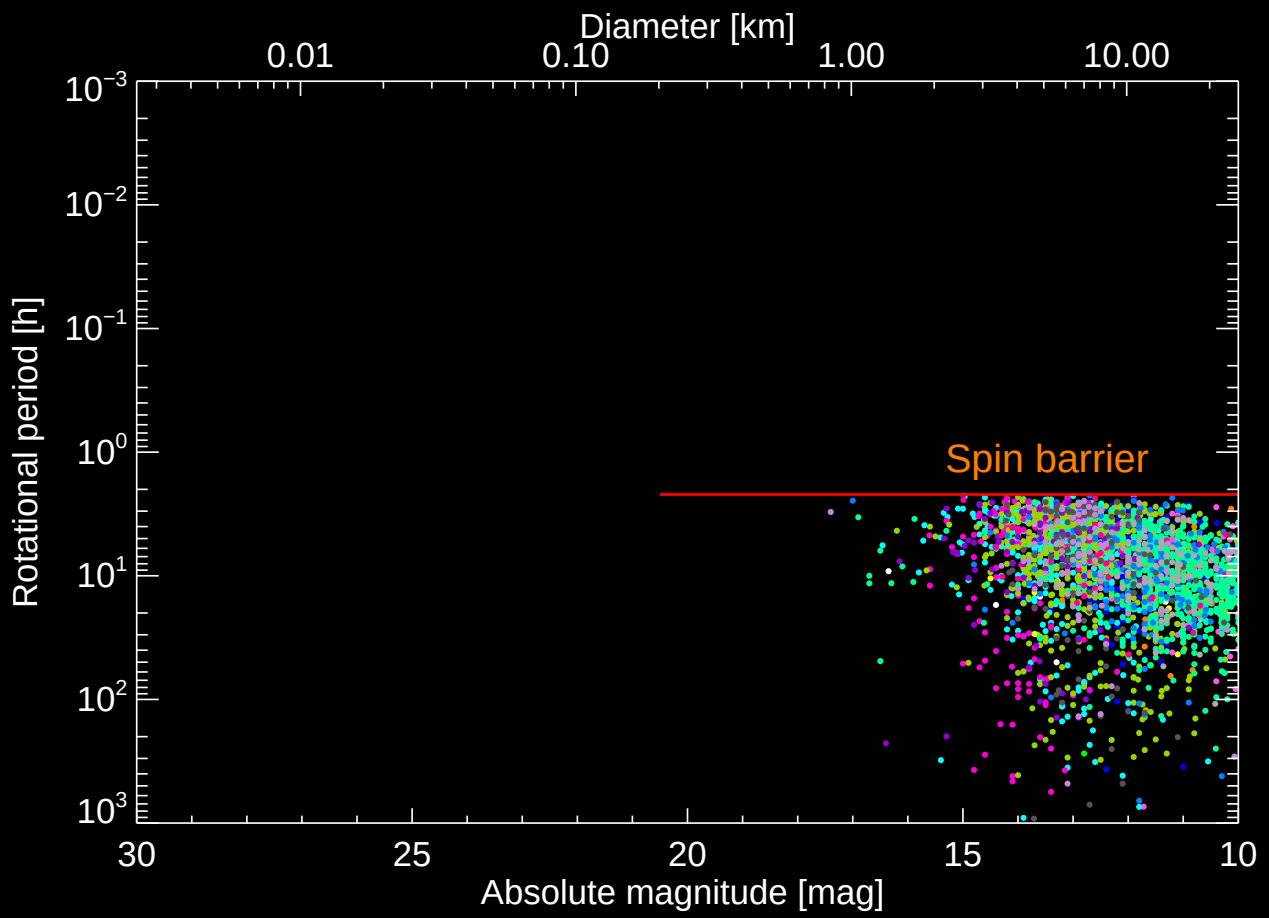

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Rubble-pile dominated by gravity.

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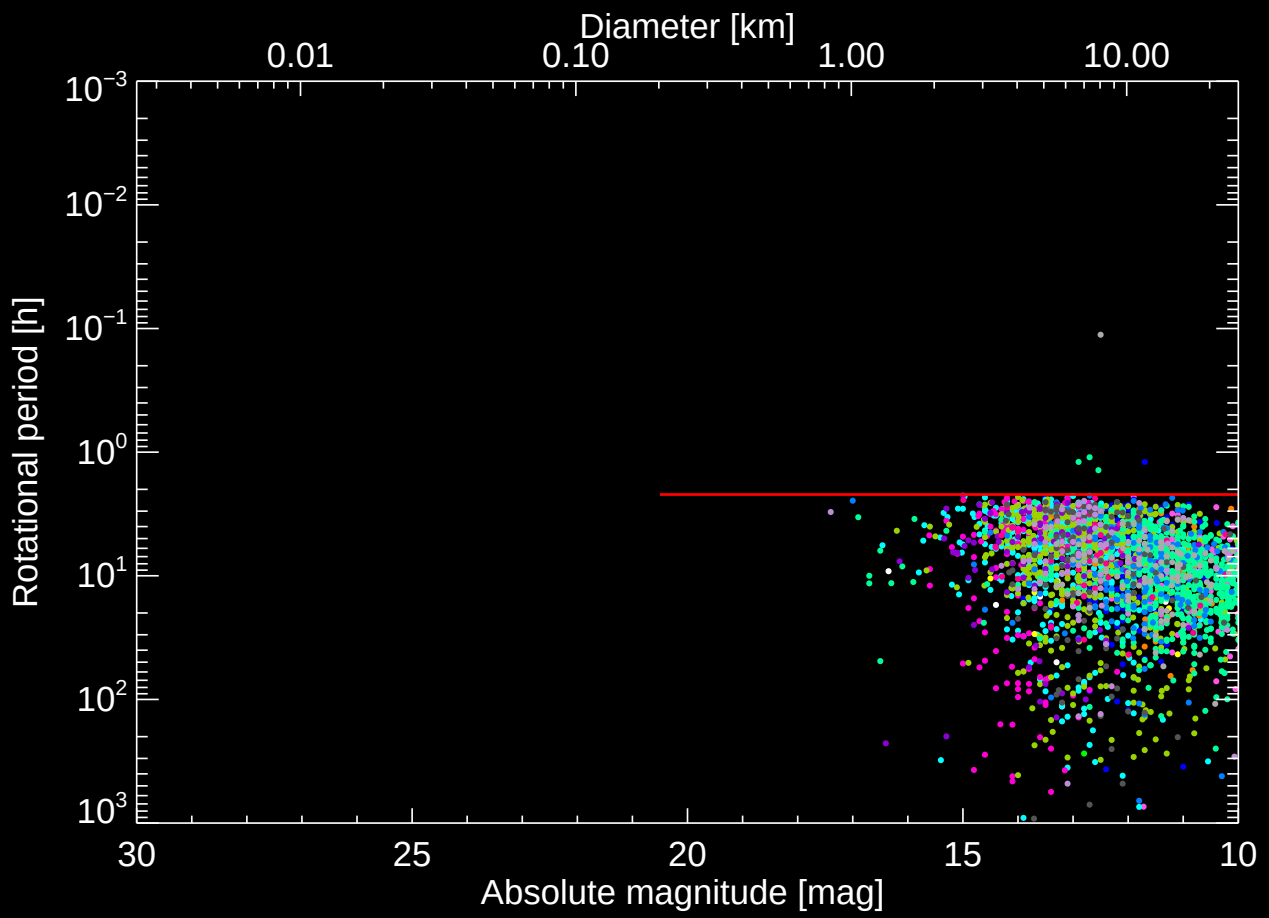

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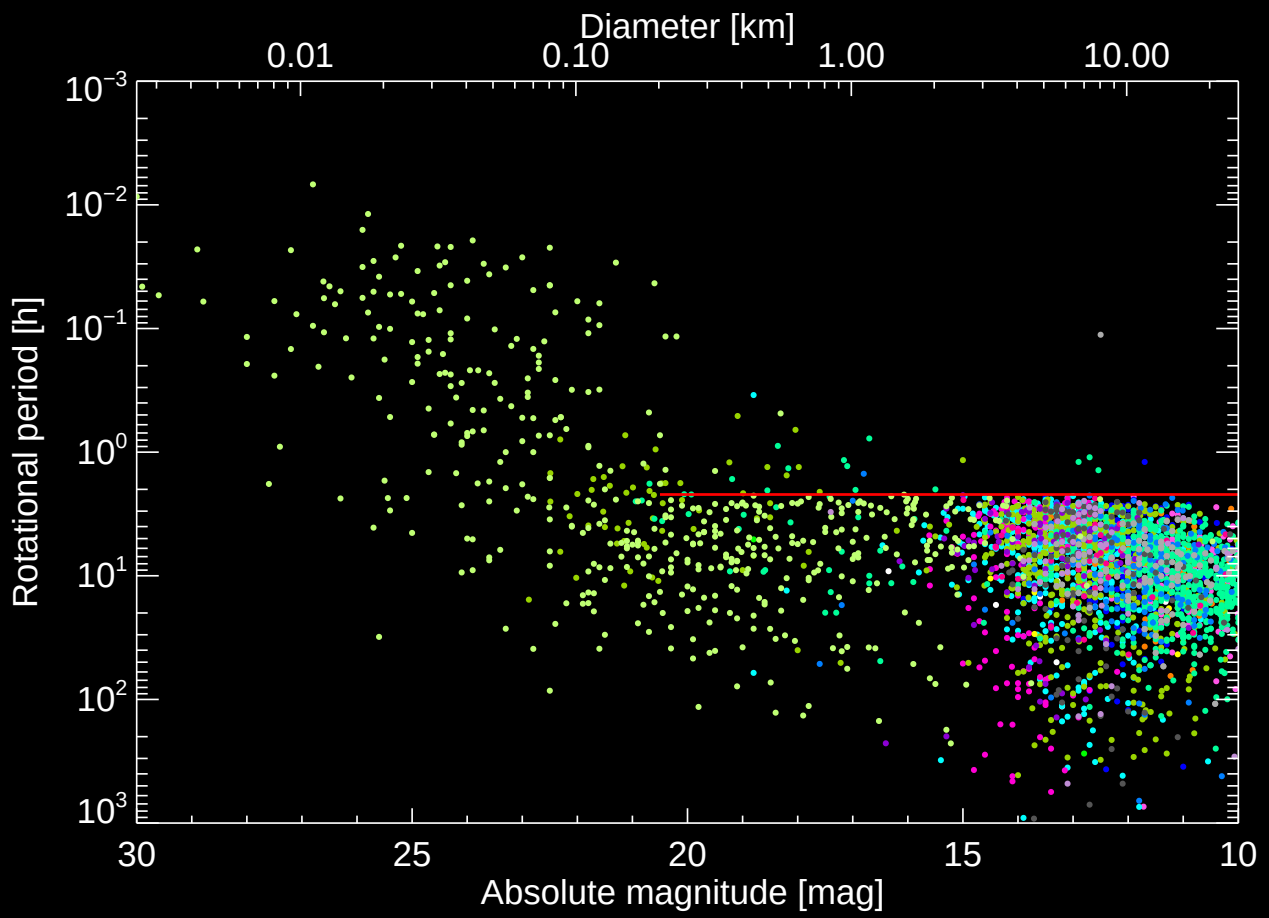

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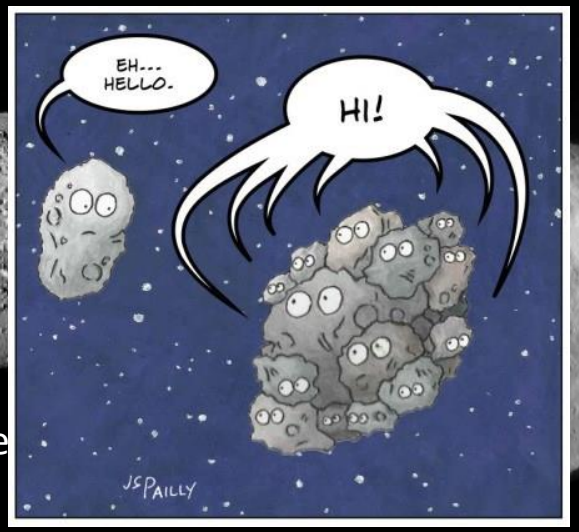

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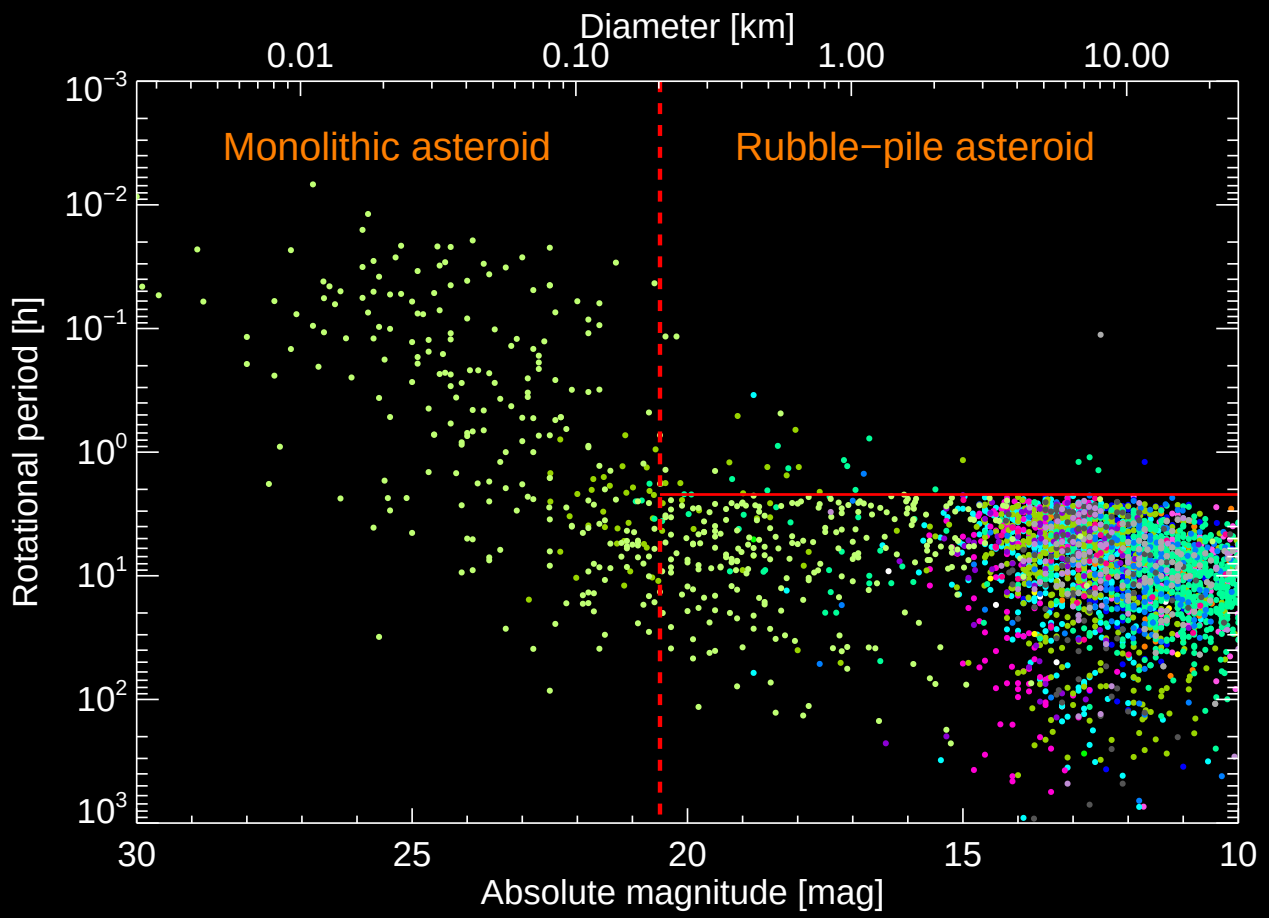

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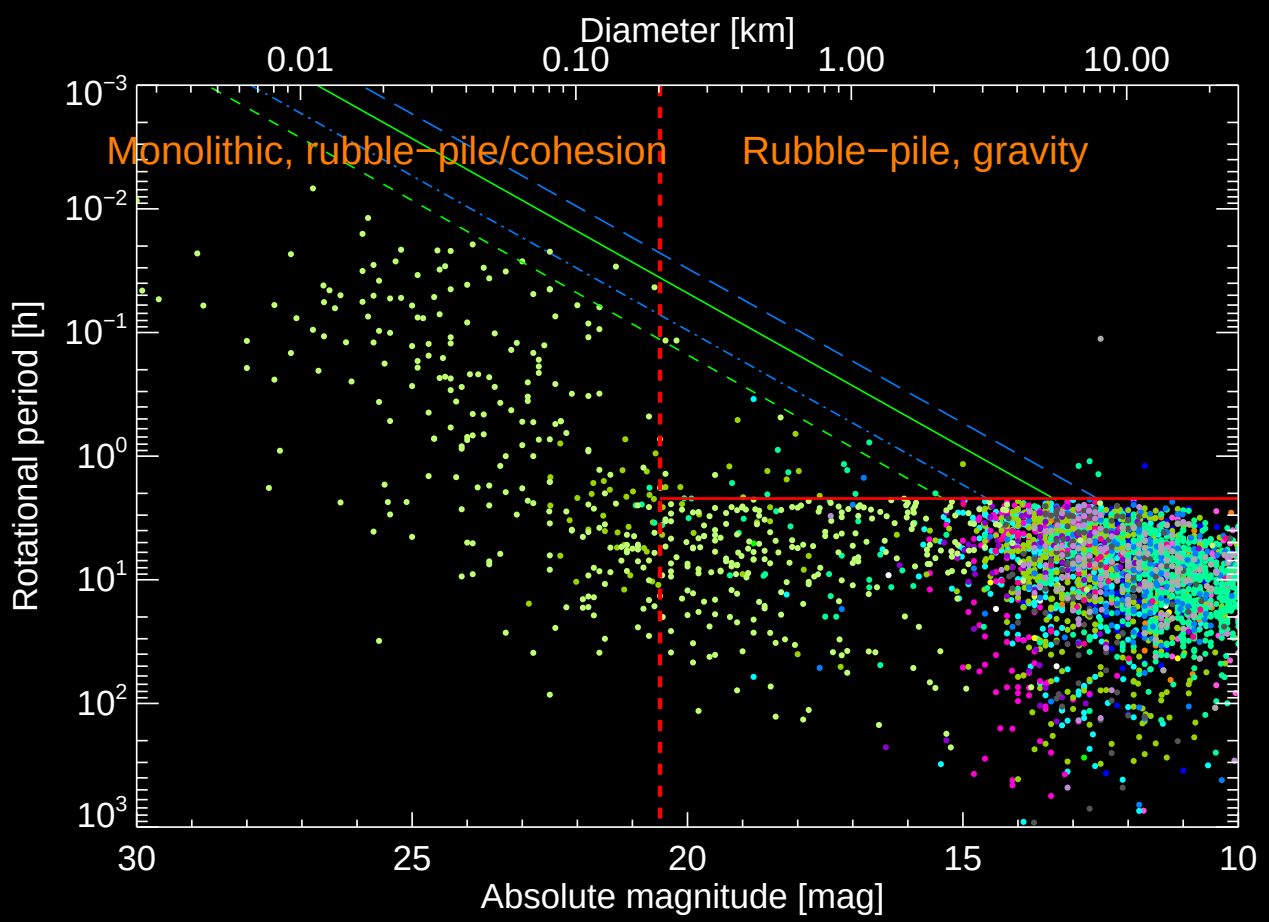

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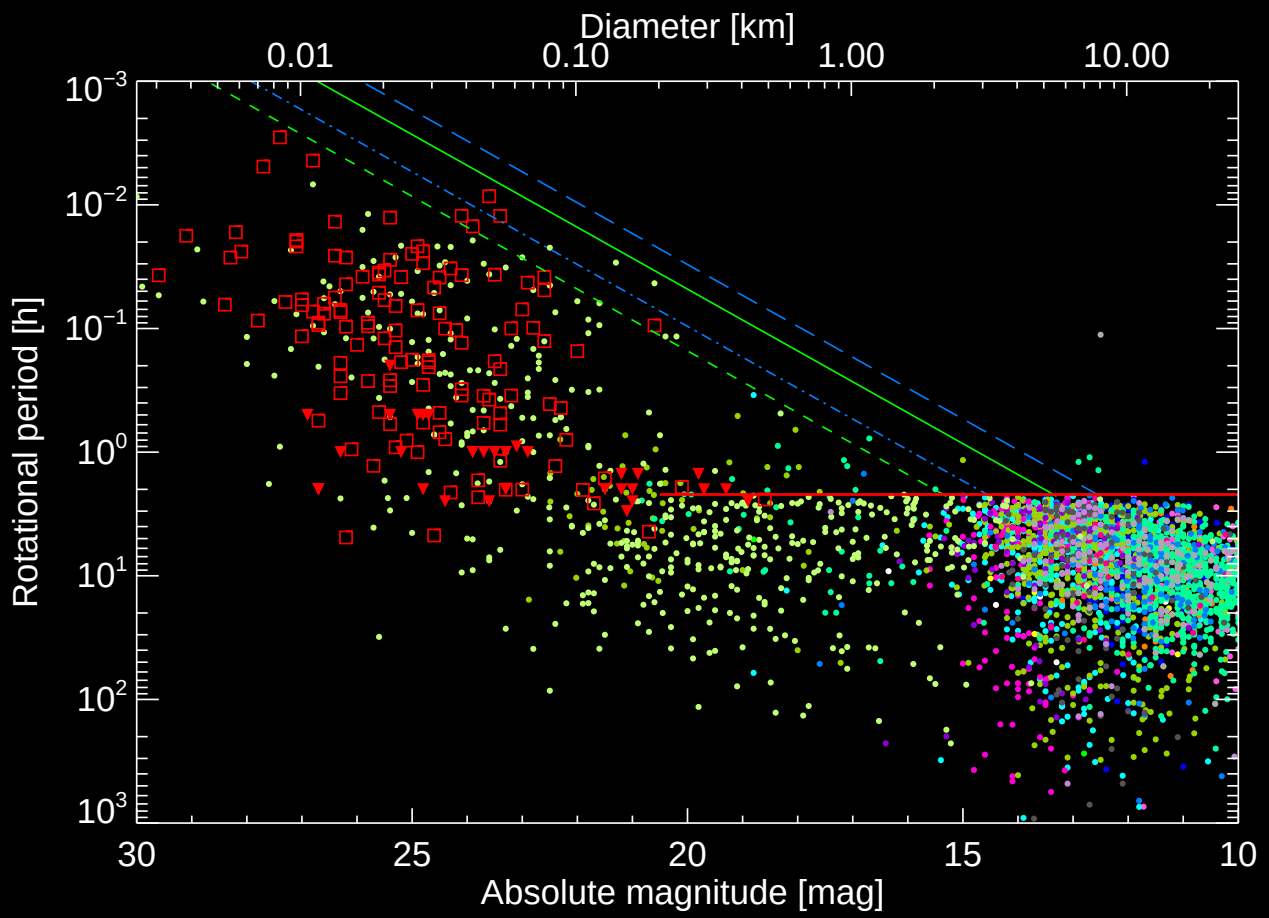
MANOS: photometric results



- 200 NEOs observed for lightcurve: 63% of full lightcurve, 16% of partial lightcurve, and 21% of flat lightcurve.
- Smallest NEO observed: diameter of $\sim$ 3m.
- Three ultra-rapid rotators: periods of 15.8 s, 17.6 s, and 18.4 s.