NEO Physical Characterization: Spin Rates and Spectra

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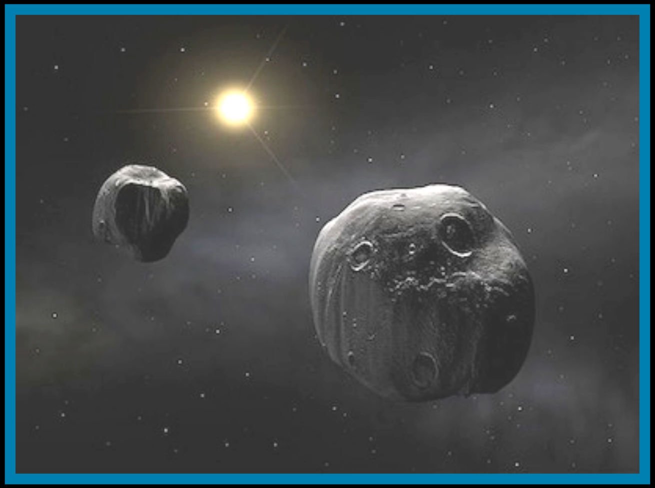
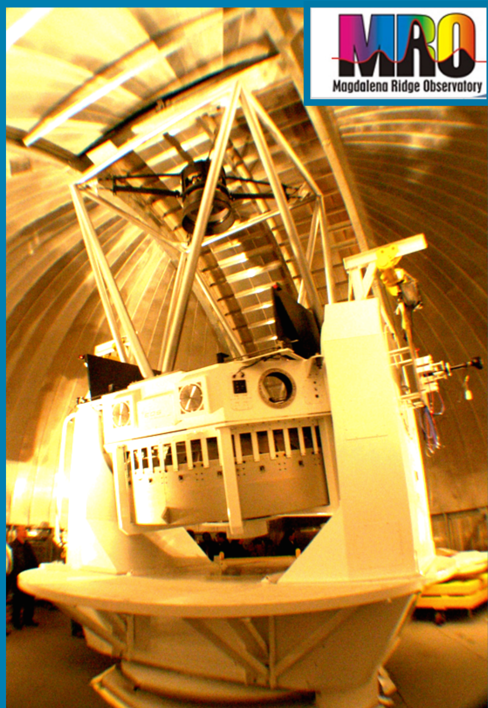
Target Characterization



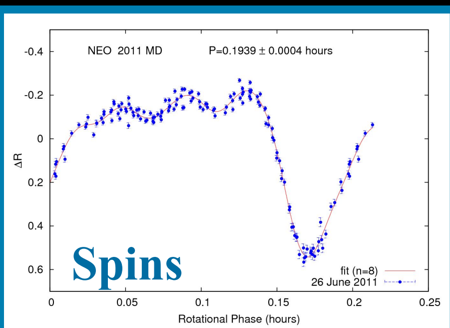
- After discovery, more information to characterize the NEO population is needed: size, composition, & rotation rate; this information is also useful for selecting human spacecraft mission targets (maybe asteroid retrieval?).
- Timing for asteroid follow-up and physical study is <u>critical</u>: when objects are first discovered they are in a prime location with respect to visibility (i.e., brightness) from the Earth. Access to larger telescopes on short notice is advantageous (rapid response).

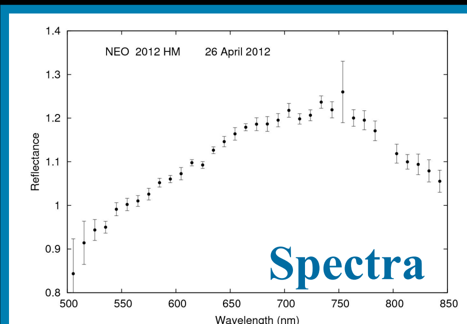
Magdalena Ridge Observatory 2.4m Telescope

(Eileen and Bill Ryan, Socorro, NM



Limiting Magnitude V~24.5





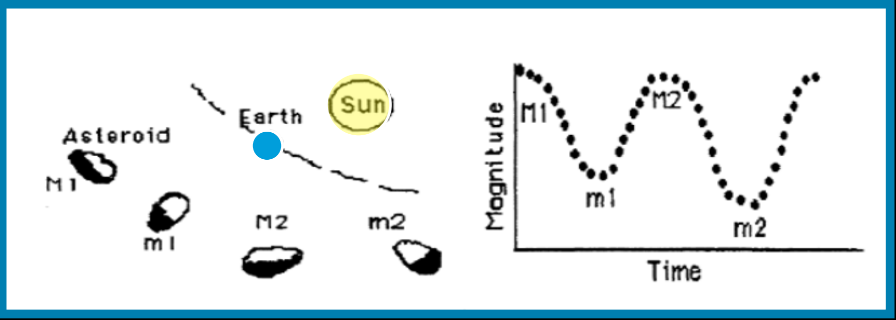
- **The MRO 2.4-meter is part of NASA Spaceguard, and does follow-up on even the smallest asteroids ~9 nights per month**
- **Capitalizes on real-time opportunities to observe close-approaching, NEAs to calculate spin rates, and roughly determine composition.**
- **Coordinates with Radar**
- **Characterizes Potential Spacecraft targets**

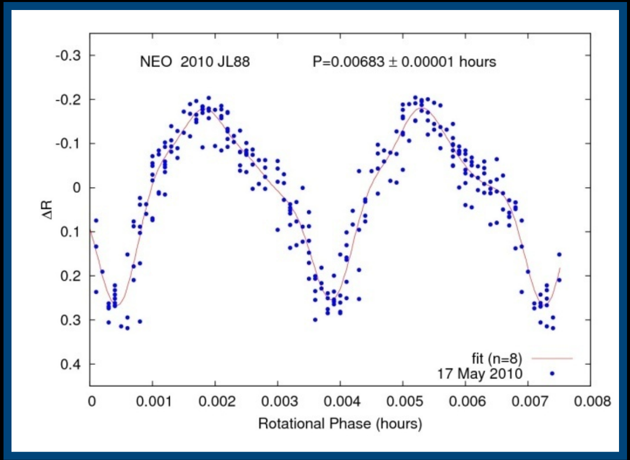
Research Objective:

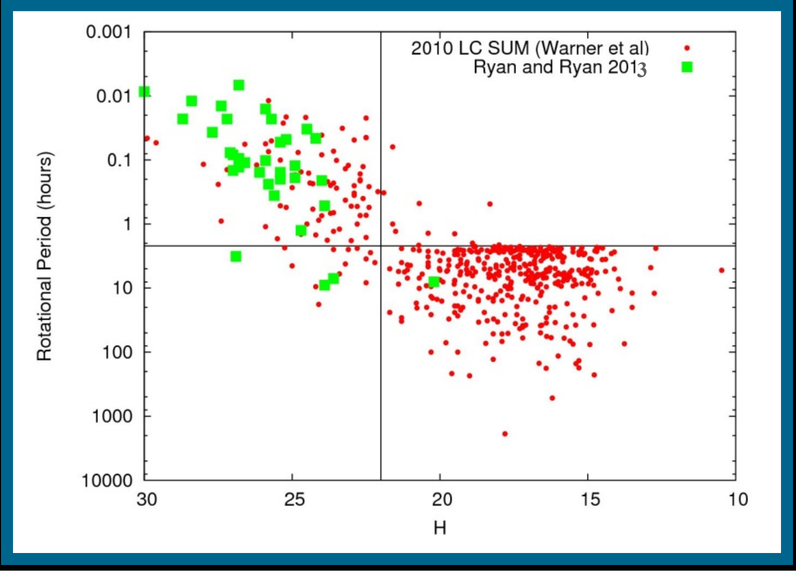
- **Problem**: there is limited data on physical properties such as **rotation rate** and **composition** for the very smallest **(< 200 m in diameter) Near-Earth Asteroids** (NEAs) being discovered.
- **Objective**: **Observing Program** to gather data needed to better understand the **spin rate distribution** for the NEA population as a function of size, and to test current theories of the relationship between **spin limits and overall strength.**
- **Dataset**: **~60 lightcurves of NEAs** collected at the Magdalena Ridge Observatory's **(MRO) 2.4-meter telescope** reduced for rotation rates. Initiating **visible spectroscopic** database.
- **LC Amplitudes**: can infer degree of **internal fracture** (i.e., rubble pile objects would tend to exhibit different **axial ratios** than monolithic fragments created via impact events.

Target Characterization: Spin Rates

Again, timing for asteroid follow-up and physical study is <u>critical</u>: after first discovery, objects may only be observable for a few days.

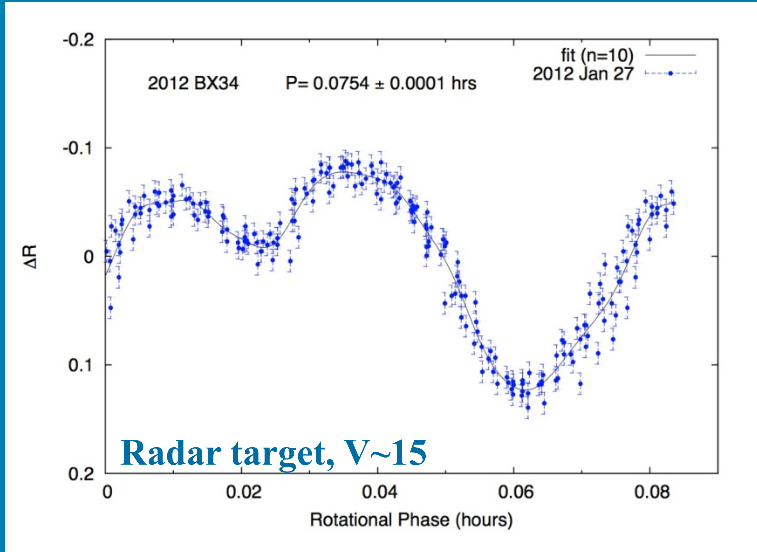


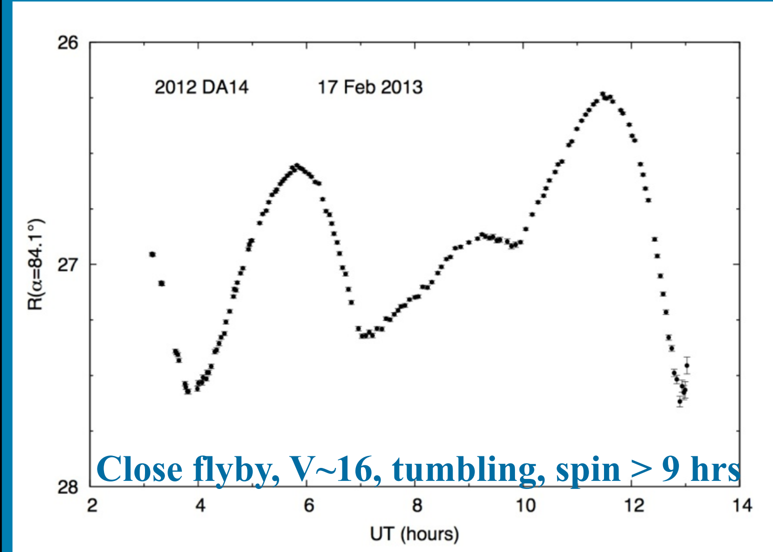


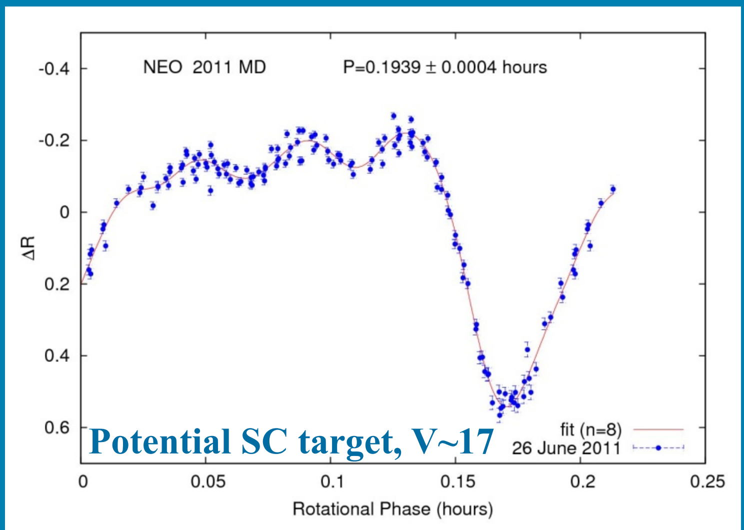


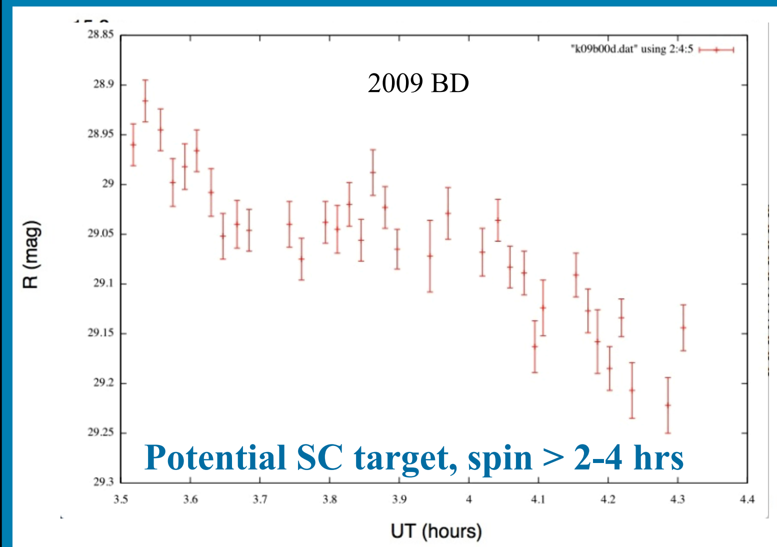
The lightcurve for NEA 2010 JL_{88} (H=26.8, diameter ~19 m), taken when the object had a visible magnitude of V~16.5. This object is spinning at a rate of 24.5 seconds, which is the fastest NEO rotation rate currently observed.

MRO 2.4m Telescope: Characterization of Flybys

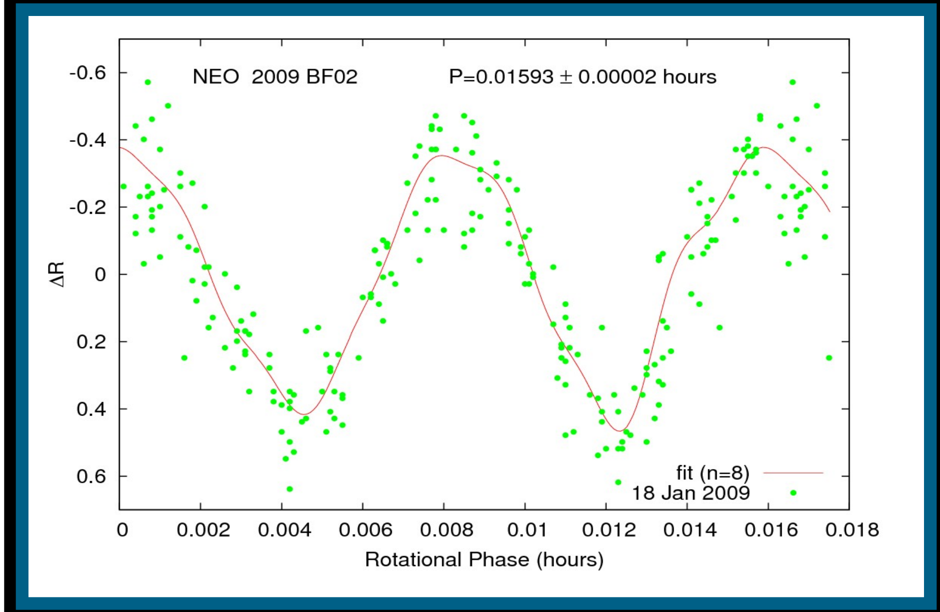


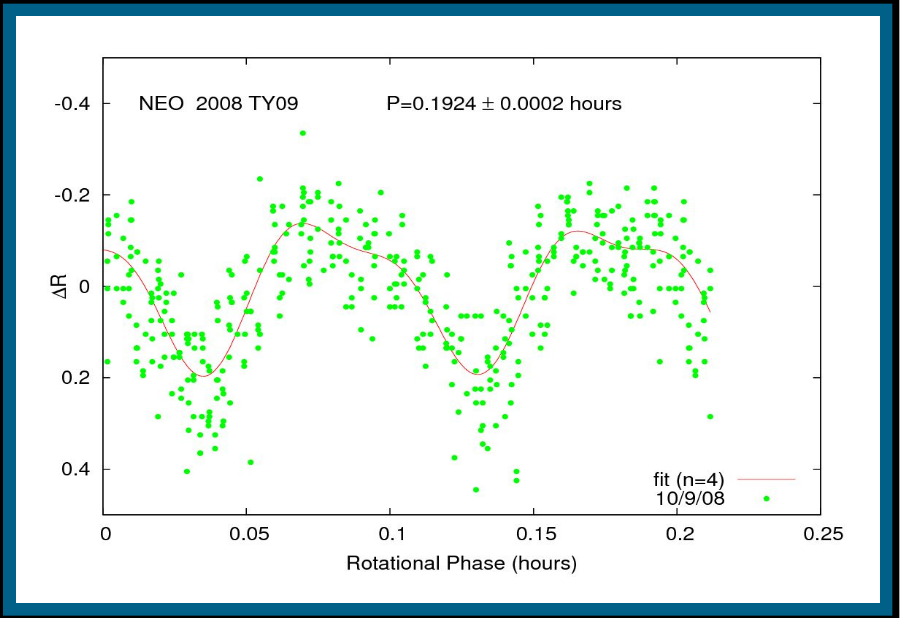






Fast, Small Diameter Rotators



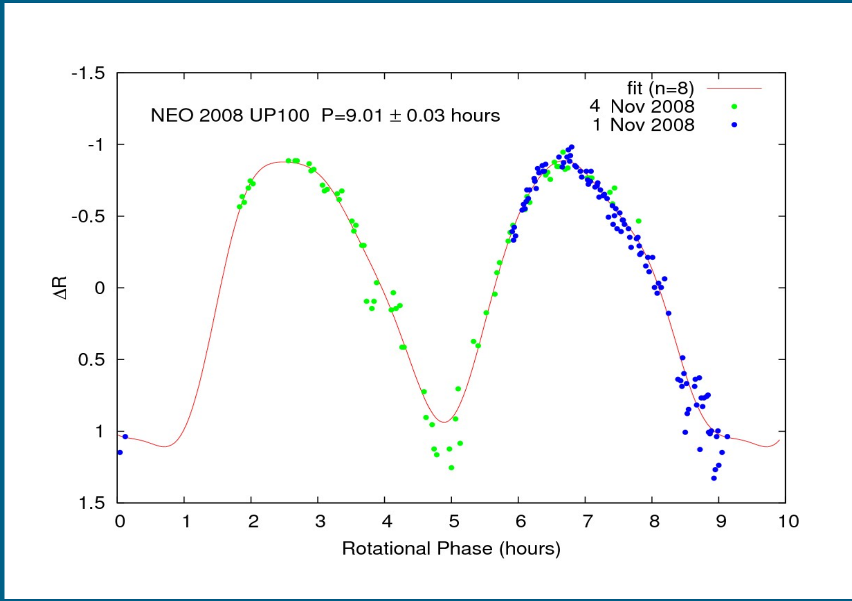


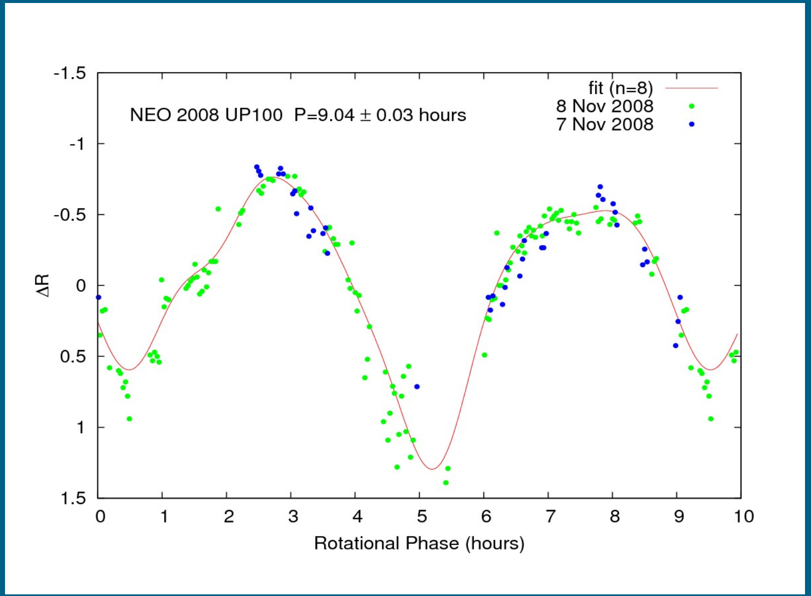
Size=20-50 m; V~18.3; motion 19"/min

Size=25-75 m; V~19.5; motion 10.42"/min

The lightcurve for NEO 2009 BF$_2$ is shown on the left. It's 57 sec rotational period and is *indicative* of a monolithic body. On the right is the lightcurve for NEA 2008 TY$_{09}$, which has a period of 11.5 min.

Large Amplitude Variation





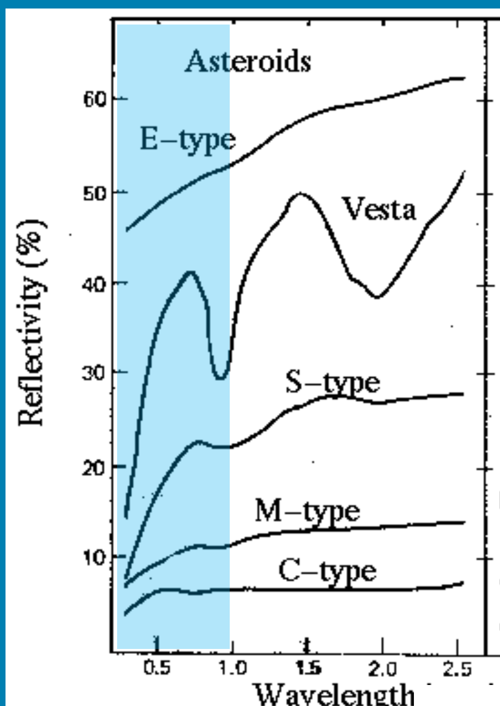
NEO 2008 UP_{100} (H=23.9; diameter ~50 – 100 m) during 4 nights in Nov. 2008. Solar phase angle was 29 - 39° for Nov. 1-4 and 21 - 23° degrees for Nov. 7-8. A large amplitude of ~2 magnitudes is still evident at the lower phase angle. Rotation rate is 9 hours.

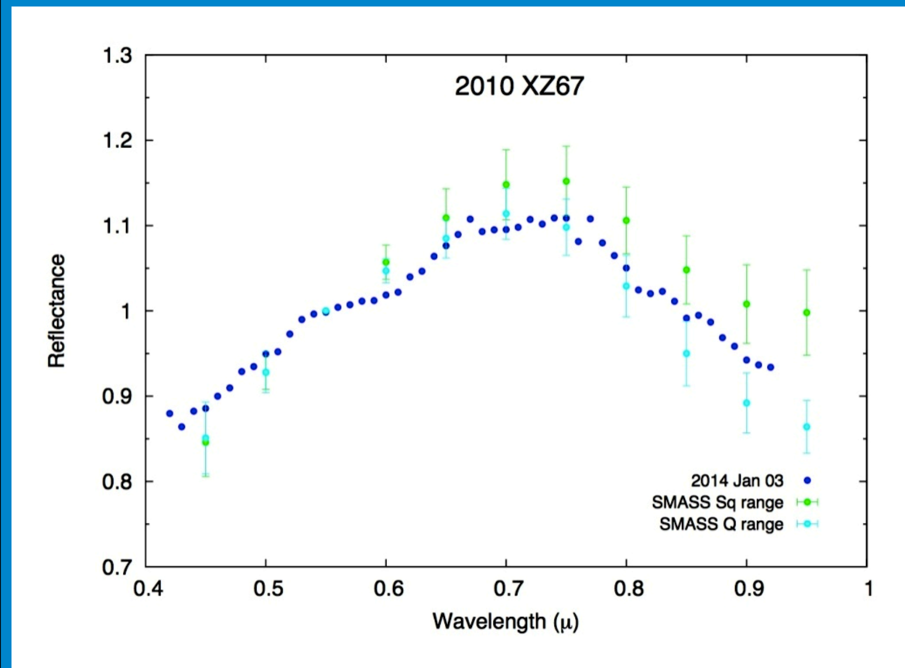
Recent modeling of rubble pile structures by Harris et al. (2009) indicates that this amplitude borders on or exceeds the elongation limit of a slowly rotating strengthless object, implying that this asteroid may have a non-negligible material strength.

Target Characterization: Visible Spectra

Asteroid 2010 XZ_{67}

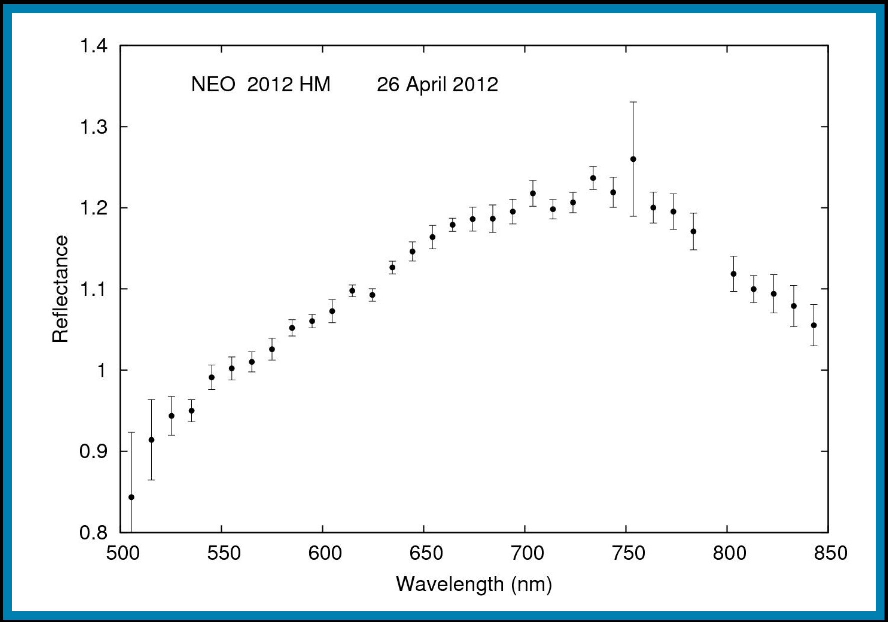
Asteroids are varied mixtures of metals (M-type), carbon (C-type) and silicon (S-type) compounds. We do a first-order match of telescope-acquired spectra to known materials. Composition helps constrain size (albedo).

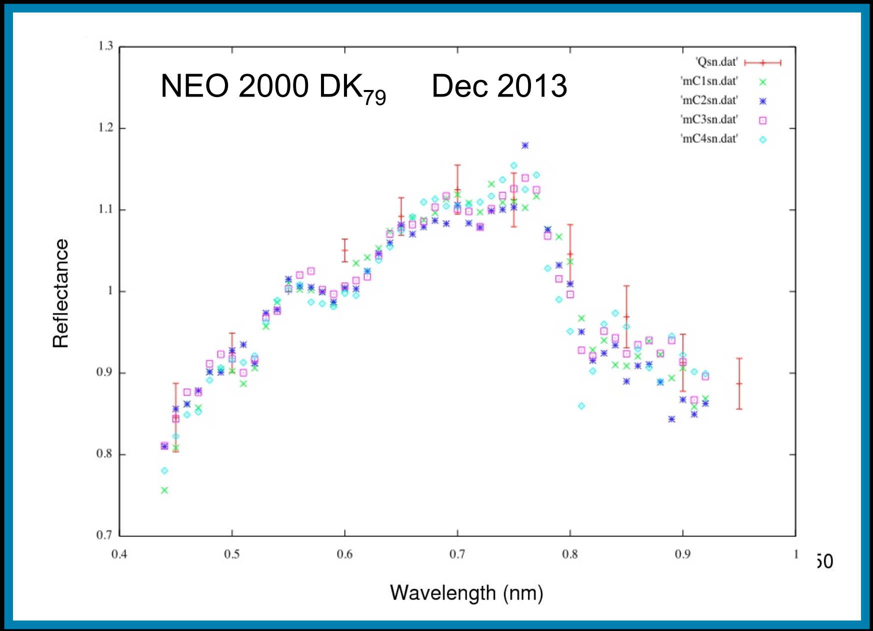




Visible spectrum of asteroid 2010 XZ_{67} (dark blue symbols) indicating an Sq-Q-type composition (silicate/metallic). Comparison spectra are shown (green & light blue symbols).

Target Characterization: Visible Spectra





Spectral characteristics (visible wavelengths) of NHATS list target 2012 HM (left); the spectrum indicates that it is likely an S-type asteroid: characteristic steep slope shortward of 0.7 µm, and a small dip at 0.63 µm. Spectrum of asteroid 2000 DK$_{79}$ (right) indicating an Sq-Q-type composition (silicates/metals). These objects were also extensively studied by radar groups.

Summary: Rapid, Real-time Follow-up of NEOs

- Follow-up Astrometry: allows accurate orbits to be calculated

- Spin Rates: reveal how fast an asteroid is rotating, whether it' s tumbling, & shape characteristics

- Spectra: Rough composition determination helps constrain size (albedo, i.e., dark or bright) and identifies interesting potential spacecraft targets