Target-of-Opportunity Characterization of Sub-200 meter Near-Earth Asteroids

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NEO Astrometric Follow Up

Single 240-second exposure of V~24.1 target 2012 QK24

10-sec exposure of V~21.1 target 2014 DF10 moving at ~8.5”/min

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Extending to Characterization

Astrometry: 2014 JR_{24} (7 May 2014):
½-second images of bright (V~15.6) target moving at 300 ″/minute

Photometry: 2015 FP_{35} (24 March 2015):
30-second images of V~18 target moving ∼40 ″/minute
Magdalena Ridge Optical Spectroscopy System (MOSS)

- Dual-use R~250 spectrometer
- Permanently mounted at the second Nasmyth port
- Current Magnitude limit V~18-19

Slitless Grating

- Filter Wheel Mounted
- Current Magnitude limit V~17-18

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Targets of Opportunity

5 - 20 km/sec ~ 0.003-0.011 A.U. per day

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Observation Timeframe: Several Days

The lightcurve for 2015 FP$_{35}$ (H~24.3) exhibits tumbling behavior with a primary periodicity of ~1 hour.
Observation Timeframe: 1-2 Days

Lightcurve (left) for 2015 DB (H~27.7) which only stayed in the characterization zone for about 2 days. A visible grating-derived spectra is shown on the right, with SMASS A-type ranges overplotted. The spectra is derived from twenty 60 second exposures summed and calibrated with a solar standard.
Asteroid $2015\,FM_{118}$ ($H\sim28.7$) was moving at approximately 80 arc-seconds per minute through a crowded star field, which made a slitless grating spectra difficult to impossible to obtain. However, a lightcurve was acquired yielding the approximately 61 second rotation period.
Interesting Results

2010 JL_{88}: H~26.8 (~12 - 25 meters)

2009 BD: H~28.1 (~8 – 15 meters)

2015 HM_{10}: H~23.6 (~50 – 100 meters)
Spin Rate vs. Size

A plot of rotation period vs. absolute magnitude (H) where the red circles are NEAs from (Warner et al. 2015) and the green squares are new data acquired via this current work.
(Naive) Rubble Pile Rotation Barrier

\[ F_{\text{gravitational}} > F_{\text{centripetal}} \]

\[ \Rightarrow \text{Period} > \sqrt{\frac{3\pi}{G\rho}} = \frac{3.3 \text{ hours}}{\sqrt{\rho}} \]

\[ \Rightarrow \text{Period} > 2.2 \text{ hours for } \rho \approx 2.2 \left(\frac{g}{cm^3}\right) \]

Pravec and Harris (2000) – But . . . .

not really that simple!! (Holsapple 2003)
Significance to Hazard Mitigation

Rebold and E. Ryan, 2015

Harris, 2010

International Schiller Institute

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Small Asteroid Impacts are *Real* Threat

- Carancas, Peru (2007) ~3 m impactor
  (Tancredi et al., *ACM* 2008)
- 2008 TC3 Sudan (2008) ~4-5 m
- 2014 AA Atlantic?? (2014) ~1-3 m
- Tunguska, Siberia (1908) ~50 m
- **Chelyabinsk** (2013) ~20 m

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Other Perspectives: Impact Experiments

- Examine initial size, rotations, and tumbling behavior of monolithic asteroidal material from fragmentation ejecta
- Validate Numerical Codes
Spin Rates:
- Not all small asteroids are fast rotators – current sample may be observationally biased. Therefore, to fully understand the structural constraints imposed by observed spin rates, effort must be made to ensure completeness of the sample (especially slower rotators)
- Compare observed spin rate characteristics with impact experiments. How much of observed spins in monolithic objects can be attributed as primordial? How much requires a ‘spin up’.

Spectra:
- Better sample composition of the small NEA population
- Provides inputs and constraints to dynamical evolution models
- Composition, along with lightcurves, can provide hints to the (ranges of) material strengths of small asteroids.
Asteroid Impact Scenario: WT1190F

Practice mission:

- MRO is a research team member of the Rapid Response Consortium (RRC) providing astrometric and characterization data for (future) asteroids impacting the Earth.

- WT1190 is likely a spent rocket body (~1 meter in size) that will impact the Earth over the Indian Ocean near Sri Lanka on Nov 13, 2015. MRO astrometric data is helping to constrain the region of impact.

- The United Arab Emirates together with the RRC is sponsoring an airborne observing campaign to study the entry of space debris object WT1190F. The European Space Agency is also conducting a ground based observational campaign.