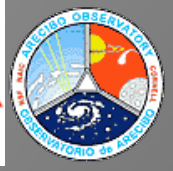
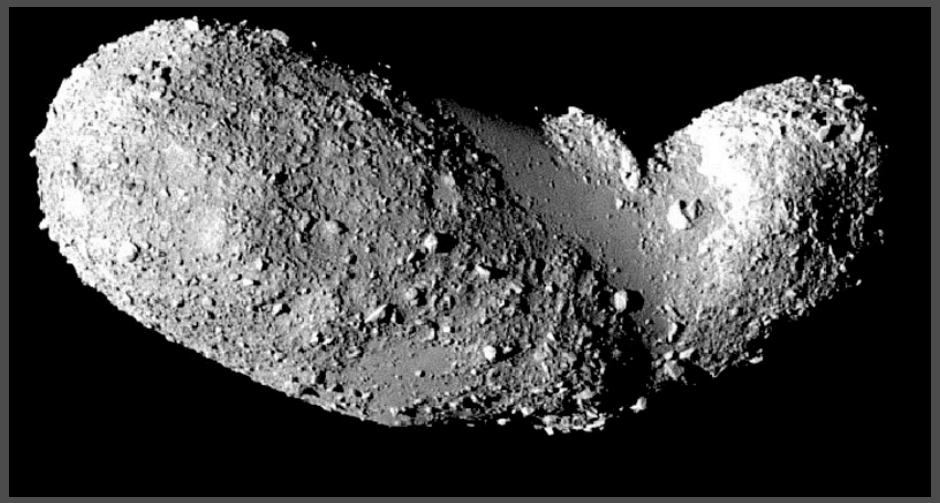


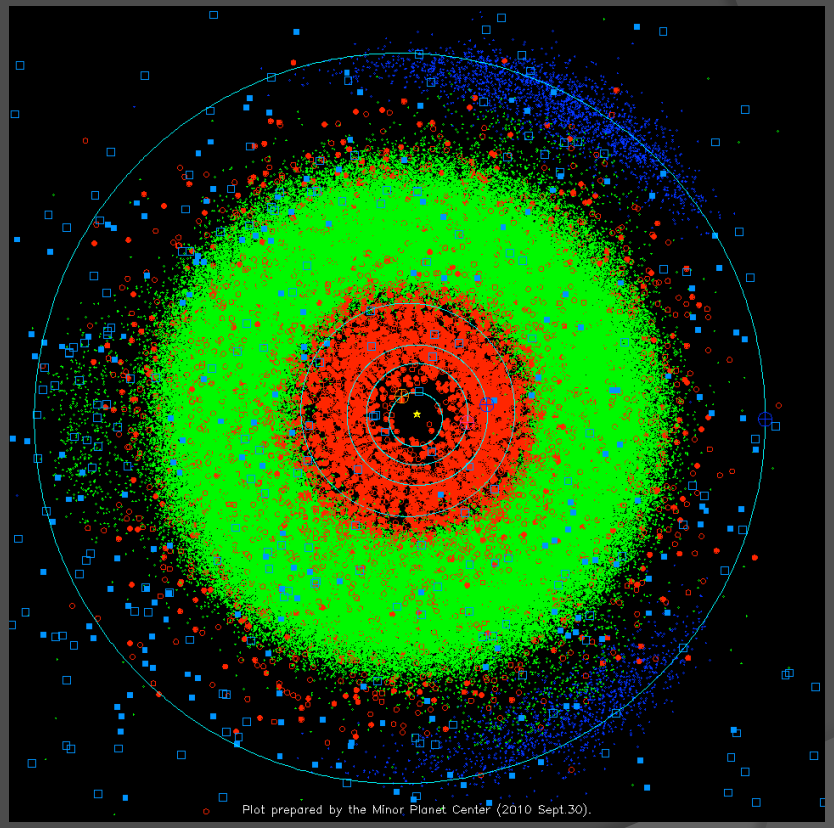
Near-Earth Asteroids And Radar Speckle Tracking

Michael Busch

Near-Earth Asteroids



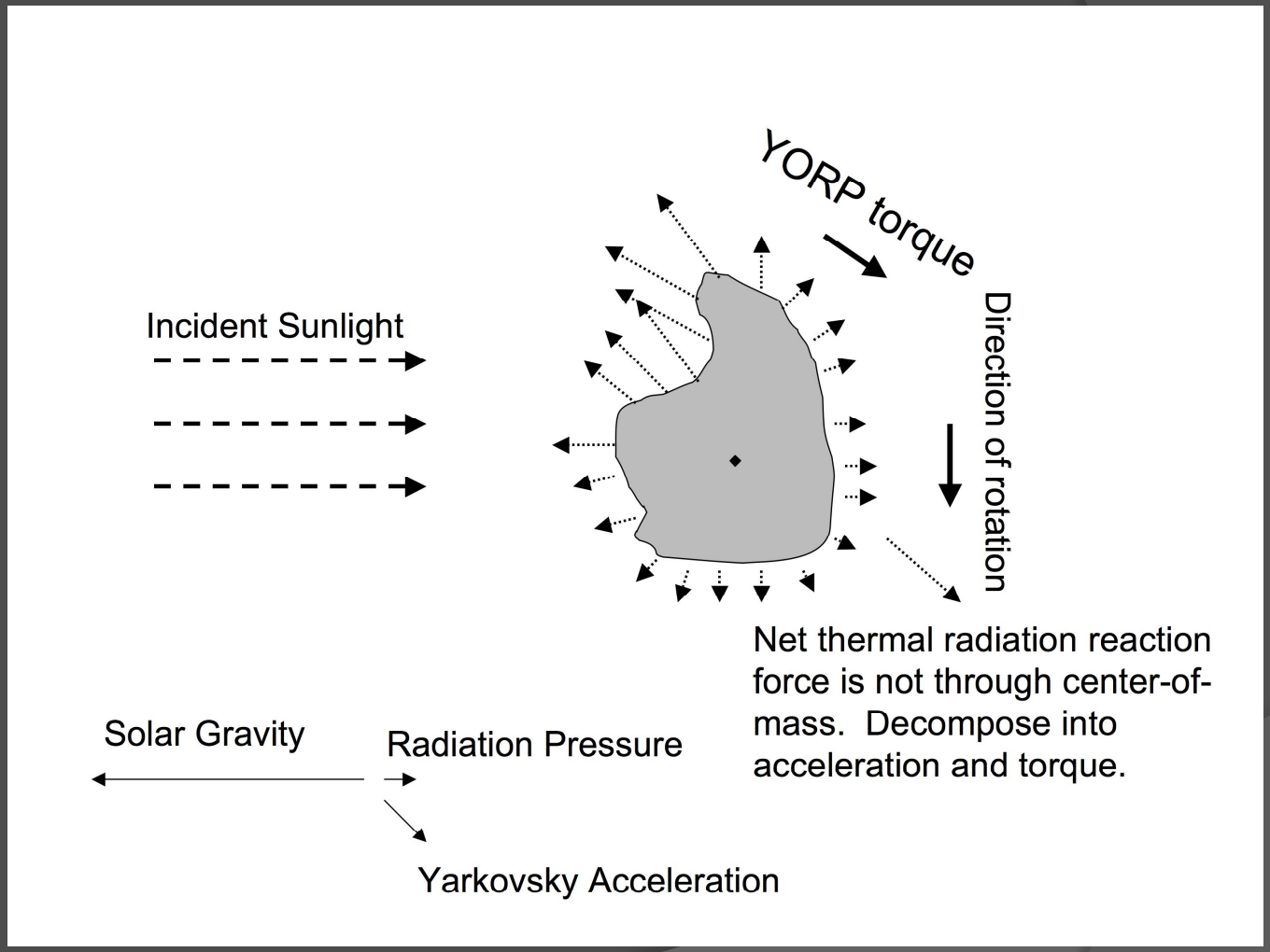
Near-Earth asteroid Itokawa, imaged by the Hayabusa spacecraft. ~450 m long.



Inner Solar System from ecliptic north. Red dots are objects on Earth-crossing orbits

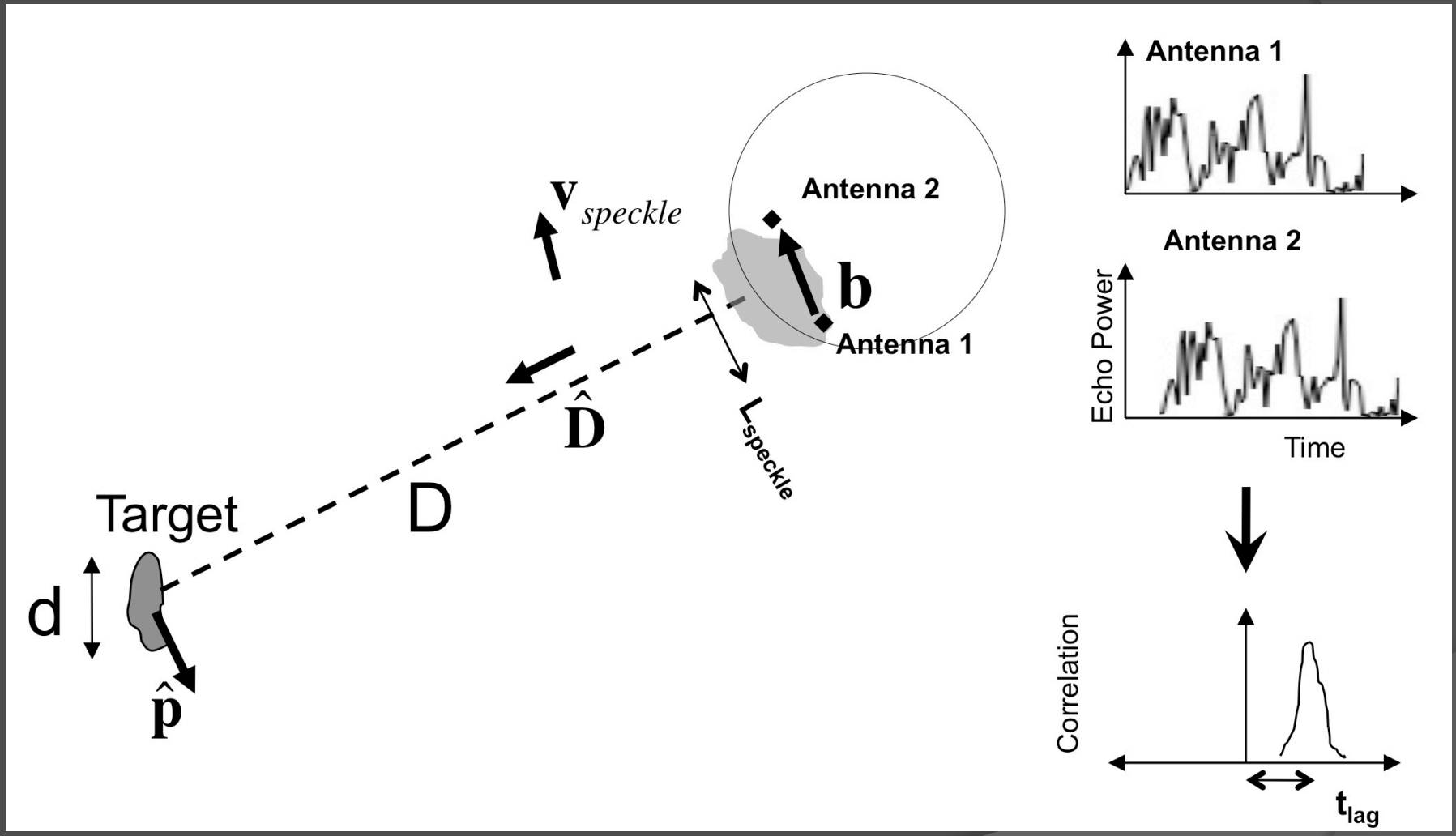
Yarkovsky & YORP Effects

Ivan Osipovich Yarkovsky, circa 1900.



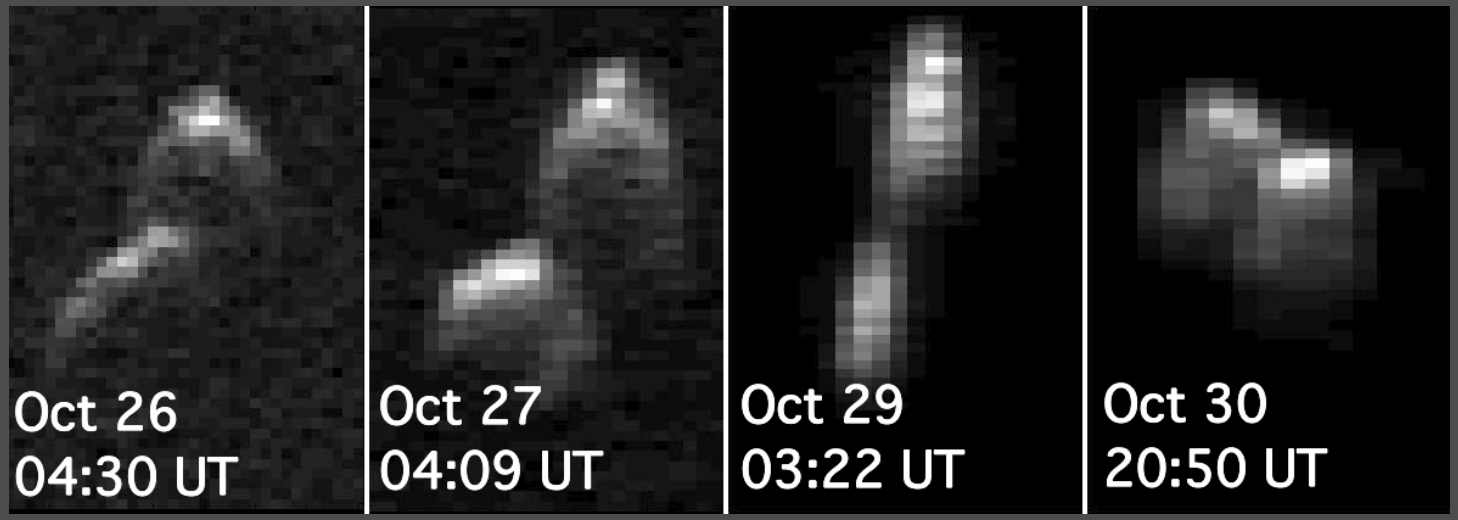
Radar Astronomy

Radar Speckle Tracking



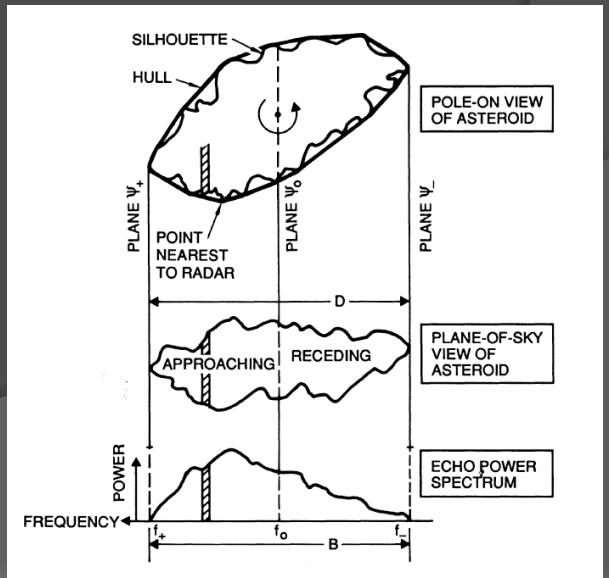
Schematic of radar speckle tracking. As the speckle pattern moves across the Earth, speckles are received at different times at different antennas. Time lag exaggerated for clarity.

An Example: 2003 UV11

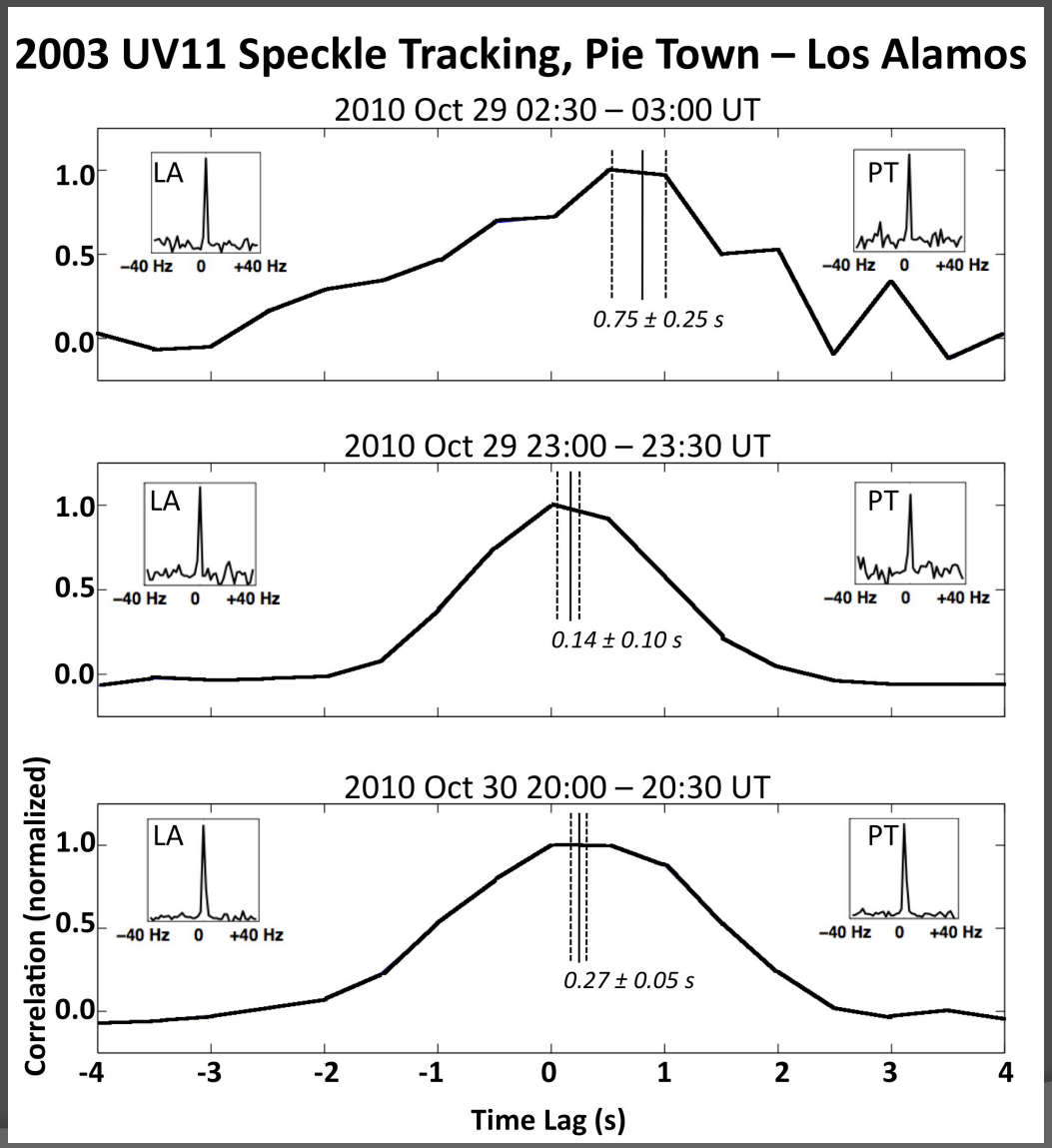


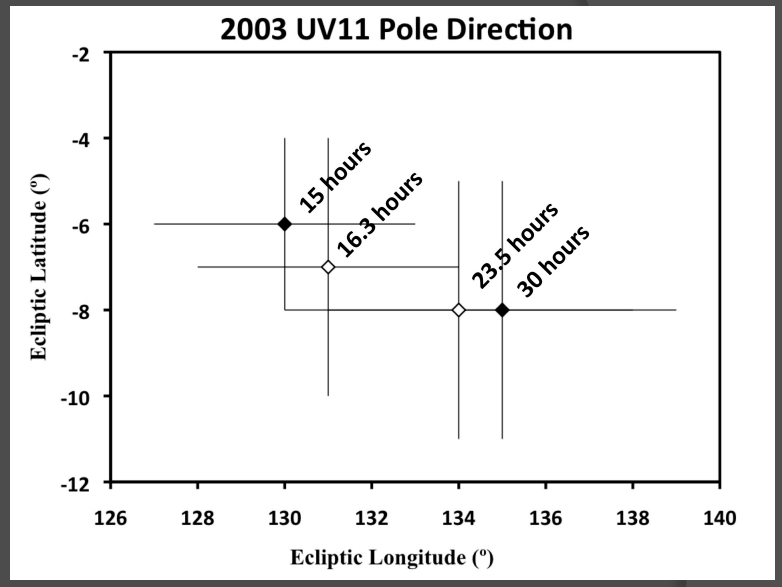
Delay-Doppler radar images of 2003 UV11, with 15-m range resolution. Times are in 2010 October.

Like Itokawa and 10-15% of all near-Earth asteroids larger than 200 m, UV11 is a contact-binary asteroid. Its shape consists of two lobes in mutual contact.



UV11's Pole Direction





UV11's obliquity is ~104°. The asteroid's spin axis is nearly in its orbit plane.

Contact Binary Obliquities

High-Obliquity Objects (50º – 130º)

Object	Obliquity (º)			Reference
Mithra	68 ± 6	or	105 ± 6	Brozovic et al. 2010
Castalia	126 ± 13	or	74 ± 13	Hudson et al. 1997
2003 UV11	**104 ± 4**			**Busch et al. 2012**
Bacchus	110 ± 20			Benner et al. 1999
1996 HW1	129 ± 5			Magri et al. 2011
Sigurd	70 ± 20	or	110 ± 20	Busch et al. in prep
2004 XL14	57 ± 18	or	123 ± 18	Busch et al. in prep
1999 RD32	108 ± 20	or	75 ± 20	Nolan et al. in prep

Low-Obliquity Objects

2000 YF29	20 ± 30	or	160 ± 30	*Busch et al. in prep*
Toutatis*	146 ± 3			Ostro et al. 1999
Itokawa	178 ± 4			Demura et al. 2006

Is There An Excess of High Obliquities?

- 8/11 → 73 ± 16 % of contact binary NEAs have obliquities between 50º and 130º.

- 10/25 → 40 ± 13% of other single NEAs.
- 3/9 → 33 ± 19% of binary and triple NEAs

- *If the excess is real, what causes it?*