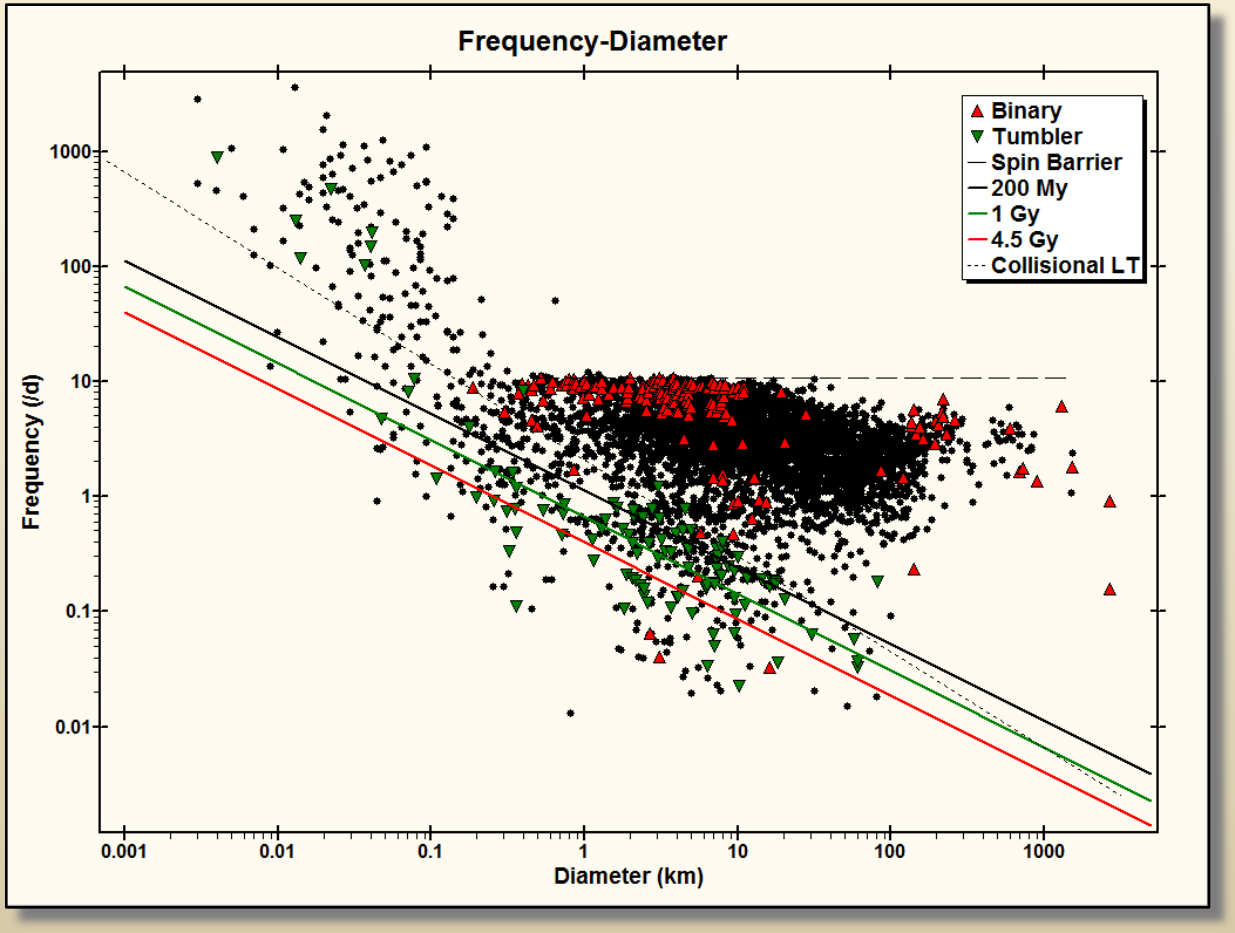
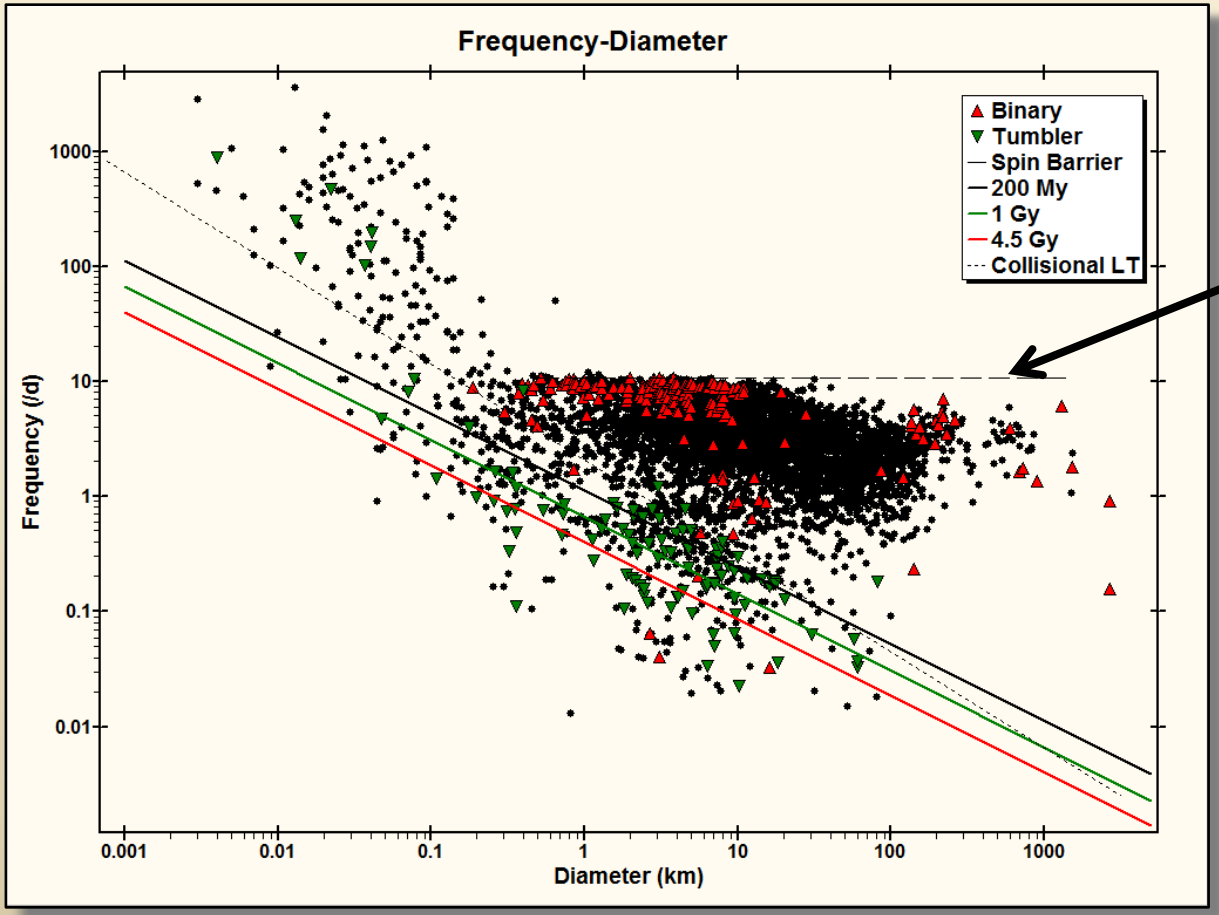
The Whys and Hows of Asteroid Rotation Lightcurves

Brian D. Warner
Center for Solar System Studies
brian@MinorPlanetObserver.com

The Whys: Rotation Statistics

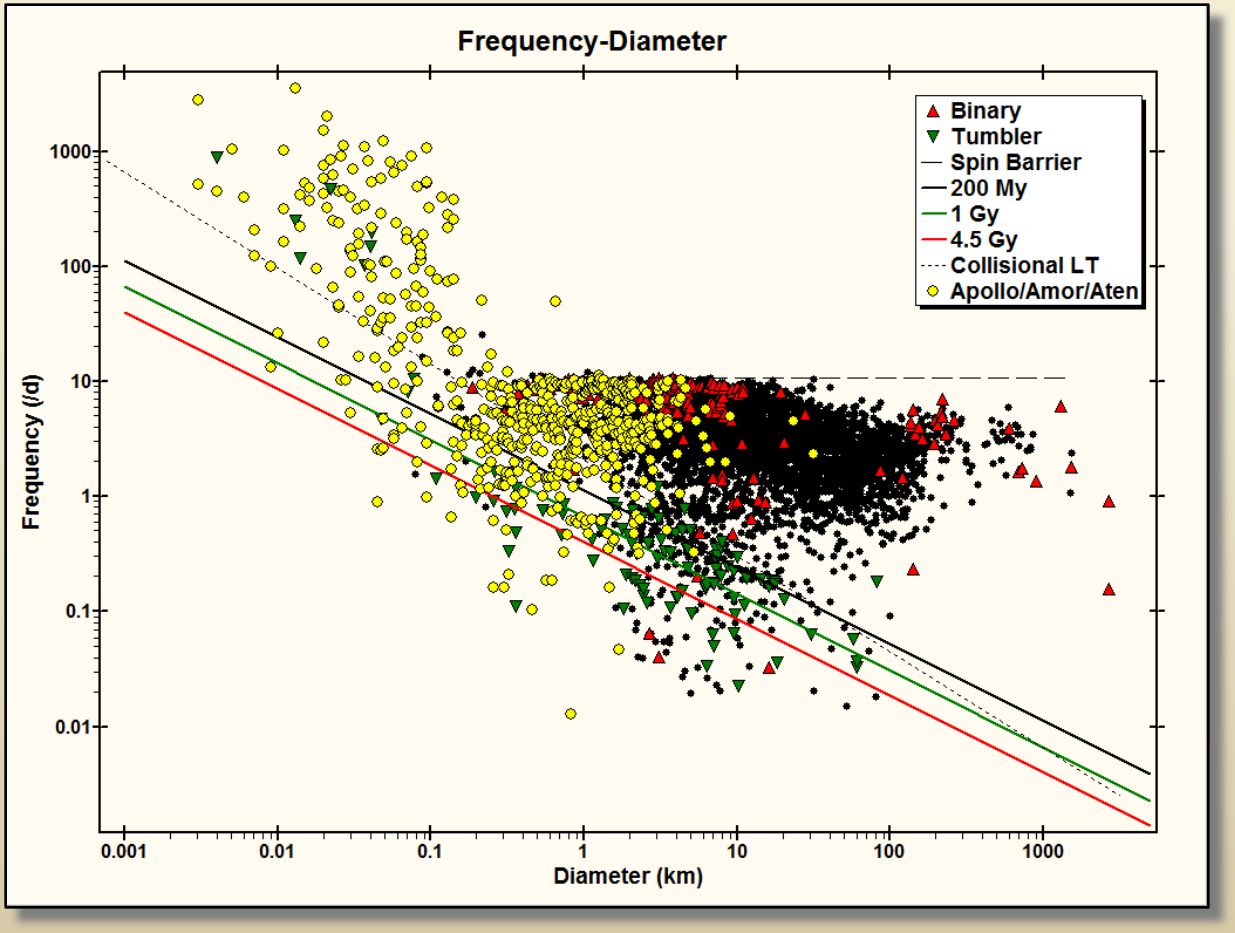


The Whys: Rotation Statistics

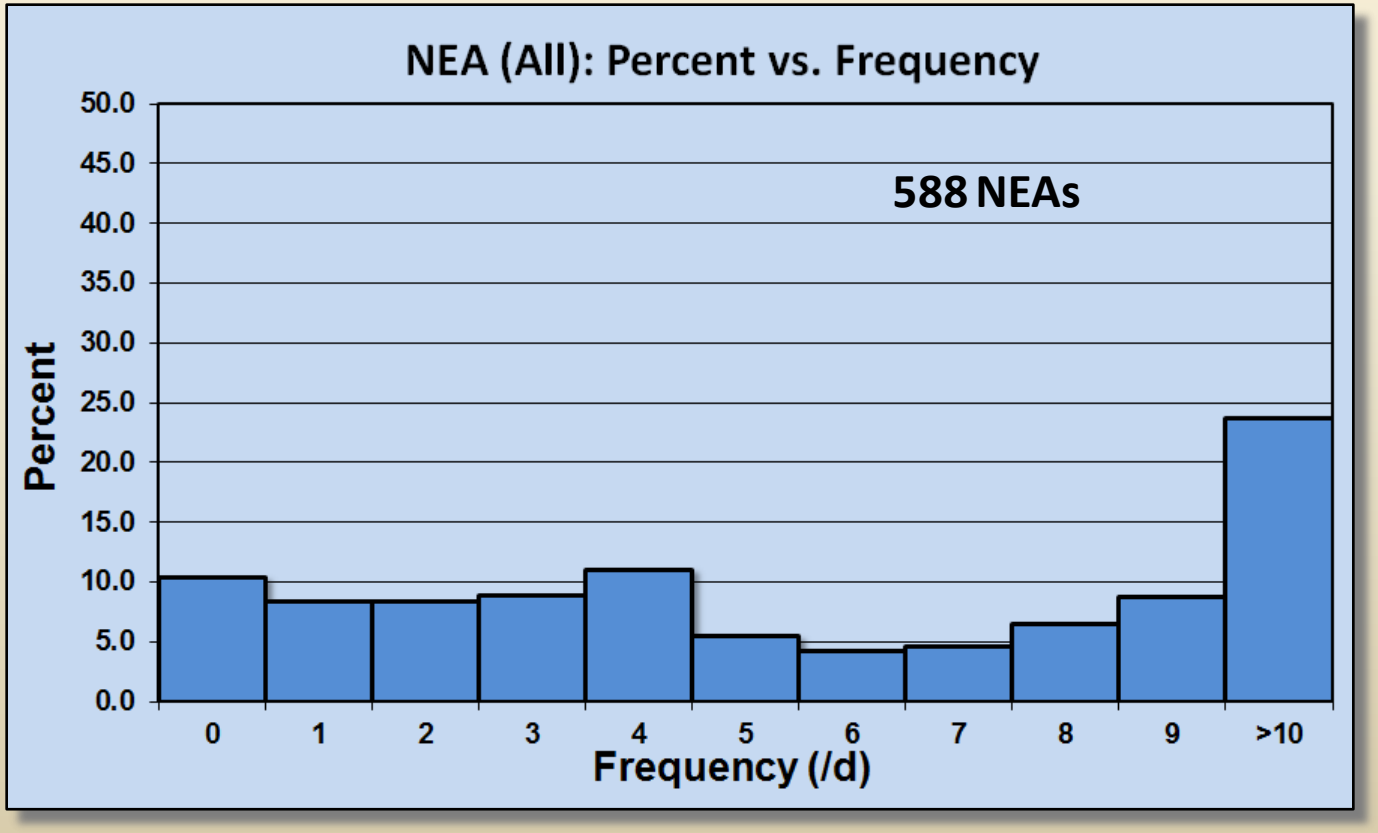


Spin Barrier

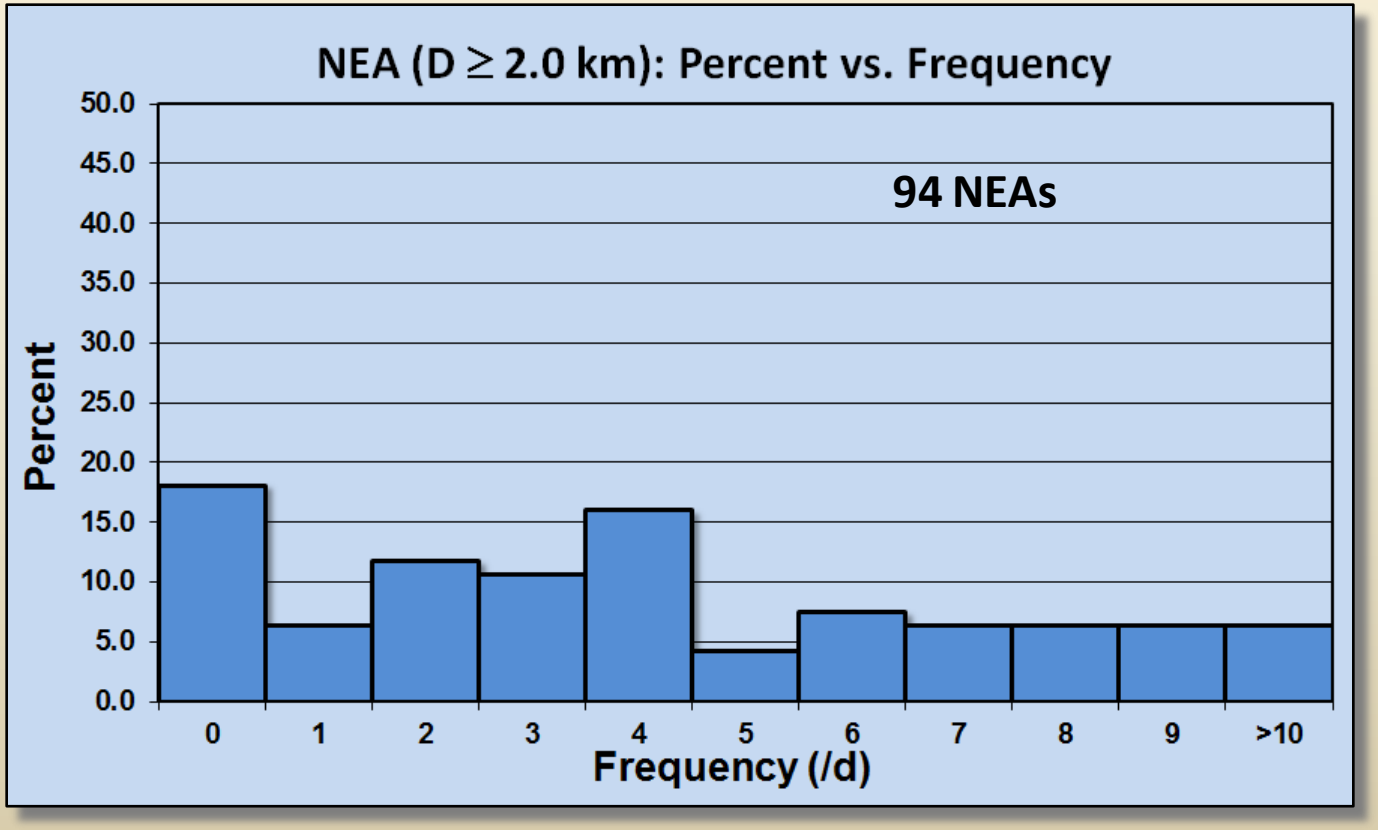
The Whys: Rotation Statistics



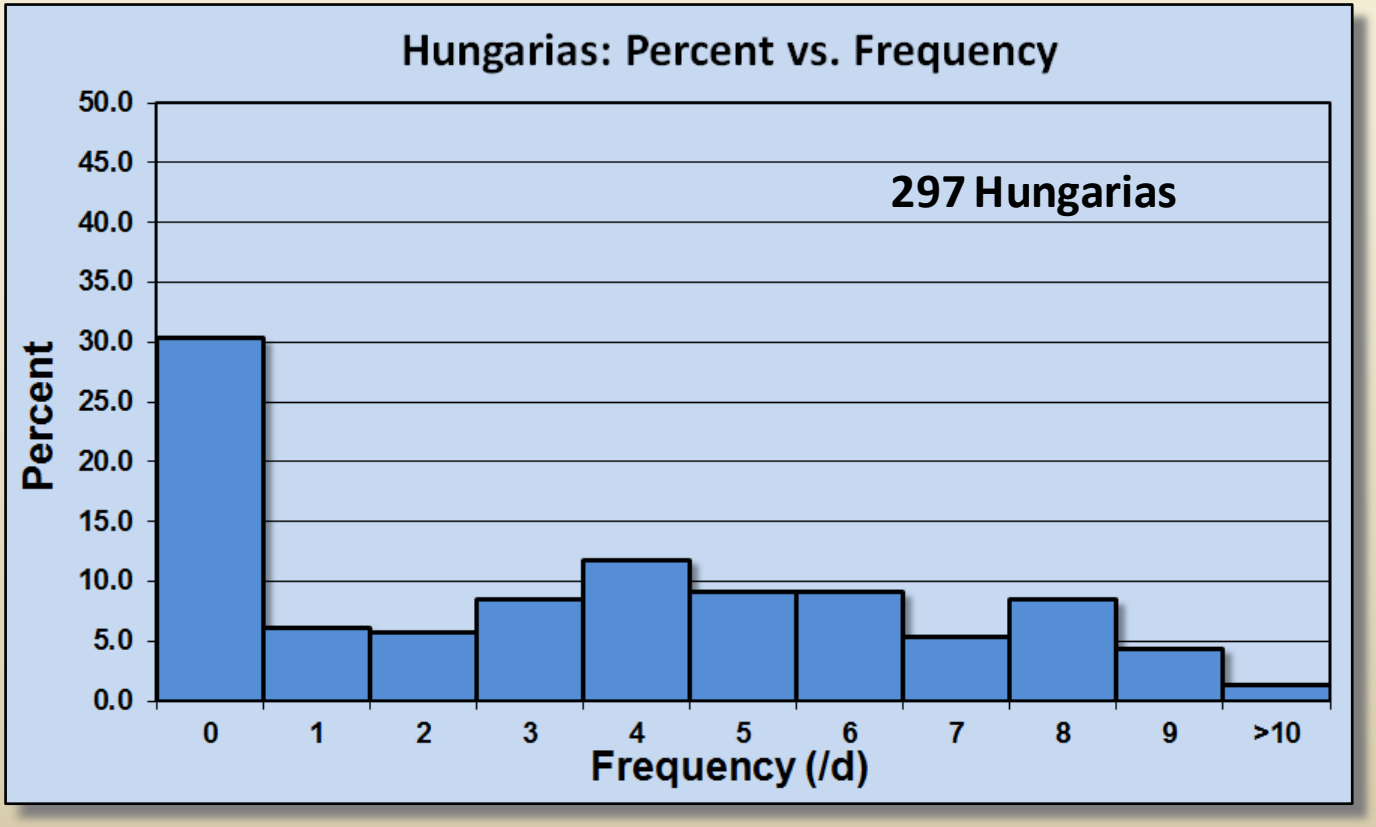
The Whys: Rotation Statistics



The Whys: Rotation Statistics



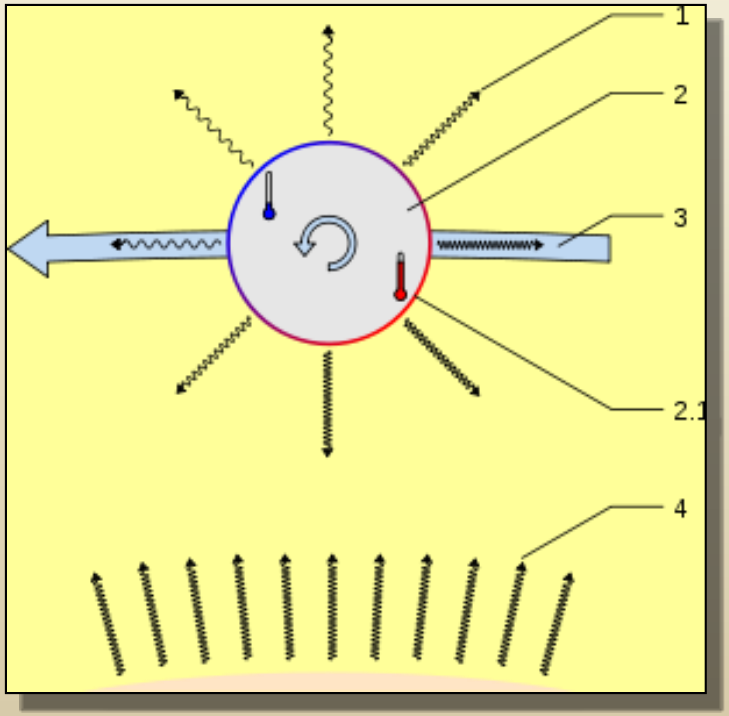
The Whys: Rotation Statistics



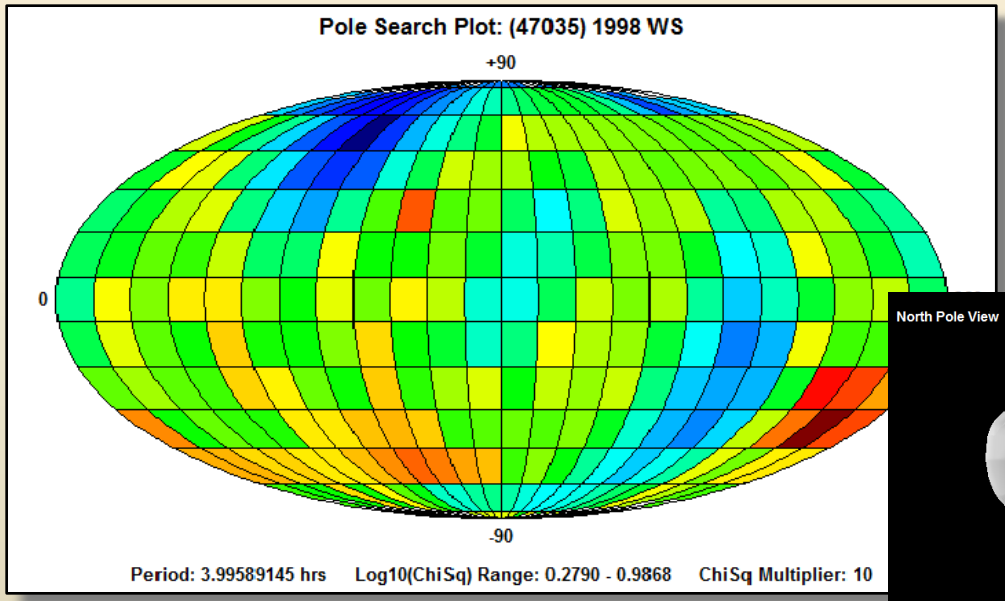
YORP Effect

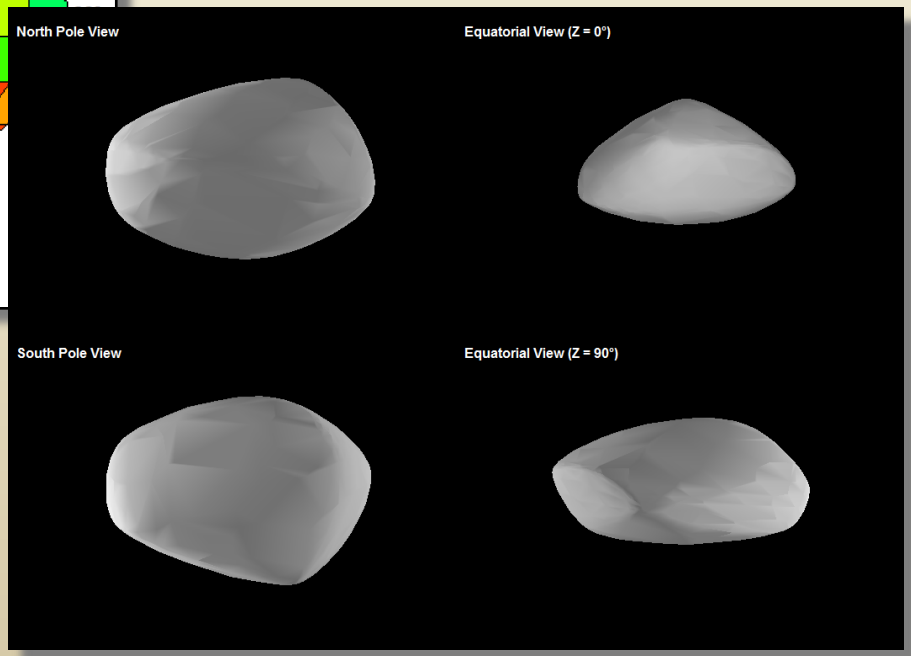
Yarkovsky–O'Keefe–Radzievskii–Paddack

- Works only on small, irregular bodies
- Proportional to D and $1/R^2$
- Spin-up can lead to binary or dual asteroid
- Spin-down might lead to very slow rotator and tumbling



The Whys: Lightcurve Inversion





The Hows: Selecting Targets

- **The Minor Planet Bulletin**
  http://www.minorplanet.info/minorplanetbulletin.html
  TargetAsteroids! and Photometry Opportunities articles

The Hows: Selecting Targets

- **The Minor Planet Bulletin**
  http://www.minorplanet.info/minorplanetbulletin.html
  TargetAsteroids! and Photometry Opportunities articles

- **MinorPlanet.Info Web Site**
  http://www.minorplanet.info/observationplanning.html
  Choose targets by family/group, visibility, without know period
  Access to on-line version of asteroid lightcurve database (LCDB)

The Hows: Selecting Targets

- **The Minor Planet Bulletin**
  http://www.minorplanet.info/minorplanetbulletin.html
  TargetAsteroids! and Photometry Opportunities articles

- **MinorPlanet.Info Web Site**
  http://www.minorplanet.info/observationplanning.html
  Choose targets by family/group, visibility, without know period
  Access to on-line version of asteroid lightcurve database (LCDB)

- **JPL Web Site**
  http://neo.jpl.nasa.gov/

The Hows: Unfiltered or Filtered

Unfiltered

- ~1 mag gain (2/3 D)
- When SNR is important, e.g., small, fast-moving
- When high-precision, standardized magnitudes not required
- Absolute magnitude (H) and phase slope parameter (G) work is still possible.

The Hows: Unfiltered or Filtered

Unfiltered

- ~1 mag gain (2/3 D)
- When SNR is important, e.g., small, fast-moving
- When high-precision standardized magnitudes not required
- Absolute magnitude (H) and phase slope parameter (G) work is still possible

Filtered

- When high-precision standardized magnitudes ***are*** required, e.g., lightcurve inversion
- More accurate absolute magnitude (H) and phase slope parameter (G) work
- Easier to combine data sets from multiple observers (if transformed to standard system) but not required

The Hows: Exposures – How Long?

- Depends on size of scope, camera sensitivity, and if filtered/unfiltered
- SNR > 100 (0.01 mag), if possible (usually only for brighter targets)
- At least 10-15 seconds to avoid scintillation noise dominating the data, but only if sky motion and rotation period allow
- Avoid excessive trailing (not always possible)
- Be wary of super-fast rotators (P < 2 hour; especially when H ≥ 21.2, $p_V \sim 0.2$) Use 0.187*P rule

The Hows: Exposures – How Many?

- **Recommendations**
  - Stay on one target all night or until you have data for at least 1.3 rotations
  - Take continuous images with a short (1-10 second) interval between, even for known long period objects
  - Occasionally break the sequence, e.g., every 10 exposures, to add randomness to the observing cadence (helps avoid aliasing in data analysis)

The Hows: Exposures – How Many?

- **Recommendations**
  - Stay on one target all night or until you have data for at least 1.3 rotations
  - Take continuous images with a short (1-10 second) interval between, even for known long period objects
  - Occasionally break the sequence, e.g., every 10 exposures, to add randomness to the observing cadence (helps avoid aliasing in data analysis)
- **Why?**
  - You may miss evidence of a satellite (mutual event)
  - Too few data points can give a false indication of the nightly trend for long period objects
  - Beat down the noise in the data when SNR is low

The Hows:
Image Measurement and Period Analysis

MPO Canopus (Measurement/Analysis)
www.bdwpublishing.com

Peranso (Analysis)
http://www.peranso.com/

AIP4WIN (Measurement)
http://www.willbell.com/aip4win/aip.htm

MaximDL (Measurement)
http://www.cyanogen.com/maxim_main.php

***IRAF* (Measurement/Analysis)**
http://iraf.noao.edu/

The Hows: Period Analysis

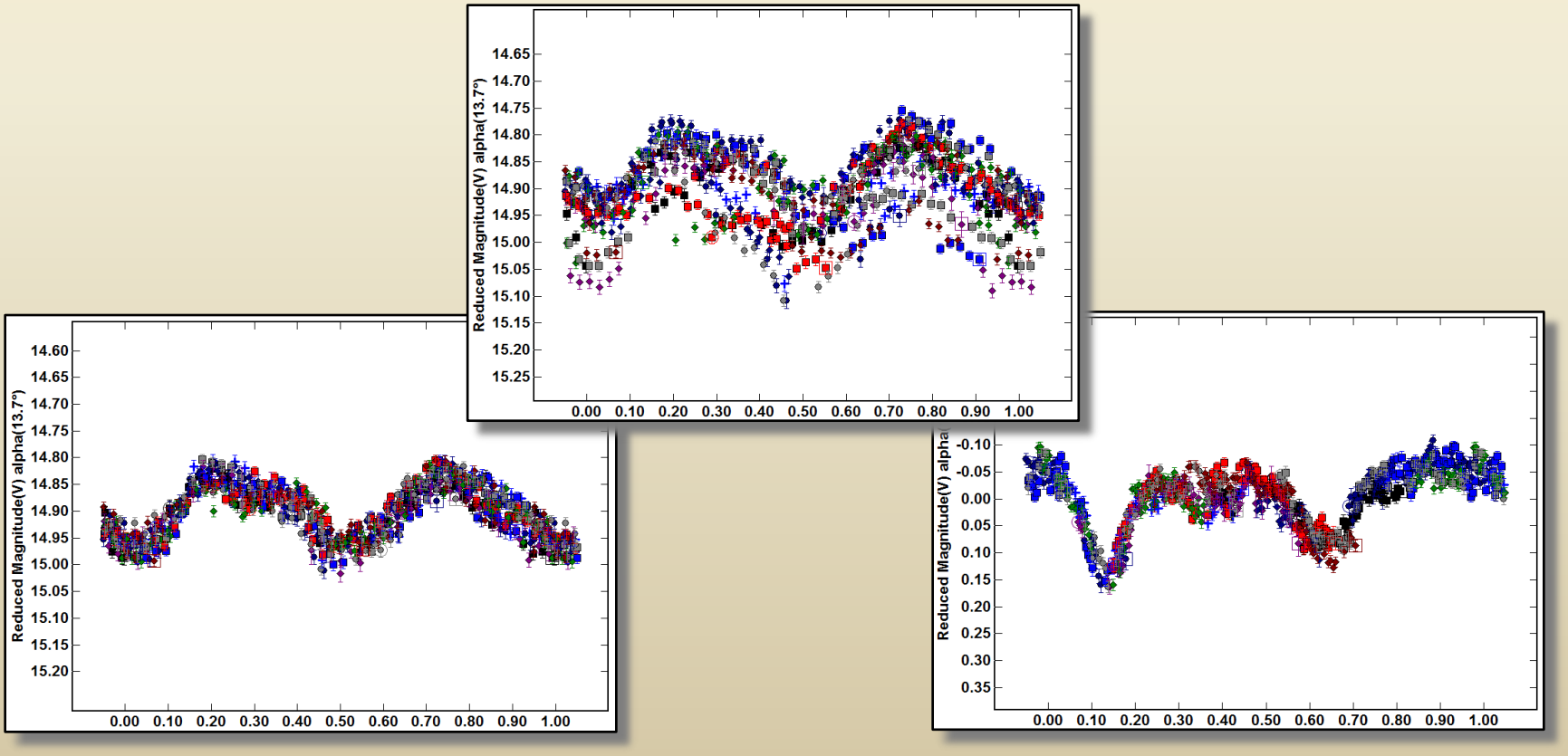
Pre-Analysis Data Considerations

- Reference to same phase angle and sun-earth distances (estimated magnitude using H-G parameters)
- Light-time corrected (when light left asteroid, not arrived at Earth)
- Use “sky magnitudes” or reduced sky magnitudes applying -5log(rR), instead of raw instrumental or differential magnitudes
- Night-to-night zero point variations, especially if using data not put on standard system, e.g., Johnson V, or using different reference catalogs.

These issues are handled (semi-) automatically in MPO Canopus, especially when using the Comp Star Selector and near solar-color stars

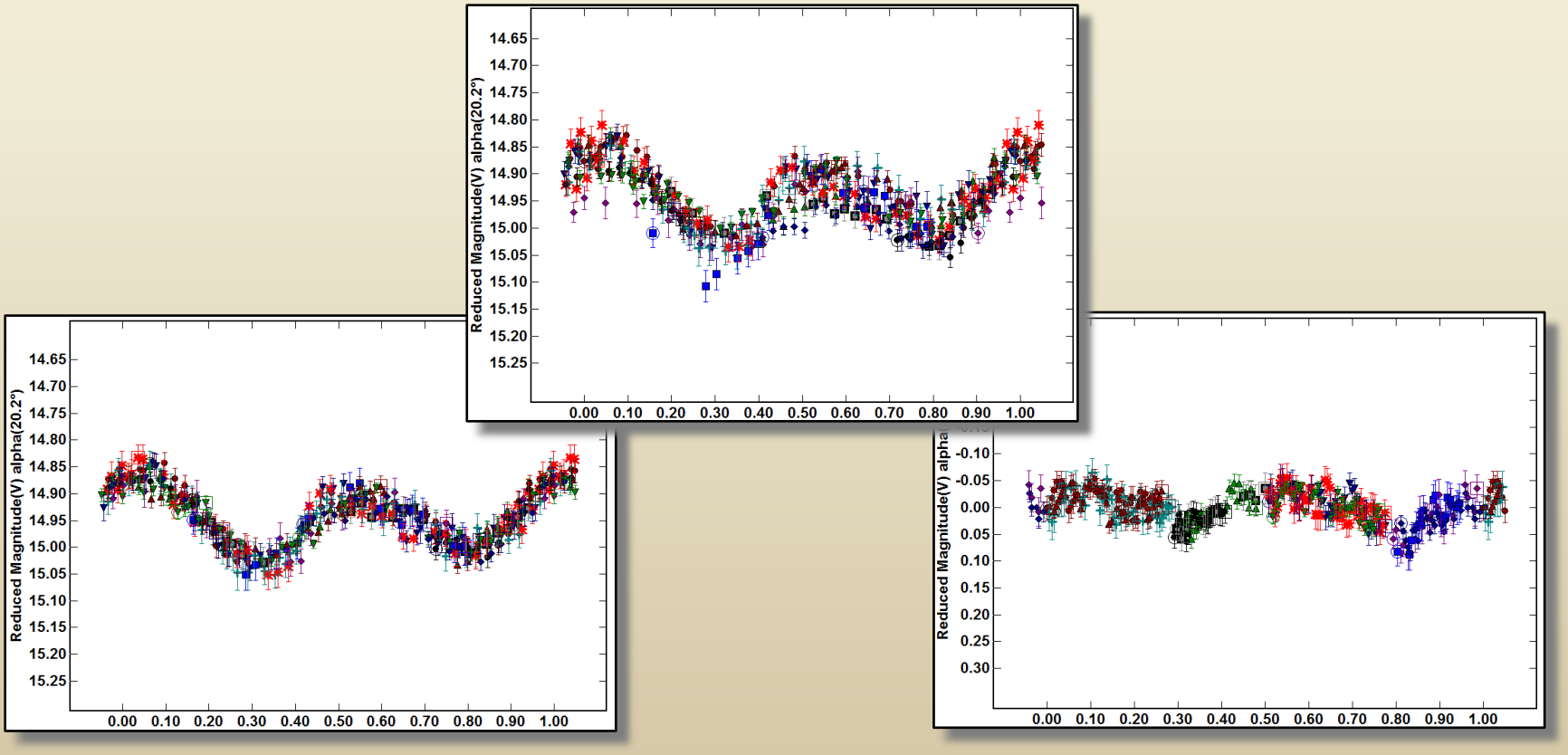
The Hows: Period Analysis – Common Errors

Missing a Satellite



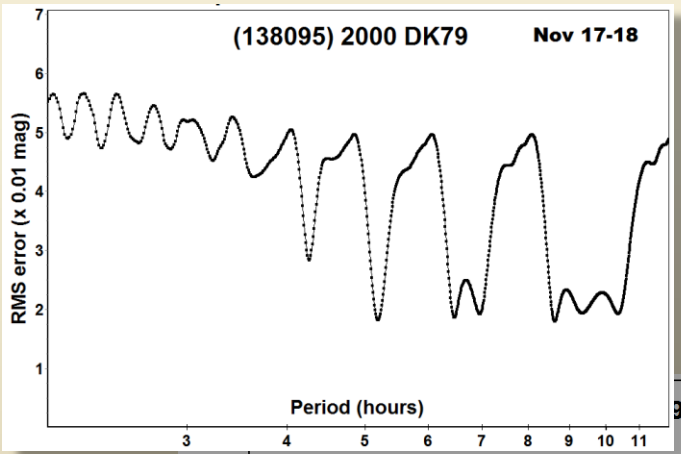
The Hows: Period Analysis – Common Errors

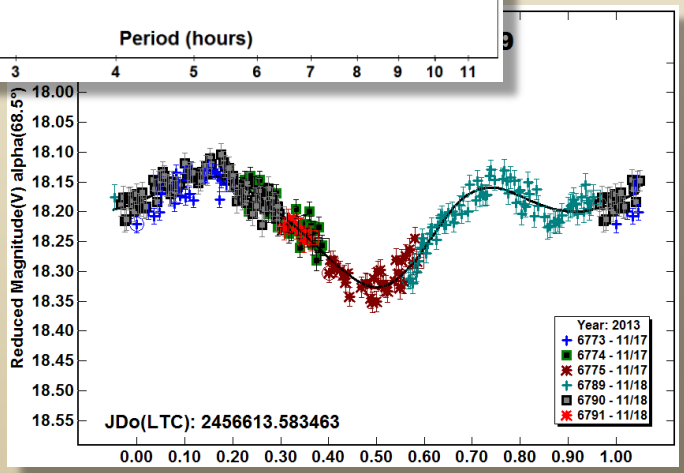
Missing a Satellite

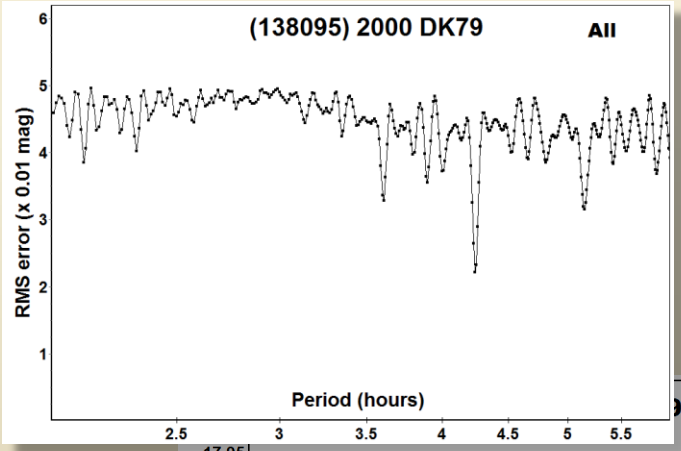


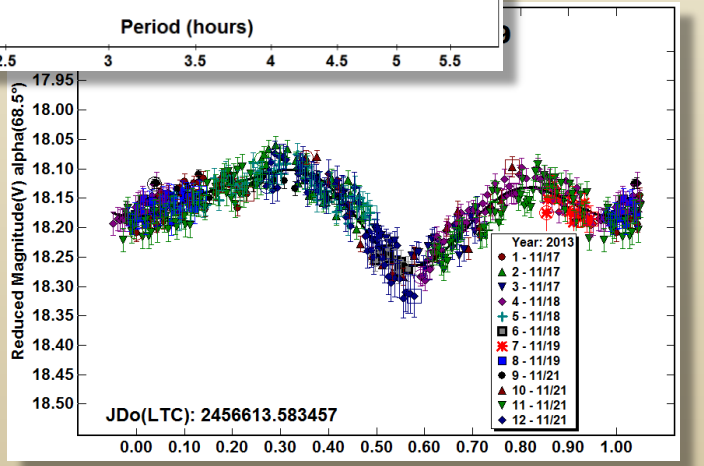
The Hows: Period Analysis – Common Errors

Jumping the Gun – Rotational Aliases









Publish Your Results!

The Minor Planet Bulletin

http://www.MinorPlanet.info/minorplanetbulletin.html

- Amateurs continue to produce the most number of asteroid lightcurves each year
- The vast majority of amateur lightcurves appear in the *MPB*
- MPB is "amateur-friendly"
  - Simple submission: email, MS Word DOC with embedded tables and graphics (can be color)
  - Word Template available at above site
  - Semi-formal to formal writing style
  - ***No page charges***
- ***Professionals: The MPB is considered a refereed journal by the ADS***

Publish Your Data!

Asteroid Lightcurve Data Exchange Format (ALCDEF)

Database hosted by the Minor Planet Center

http://www.MinorPlanetCenter.net/light_curve

- Don't let the "beer truck" take your data!
- Your ***raw*** data can help a number of researchers, e.g., those doing lightcurve inversion or rotational studies
- Researchers have been very good about giving credit (co-authorship) to those providing raw lightcurve data (see papers by Durech et al., Hanus et al., Pravec et al.)
- MPO Canopus generates ALCDEF-compliant files; other programs may follow suit

2014 March 02:
Asteroids: 2,410 Lightcurve Blocks: 19,792 Data Points: 1,595,693

The Whys and Hows of Asteroid Rotation Lightcurves

Free Copy of MPO Canopus to Participants

Mention workshop. Please consolidate requests - the DVDs can be used for multiple installations.

MinorPlanet.info Gateway

http://www.MinorPlanet.info

My Email

brian@MinorPlanetObserver.com

Good Night, and Good Luck!