What's it like to be excited?

Tomáš Henych

Department of Theoretical Physics and Astrophysics, FSc MU, Brno

supervisor Petr Pravec, Astronomical Institute AS CR, Ondřejov

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tumblers

- most asteroids in relaxed state: rotation around principal axis of the maximum moment of inertia
- some in excited state of rotation or non-principal axis rotation
- rotation about the extremal axis and precession about angular momentum vector (Kaasalainen, 2001)
- tumbling in the space, they are called tumblers

data

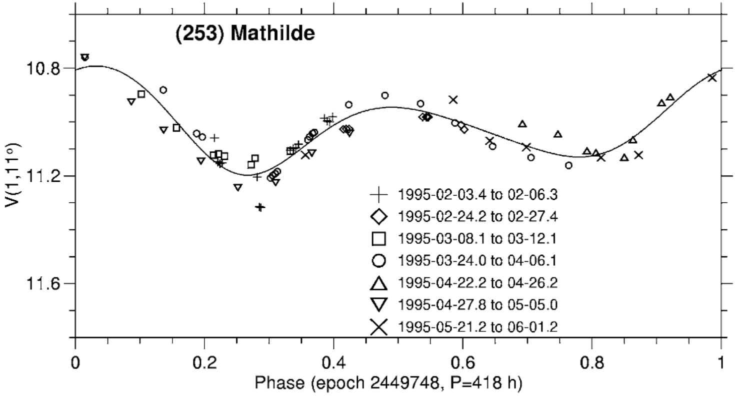
- dataset of tumblers is very limited
- some 20 pieces are unambiguously identified
- another 10 are suspect of NPA rotation

optical photometry problems

- very long periods (several days or even weeks)
- hence problematic calibration of zero points of the lightcurves

data sources

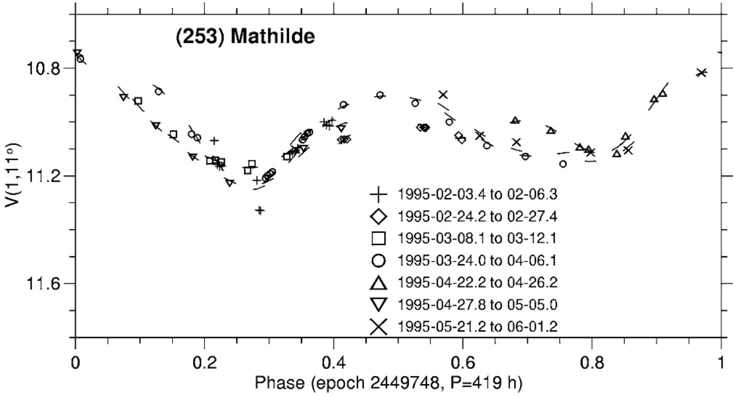
optical photometry



lightcurve of 253 Mathilde (Pravec *et al.*, 2005)

data sources

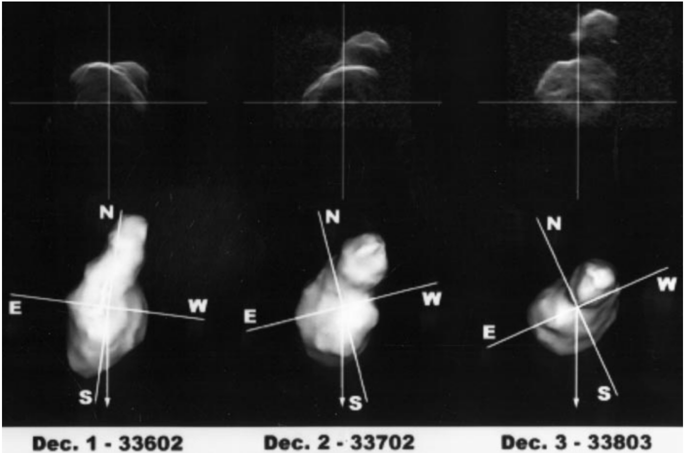
optical photometry



lightcurve of 253 Mathilde (Pravec *et al.*, 2005)

data sources

radar observations



4179 Toutatis radar observation and physical model (Ostro *et al.*, 1999)

rotational excitation

- one of the possible mechanisms causing rotational excitation sub-catastrophic collisions
- largest fragment contains more than half of the target mass (Giblin, 1998)
- either single intact fragment or gravitationally reaccumulated rubble pile
- reaccumulation becomes important in determining the mass of the largest remnant at target radii of $\sim 1\,\mathrm{km}$ (Leinhardt, 2009)

investigation methods

numerical modelling – hybrid model

1. impact phase by means of smoothed-particle hydrodynamics (SPH)
2. later phases (reaccumulation) with N-body gravity code

analytical approach

- isolated system of two gravitationally interacting bodies
- angular momentum exchange during impact
- mass ratio, velocity, impact angle, shape of the bodies, their internal structure

internal structure

- impact history changes the internal structure of the bodies
- more realistic results in family formation from simulated impacts of pre-shattered targets (consist of several parts, between them damaged zone and voids)
- more continuous size distribution and higher ejection speeds of large fragments (Michel, 2004)

investigation methods

experiments

- classical method of impact (gun in a vacuum chamber)
- impact simulated as an explosion
- contact explosives inside the stony target, high framerate cameras – some fragments were tumbling

  problems

  - we don't know if analogy between impact and explosion works
  - scaling laws

impact features

- spin rate change coupled with the asteroid size evolution
- largest angular momentum exchange in large shattering collisions, rather than by cumulation of smaller, more frequent, impacts
- angular momentum drain effect (some of the ejecta escape and carries some a. m. away) – this might be important effect (Farinella, 1992)

references

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- Leinhardt, Z.; Stewart, S. T., 2009. *Full numerical simulations of catastrophic small body collisions* Icarus **199**, 542–559.
- Michel, P. *et al.*, 2004. *Catastrophic disruption of pre-shattered parent bodies* Icarus **168**, 420–432.