DEBIASING ASTEROID SPINS AND SHAPES - OBSERVATIONS, MODELING, AND VALIDATION

A. Marciniak[1], J. J. Sanabria[2], P. Bartczak[1], G. Dudziński[1], T. G. Müller[3], R. Duffard[4], I. Konstanciak[1], and a group of observers
[1]Astronomical Observatory Institute, Faculty of Physics, A. Mickiewicz University, Słoneczna 36, Poznań, Poland (am@amu.edu.pl), [2]Instituto de Astrofísica de Canarias, C/ Vía Lactea, s/n, 38205 La Laguna, Tenerife, Spain, [3]Max-Planck-Institut für extraterrestrische Physik, Giessenbachstrasse 1, 85748 Garching, Germany, [4]Departamento de Sistema Solar, Instituto de Astrofísica de Andalucía (CSIC), Glorieta de la Astronomía s/n, 18008 Granada, Spain

Introduction: The available set of spin and shape modeled asteroids is strongly biased against slowly rotating targets, and those with low lightcurve amplitudes. It is due to the observing selection effects [1]. As a consequence, current picture of e.g. asteroid spin axis distribution, rotation rates, thermal inertia, and internal strength can be biased too.

Detailed asteroid shape models created using dense lightcurves have a variety of applications. They are in high demand for e.g. precise density determinations, Yarkovski/YORP effect modeling, or reliable predictions of infrared flux of calibration asteroids [2].

In this work we conduct photometric observations of asteroids omitted in most of previous studies, perform their spin and shape modeling, and compare model solutions obtained with both convex [3] and nonconvex [4] lightcurve inversion methods. In a next step we verify those models against data from complementary techniques like stellar occultations and thermophysical modeling.

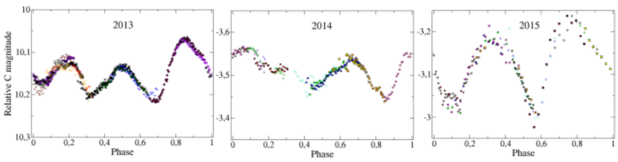

Figure 1. Lightcurve morphology changes observed for asteroid (329) Svea. P=22.78 h, amp. 0.12 – 0.24 mag.

Observing campaign: Our targets are a sample of around 100 long-period (P>12 hours) and low-amplitude (max amp.<0.25 mag) Main Belt asteroids [1]. These targets, with their complex lightcurves (eg. in Fig. 1.), are especially demanding, requiring an involvement of multiple observing sites and good S/N ratio, but also provide a good testing ground for shape modeling techniques. So far we have gathered around 6000 hours of observational material. Our results have shown that within the studied group over 25% of targets previously had incorrectly determined rotation periods [1]. For most of the targets we collected multi-apparition data that combined with available data, gradually facilitate creating their models.

Methods: We conduct spin and shape modeling using convex inversion method by Kaasalainen et al. [3], and nonconvex SAGE algorithm by Bartczak et al. [4], applied on the same datasets. Both methods search for the lowest deviations between observed and modeled lightcurves, though using different approach. Unlike convex inversion, SAGE method allows for existence of valleys and indentations on the shapes (Fig. 2).

Results: When such models are compared to stellar occultation chords, they get an absolute size scale and also major topographic features of the shape models are confirmed this way. When applied in thermophysical modeling, they provide a very good fit to the infrared data, substantially better than most commonly used sphere or ellipsoid.

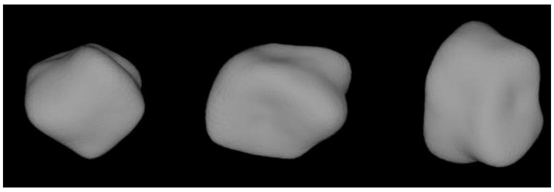

Figure 2. SAGE shape model of (329) Svea

Acknowledgments:
The research leading to these results has received funding from the European Union's Horizon 2020 Research and Innovation Programme, under Grant Agreement no 687378; and from the National Science Centre, Poland by grant no. 2014/13/D/ST9/01818.

References: [1] Marciniak A. et al. (2015) *Planet. Space Sci.*, 118, 256. [2] Müller T. G. and Lagerros J. S. V. (2002) *Astronomy Astrophys.*, *381*, 324. [3] Kaasalainen M. et al. (2001) *Icarus.*, *153*, 37. [4] Bartczak P. et al. (2014) *MNRAS*, *443*, 1802.