ISAM
Interactive Service for Asteroid Models

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Abstract

We present an interactive web service for past and future physical ephemeris of polyhedral asteroid shape models obtained mainly with the *lightcurve inversion* method.
Our tool allows for plane-of-sky views of the models, that can be then compared with asteroid images obtained using different techniques like occultations, adaptive optics, radar or thermal infrared. Additionally, lightcurves, animated views, and stereoscopic images can be generated by the users.
The service is available at the address:
`http://isam.astro.amu.edu.pl`

1 Introduction

Polyhedral asteroid models are mostly obtained with a *lightcurve inversion* [3] method from disk-integrated photometric observations, but can be generated from other techniques as well. Those from the inversion method are being gathered in DAMIT database ([1], `http://astro.troja.mff.cuni.cz/projects/asteroids3D`). The physical asteroid models derived from photometry are described by a sidereal period of rotation, spin axis orientation and a convex shape model. Additional parameters like surface scattering properties, or the period evolution over time can be sometimes determined. But to compare these models with other methods' outcome one needs to orientate them with respect to an earthbound observer. This can be easily done in our service. A detailed description of the service structure and usage will be made in the paper [5].

2 Service structure

The service is developped in LAMP (Linux, Apache, MySQL, PHP) technology. It works on Debian GNU/Linux 6.0 operating system. Management of the www sites is done with Apache ver.2, while the site is based on the PHP 5.0 language and HTML forms with the addition of JavaScript. The PHP code works with the programmes written in C++ language. The C++ codes use the "z-buffer" algorithm to plot the asteroid orientation and they return "png" type of images. In modifying the images, animations, and creating the 3D effects the functions "convert" and "composite" from the Image Magick package are used. Data on the asteroid models and their orbital parameters are stored in MySQL database. Such solution allows for efficient application run. In the near future the applications will be installed on the computer cluster and they will be managed with the CORBA (Common Object Request Broker Architecture) and CUDA (Compute Unified Device Architecture) technologies, using GPU.

3 Applications

The tool already proved its efectiveness and reliability allowing the comparison of adaptive optics image of asteroid (679) Pax with the model obtained from disk-integrated photometry [6]. Figure 1 shows that one of two possible pole and shape solutions is confirmed by AO image.

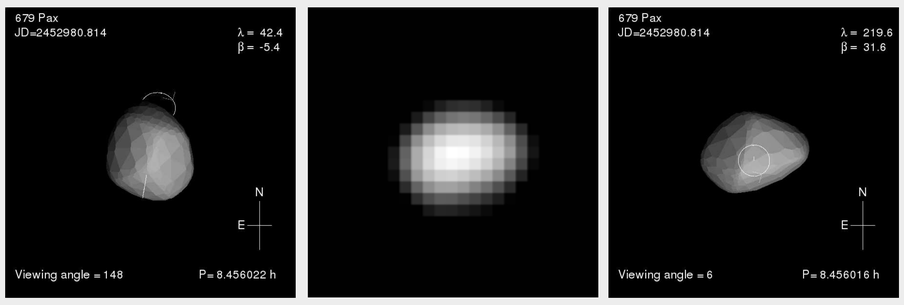

Fig. 1. Shape models of the Pole 1 and Pole 2 solutions for (679) Pax (left and right image, respectively) compared to the adaptive optics image (middle) [4] at the same epoch and viewing geometry.

Another axample of possible applications are the asteroid profiles from stellar occultations. With the ISAM service one can easily generate plane-of sky projections of asteroid models to superimpose them on the occultation chords (Fig. 2).

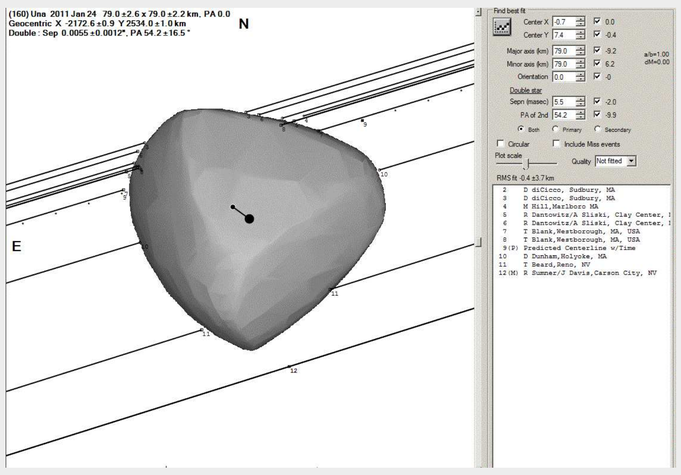

Fig 2. Occultation chords with superimposed plane-of-sky projection of (160) Una (model 1). The event was at 24 Jan 2011, around 4:15 UTC, and the occulted star occured to be a close double (after [2]).

[1] Ďurech, J., Sidorin, V., Kaasalainen, M., *Astron. Astrophys*, Vol. 465, p. 331, 2010

[2] George, T., Timerson, B., Beard T., et al., *Journal of Double Star Observations*, Vol 7, p. 175, 2011

[3] Kaasalainen, M., Torrpa, J., & Muinonen, K., *Icarus*, Vol. 153, p. 37, 2001

[4] Marchis, F., et al., *Icarus*, Vol. 185, p. 39, 2006

[5] Marciniak, A., et al. "Photometry and models of selected main belt asteroids IX. Introducing ISAM", in preparation

[6] Marciniak, A., Michałowski, T., Polińska, M., et al., *Astron. Astrophys* Vol. 529, A107, 2011

4 Service Functionalities

To use the service, one has to choose from the list of existing asteroid models. For the moment these have been transferred from the DAMIT database, with an addition of (25143) Itokawa detailed model from Hayabusa spacecraft. In the future the polyhedral shape models from any technique can be incorporated into the service. There are three main viewing modes available, these are: Model, Orientation and Video Mode. One can also browse the galleries of various service outcomes for a given object.

Model

It allows for viewing the shape model from different directions and in different lighting geometries. If the object is nonconvex, the shadowing of various surface areas can be noticed.

Orientation

This is the main mode for scientific purposes. It allows for displaying an asteroid model plane-of sky view for a requested date. The shape model can be illuminated only by the Sun, or the full silhouette of the model can be displayed. The latter is designed for observers of stellar occultations by asteroids. If needed, the Light-Travel time correction can be applied, because by default a view for an earthbound observer is generated. The spin axis is visualized and its changing orientation in different aspect angles can be seen.

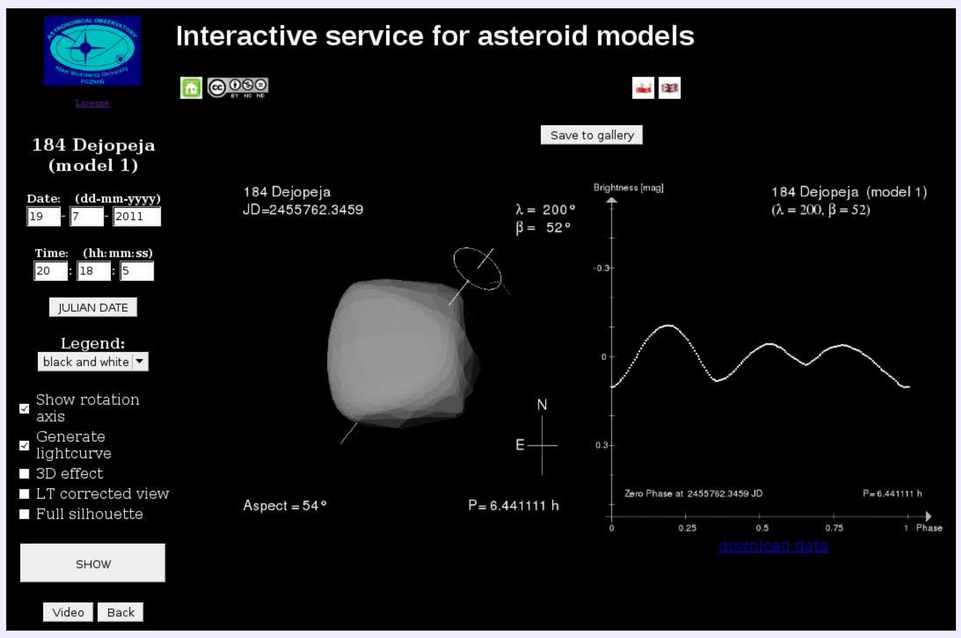

Fig. 3. The view of the service page in the Orientation mode.

For a given starting epoch, the lightcurve over one rotation can be quickly generated. It can be downloaded, the same as a model view, and used for further research. In Figure 3 the web page view in the Orientation mode is shown. Possible options are on the left, and the generated view for the model is described by all the model parameters, the date, aspect angle and on-sky directions. If needed, a shape model without any descriptions can be displayed. One can also generate stereoscopic views in three different forms: an anaglyph, cross-eye view and parallel view. The two latter 3D effects do not require usage of any glasses (see Fig. 4 for a cross-eye view of (25143) Itokawa).

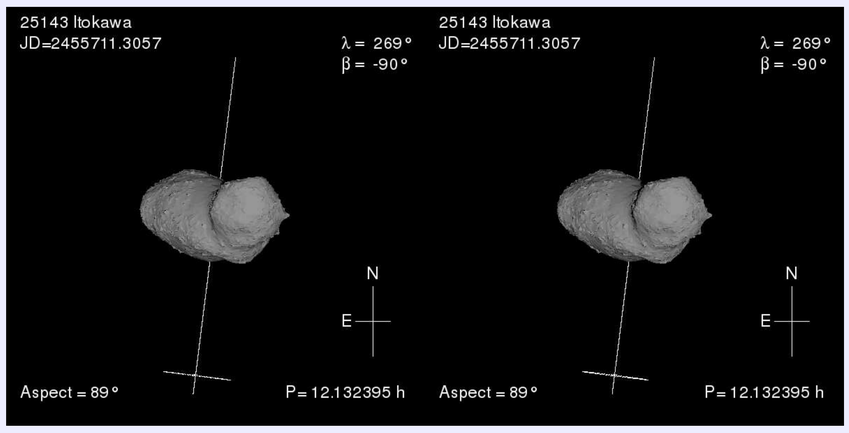

Fig. 4. Two views of (25143) Itokawa for a cross-eye stereoscopic effect.

Video

The video mode allows for the animated rotation of an asteroid model, also with a lightcurve generated in a real time. It enables an analysis of how various features of the lightcurve are bound to certain areas on the model surface. Choosing a greater number of frames per period creates slower movies, thus allowing for more detailed analysis. The movies with rotating asteroid can also be stereoscopic, provided the lightcurve option is not chosen.

Summary

We believe that the service fulfills the needs of asteroid researchers and amateur observers, allowing for straightforward and interactive plotting the models on-sky orientations. As a consequence it fills the gap between photometric models and those obtained in other ways. It also allows for visual connecting a rotating shape model with its lightcurve, making it a tool that can be widely exploited, also by a public.
In the nearest future we are planning to move the service to a computer cluster, which will improve its functionality. The models in the database may come from varius sources and techniques, and we plan to place there models from i.e. radar imaging or space probes (like already available here (25143) Itokawa). Another planned option is that users could temporarily upload their own models to check their lightcurves and orientations.