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Shapes of binary asteroid primaries from photometric observations

P. Scheirich
Astronomical Institute of Czech Academy of Sciences, Fricova 298, Ondrejov, 25165, Czech Republic
(petr.scheirich@gmail.com)

Abstract

I will present results from a method which combine lightcurve inversion for single bodies and the method for inversion of lightcurves of occulting/eclipsing binary systems. Using the method we obtained shapes of primaries of binary systems and increased a precision of modeling of occultation/eclipse events in photometric data.

1. Introduction

A large fraction of NEA binaries and most of small MB binaries were discovered from photometry. A key to the method is presence of mutual events (occultations and eclipses) of the two components of a binary system in the lightcurve. In our works we described a technique of reduction and modeling the photometric data [1, 2]: a rotation lightcurve of the primary is fitted outside the events and then subtracted from the data, creating a long-period component of the lightcurve. The long period component is then modeled using spheroidal primary and prolate secondary, orbiting each other. The modeling enables to derive the orientation of the mutual orbit, size ratio and ellipsoidal shape axial ratios of the components.

2. Primary shape model

A code developed by M. Kaasalainen and J. Ďurech for inversion of lightcurves of single bodies is adapted to fit an updated shape model of the primary. The original code uses a slightly elongated ellipsoid as an initial shape for optimization. We substituted this ellipsoid with a variety of shapes using Gaussian random spheres. This allowed the optimization algorithm to iterate to a range of final shapes. For each binary system, the short-period (rotational) component of its lightcurve is inverted using this code and a set of possible shapes of the primary are obtained. In the next step these shape models of the primary are, one by one, incorporated into the full model of the binary system and complete photometric data including the mutual events are fitted. Comparing synthetic lightcurves of the best-fit solutions with the observed data enables another narrowing of the selection of the possible shapes of the primary. This process is based on the times of phases of mutual events occurring on different geometries (i.e. the secondary passing in front of/behind the primary not only equator-on).

3. Primary of 1999 KW4 used as an archetype

We will also test a hypothesis that most of the primaries of the binary systems are similar in shape to each other. A figure resembling the shape of the primary of 1999 KW4, i.e., the top-shaped object with an equatorial ridge, will be used for the primary's shape. Its main characteristics – a polar flattening and width and height of the equatorial ridge, will be used as independent parameters. A variety of the shapes generated by a combination of these parameters will be used as an initial shapes for the optimization using the code described above.

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