Centre for Astrophysics and Planetary Science

PHYSICAL CHARACTERISATION OF NEAR-EARTH ASTEROID (68346) 2001 KZ66 FROM OPTICAL AND RADAR OBSERVATIONS

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Introduction

Since April 2010, our European Southern Observatory Large Programme has been observing a sample of NEAs to detect the influence of YORP [1]. We will report here our latest results for (68346) 2001 KZ66 (hereafter referred to as KZ66). We have been optically monitoring KZ66 for almost a decade, primarily with the ESO New Technology Telescope, La Silla, Chile. Our analysis also utilises radar observations from Arecibo Observatory, Puerto Rico and published optical light curves [2-5]. We present our radar-derived shape model for KZ66 and report the direct detection of a YORP-induced spin up.

Observations of KZ66

The optical light curve dataset for KZ66 covers the period from April 2010 to January 2019. The primary source of data is the NTT. Observations were taken in 2010, 2012, 2014, and 2019 with a total of nine light curves. An additional light curve was obtained from the Isaac Newton Telescope, La Palma in 2012. Previously published data for KZ66 include seven light curves from various observatories over 2016 [4-5].

Radar observations from the William E. Gordon telescope in Arecibo were also included in this analysis. The observations were performed over two nights: 28 and 29 Oct 2003. The observations comprise of two continuous-wave spectra taken on each night, in addition to imaging with a resolution of approximately 15 m. These data were used for our shape modelling and spin-state analysis.

Shape modelling of KZ66

Analysis of our optical data only, using convex inversion techniques [6-7], indicates that KZ66 has a rotational period of 4.985988 ± 0.000119 hours. The pole orientation of the asteroid was also determined using a grid of possible positions covering the celestial sphere with a resolution of 5º x 5º. This scan showed that the pole was tightly constrained in the southern hemisphere, below a latitude of -60º. The best pole given at an λ = 170º, β = -85º. Using the radar observations, a model was also produced using the SHAPE modelling software [8-9]. The resulting model is shown in Figs. 1 & 2. KZ66 is a bilobate NEA, similar to Itokawa [10], comprising of a larger ellipsoidal lobe and a smaller distorted lobe. The maximum extents (x, y, z) of the asteroid along its body-centric axes are 1.513 × 0.635 × 0.780 km.

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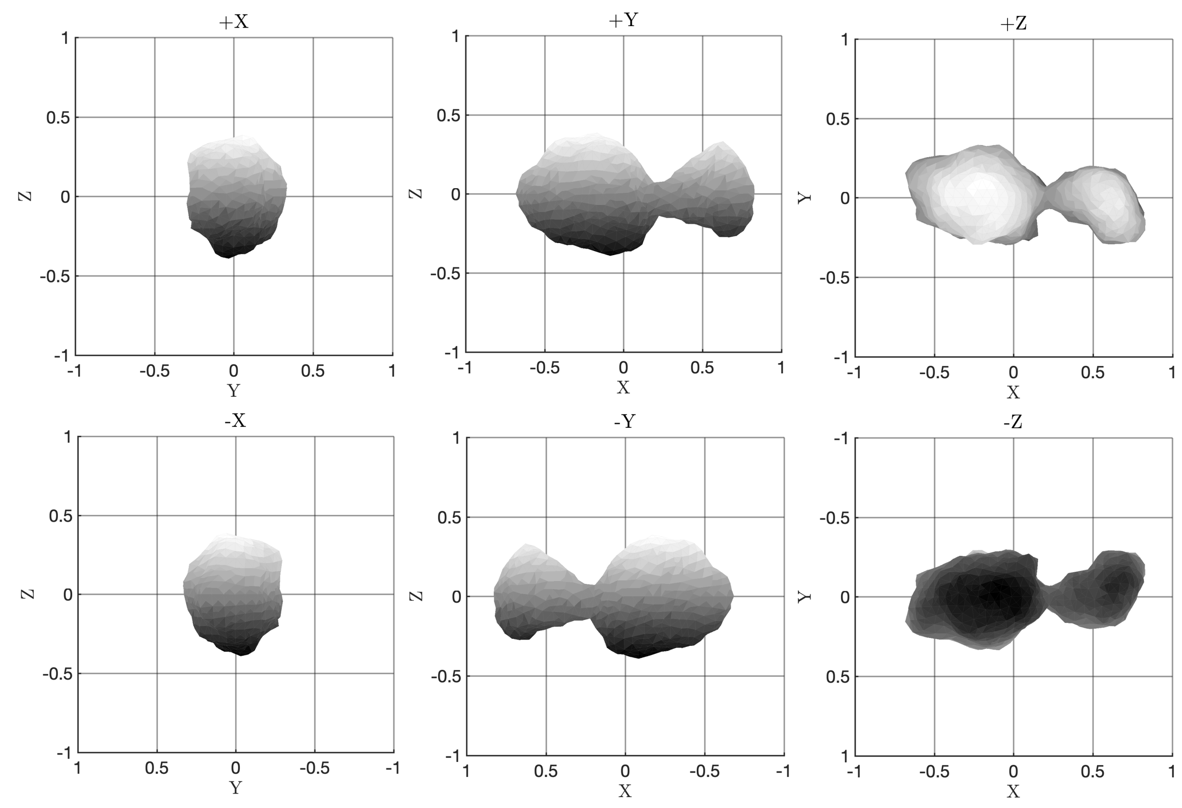

Fig. 1: The best-fit vertex shape model of (68346) 2001 KZ66. The model was derived from *continuous-wave* spectra, *delay-Doppler* images, and a selection of optical light curves. Views are along the body-centric axes.

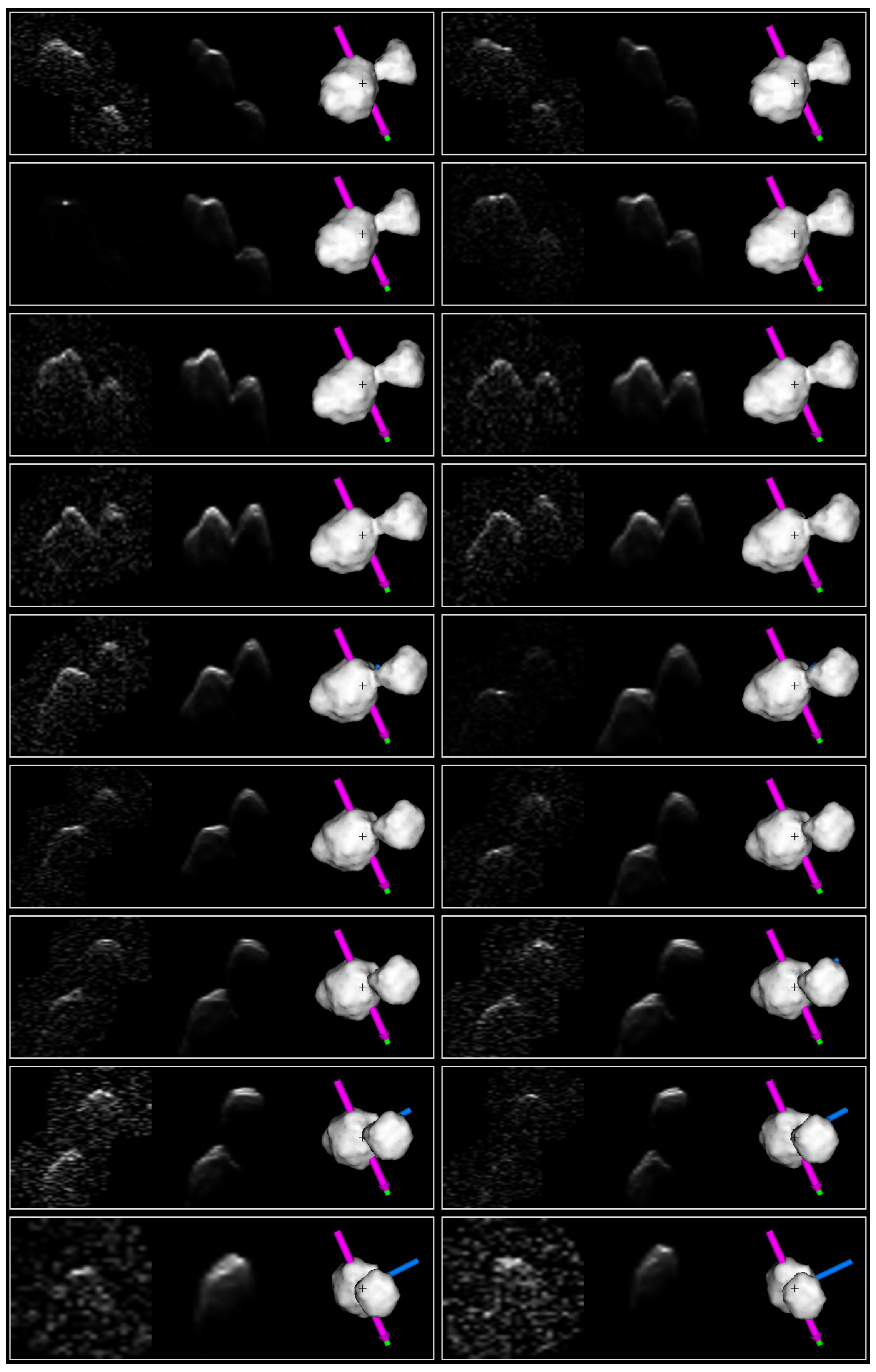

Fig. 2: Fits of the radar-derived shape model of asteroid (68346) 2001 KZ66 to the radar data. Each three-image sub-panel is made of: the observational data (left panel), echo simulated from the best-fit model (middle panel), and plane-of- sky projection of the best-fit model (right panel).

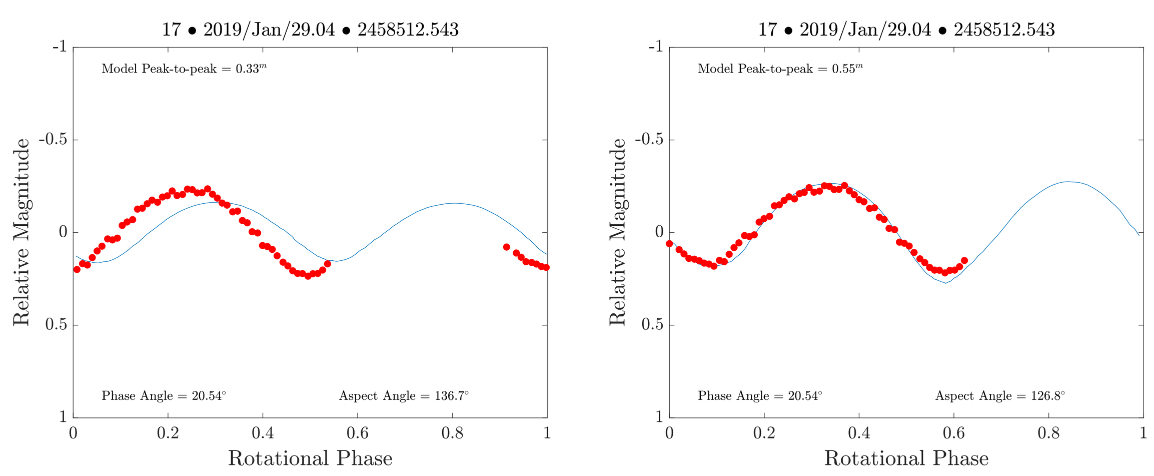

Fig. 3: Example synthetic light curve generated using the radar-derived shape model of (68346) 2001 KZ66 (blue lines) with (right) and without (left) YORP. With the optical data over plotted (red dots) as a function of rotational phase.

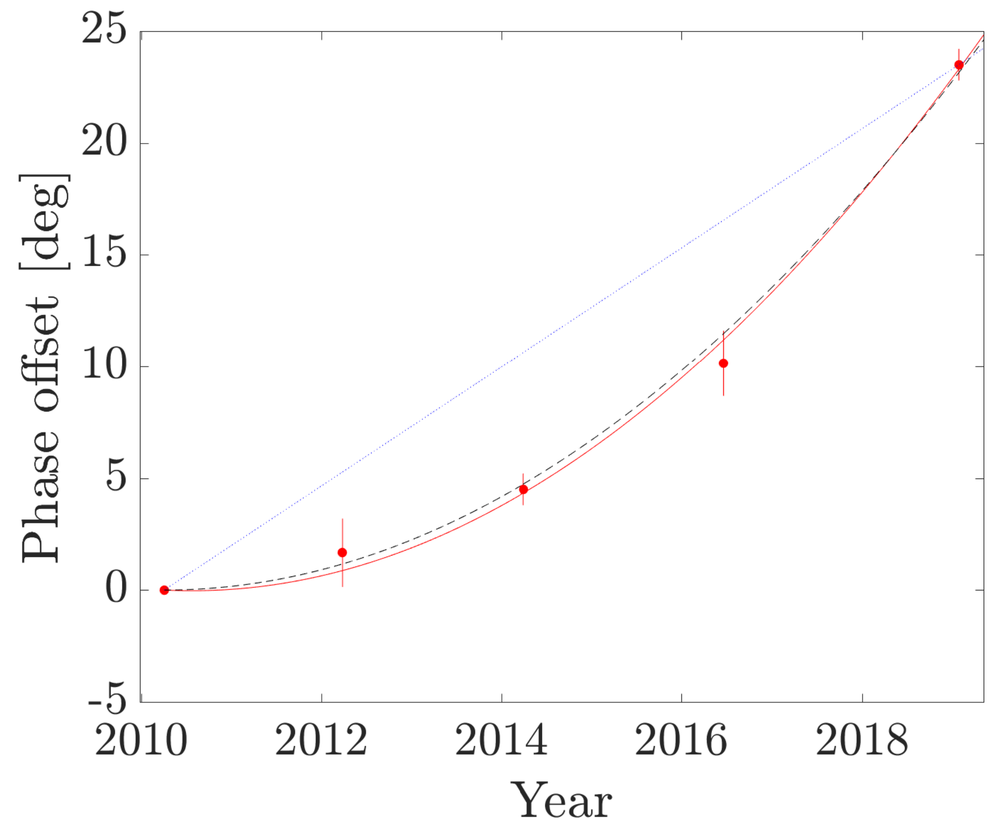

Fig. 4: Phase offset measurements for the radar-derived shape model of asteroid (68346) 2001 KZ66, with λ = 175°, β = −75°, P = 4.985997401 h, and starting point T_0 = 2455290.983 (April 2010).The red circles represent averaged phase offset measurements for light curves grouped by year. The uncertainties are given by the standard deviation of the individual light curves within each year. The red solid line marks the best-fit YORP solution, ν = (8.42 ± 0.83) x 10^{-8} rad/day^2.

Detection of YORP

Spin-state analysis of asteroids involves precise investigation of the timing information contained within light curve observations. When the rotation period of the object is known light curves can be expressed in terms of rotation phase, φ. Accounting for YORP's linear affect on the rotation rate, the rotation phase of an asteroid can be expressed as:

$$\varphi(t) = \varphi\left(T_0\right) + \omega\left(t - T_0\right) + \frac{1}{2}\nu\left(t - T_0\right)^2$$

Our approach is to measure the rotational phase offsets, Δφ, between our light curves and synthetic light curves generated from the radar-derived model. The model is propagated forward from T_0 (April 2010) to the epoch of each of the light curves in order to create the synthetic light curves. The required phase offset to align the synthetic light curve with the data is then recorded. If the asteroid was rotating with a constant period then the phase offsets could be fit by a straight line. However, the phase offsets are fit by a quadratic trend, indicating that KZ66 is undergoing a YORP acceleration. The YORP strength measured by the fit is ν = (8.42 ± 0.83) x 10^{-8} rad/day^2, see Figs. 3 & 4.

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Also see presentations: B279, B188, B167

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