Spin-state and thermophysical analysis of the near-Earth asteroid (8567) 1996 HW_1

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The asteroid (8567) 1996 HW_1 is a near-Earth Amor-class asteroid. It has been a target of visual lightcurve observations during the two apparitions in 2005 [1,2] and 2008 [3]. The lightcurve datasets were complemented by the radar data obtained at Arecibo during the close approach in September 2008 [4]. The data was combined to constrain the shape and spin state of the asteroid. The sidereal spin rate was measured to be $P = 8.76243$ hours, and pole position expressed in ecliptic coordinates as $\lambda = 281°$, $\beta = -31°$, with a complex rotation state not being ruled out. The shape of the asteroid resembles a contact binary with two components connected by a narrow neck. It was predicted that the asteroid's rotation rate is decreasing due to the Yarkovsky-O'Keefe-Radzievskii-Paddack (YORP) effect.

We aimed to verify the predicted YORP-induced period change [4]. The asteroid (8567) 1996 HW_1 has been selected as one of the targets of an ESO Large Programme led by Dr. S. Lowry. The programme includes photometric monitoring, infrared thermal observations, and visual near-infrared spectroscopy of selected near-Earth asteroids. Within the ESO LP, the asteroid has been observed on six runs between April 2010 and April 2013 with ESO's 3.6-m NTT telescope (Chile) to acquire optical lightcurves, and in September and December 2011 the infrared observations were performed with the VISIR instrument at the ESO's 8.2-m VLT telescope (Chile). The data set is completed by the visual lightcurve observations gathered from supporting programmes at JPL's Table Mountain Observatory (USA), Palomar 200-in telescope (USA), and the 2-m Liverpool Telescope (Spain).

The visual lightcurves from our 2010–2013 observing campaign were combined with the previously published lightcurves from 2005–2009, doubling the time span of the observations for the purpose of the potential YORP detection. The shape model developed from radar and lightcurve data [4] has been used in the spin-state analysis. The current spin-state model reproduces the shape of all the lightcurves obtained over the eight years very well. We do not detect any signature of YORP in our data despite the long time base of our observations and the quality of the data obtained.

The updated and improved spin-state model was used to determine the rotation phase of thermal fluxes obtained with VISIR very precisely. The thermal data was analysed using the Advanced Thermo-Physical Model (ATPM) [5,6]. The effective diameter is estimated to be 2.18 ± 0.05 km, which is consistent with the radar estimate of 2.02 ± 0.16 km. Thermal inertia is at the level of $170 \pm 50\,\mathrm{J m^{-2} K^{-1} s^{-1/2}}$ with roughness fraction above 75 %. The geometric albedo (using $H = 15.27$) can be constrained to $P_\nu = 0.29 \pm 0.01$.

The ATPM modelling indicates a small YORP-induced *acceleration* at a rate of about $2.6 \times 10^{-10}\,\mathrm{rad\,d^{-2}}$ and an obliquity change of 0.9° per 10^5 years. The current value of obliquity, around 129.2°, is close to the critical value where the rotational component of YORP disappears. This result is in agreement with the results of our spin-state analysis. The detection of a period change at the predicted level may require a much longer observational time span. We note the difference in the sign between this prediction and the earlier estimates coming from the inclusion of large-scale self-heating in our analysis. For an object with a major concavity, it might occur that some parts of its surface will be irradiated by sunlight reflected off the other parts of the surface. This self-heating can significantly change the outcome of the YORP torque computation [7].

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