DIMORPHOS'S POST-IMPACT LIGHTCURVES AND CONSTRAINTS ON ITS POST-IMPACT SPIN STATE AND SHAPE. P. Pravec[1*], P. Scheirich[1], A. J. Meyer[2], H. F. Agrusa[3,4], R. Nakano[5], M. Hirabayashi[5], D. C. Richardson[3], S. D. Raducan[6], [1]Astron. Inst. Czech Acad. of Sciences, Ondřejov, Czech Republic (petr.pravec@asu.cas.cz), [2]CU Boulder, Boulder CO, USA, [3]U Maryland, College Park MD, USA, [4]U Côte d'Azur, Obs. Côte d'Azur, CNRS, Lab. Lagrange, Nice, France, [5]Auburn U., Auburn AL, USA, [6]U Bern, Bern, Switzerland.

Introduction: On 26 September 2022, NASA's DART spacecraft safely impacted Dimorphos, the secondary member of binary asteroid (65803) Didymos, in a successful demonstration of kinetic impactor technology [1]. Ground-based observations indicated a 33.0 ± 1.0 (3σ) min reduction in the secondary's orbit period [2], implying an along-track change in orbital speed of –2.70 ± 0.10 (1σ) mm s^{-1} and an estimate of $\beta = 3.61^{+0.19}_{-0.25}$ (1σ) for the momentum enhancement factor resulting from escaped ejecta, if the bodies have the same bulk density [3]. Images taken from DART revealed that the pre-impact shape of Dimorphos was close to an oblate spheroid with equatorial axis ratio a/b = 1.02 ± 0.02 [1]. Its pre-impact spin state was not directly measured but the body was expected to be in a relaxed, tidally locked state, like the secondaries of all other well-observed binary asteroids with parameters similar to those of Didymos [4]. It was predicted that the DART impact would change not only the orbit but also the spin state and shape of Dimorphos [5].

We present observations of Dimorphos' rotational lightcurves taken in December 2022 and January 2023 that showed significant amplitudes, and analyze how they constrain the post-impact rotation and shape of Dimorphos.

Dimorphos lightcurve observations: The rotational lightcurve of the secondary member of a binary asteroid is derived from its photometric observations by lightcurve decomposition [6]. For Dimorphos, the pre-impact observations showed no significant rotational lightcurve amplitude, which was consistent with its spheroidal shape in a tidally locked state [6]. Photometric observations taken during the first 75 days after the DART impact were not adequate for detecting Dimorphos's rotational lightcurve, as the measurements were contaminated by ejecta during the first few weeks after the impact and then the binary system was in geometry unfavorable for measuring the secondary's lightcurve until mid-December. Dimorphos's lightcurve was first detected in our observations taken with the 1.54-m Danish telescope at La Silla Observatory on December 22. By January 29, we detected it on 7 nights in total. An example of the observations is shown in Fig. 1.

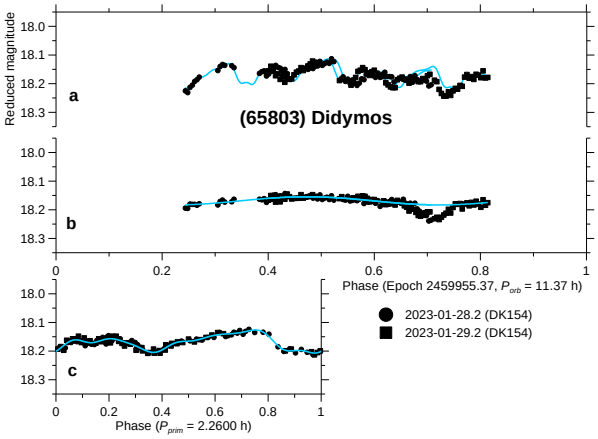

Fig. 1: Decomposition of the Didymos lightcurve data from 2023-01-28 and 29. Dimorphos's rotational lightcurve is shown in panel b (blue curve).

Constraints on Dimorphos' spin state and shape: The observed Dimorphos lightcurve amplitudes (in the total light from the primary and the secondary) were from 0.007 to 0.028 mag, with an average of 0.017 ± 0.003 mag. Correcting for the amplitude-phase effect and assuming zero obliquity of Dimorphos, the post-impact equatorial axis ratio is estimated to be a/b = 1.34 ± 0.10, which differs significantly from the pre-impact axis ratio. If there are significant obliquity variations, however, this estimate would represent an upper limit on the axis ratio. These preliminary estimates indicate that Dimorphos either underwent significant reshaping due to the DART impact or is in an excited non-principal-axis (NPA) rotation state, or both.

The minima of Dimorphos's lightcurve coincide with the times of mutual eclipse events. This indicates that the long axis of Dimorphos approximately pointed towards Didymos (to within a few ten degrees). However, shape change following the DART impact may have contributed to a complex rotation of Dimorphos that may not be captured well in the lightcurve. Mutual dynamics simulations that account for the DART impact and shape change will help to interpret the lightcurve data to get tighter constraints on Dimorphos's spin state and shape.

References: [1] Daly R. T. et al. (2023) *Nat.* in press. [2] Thomas C. A. et al. ibid. [3] Cheng A. F. et al. ibid. [4] Pravec P. et al. (2016) *Icar.*, 267, 267. [5] Raducan S. et al. (2023) submitted. [6] Pravec P. et al. (2022) *PSJ*, 3:175