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THE DISCOVERY OF BINARY ASTEROID 5674 WOLFF AT ISAAC AZNAR OBSEVATORY

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We report on the discovery that minor planet 5674 Wolff is a fully-synchronous binary system with an orbital period of 93.7 ± 0.2 h. The combined primary+secondary rotation amplitude is 0.52 ± 0.02 mag. A lower limit on the secondary-to-primary mean diameter ratio is D_2/D_1 = 0.80.

5674 Wolff is a main-belt asteroid that was discovered in 1986 by E. Bowell at Anderson Mesa Station, Lowell Observatory. We found no previous reported lightcurve data for Wolff.

Aznar used a Meade LX200 GPS 0.35-m *f*/10 Schmidt-Cassegrain telescope (SCT) and SBIG STL-1001E CCD camera with adaptive optics accessory. The system produced an image scale of 1.44 arcsec/pixel. Oey made his observations with a 0.35-m SCT operating at *f*/5.9 and SBIG ST8XME CCD camera. The image scale was 0.88 arcsec/pixel. Groom's observations were made with 0.30-m SCT operating at *f*/7.4 and SBIG ST8XME CCD camera. The image scale was 0.84 arcsec/pixel. All images were unfiltered with exposures of 300 seconds each.

A library of bias, flat, and dark frames were used for image processing. Period analysis was done using *MPO Canopus* version 10.7.1.4 , which incorporates the FALC algorithm (Harris *et al.*, 1989), and *Asteroid LightCurve Analysis* software, developed by Pravec (Pravec *et al.*, 2006). Both Aznar and Oey reduced their data using the Comp Star Selector utility in *MPO Canopus* and magnitudes from the CMC-15 catalog. This catalog provides Sloan r´ and 2MASS JHK magnitudes. V and R magnitudes were derived using formulae by Dymock and Miles (2009). This method of data reduction has improved the nightly linkage errors to 0.10 mag.

Observer	Sessions	Session number
Aznar	19	1-68 (noncontiguous), 74, 76, 86, 92, 96
Oey	4	80, 94, 99, 101
Groom	4	73, 85, 90, 98

Table 1. The number of sessions and session numbers for each observer.

Aznar started observing 5674 Wolff in 2015 October and completed it in December. During that time, he discovered the typical appearance of mutual events in the lightcurves during the 19 nights of observations. He requested assistance from Oey and Groom in early December. They obtained an additional 10 nights of observations to improve the lightcurve. During the span of the observations, the asteroid moved from phase angle +5° to +28° (post opposition) while the phase angle bisector longitude (L_{PAB}) increased from 9° to 23° and the latitude (L_{PAB}) remained at about –1°. All dates and time included in this paper are in the UTC and light time corrected.

Some of the original data sets were excluded from the analysis due to low photometric quality. Within those remaining, some of individual data points were excluded because of hot pixels, clouds, or background stars. The result was a much-improved, calibrated composite lightcurve that allowed proper analysis. Two short sessions within the events were also removed since it could lead to ambiguities where they could latch on to the wrong portion of the double events. The discovery data are considered borderline despite full coverage of the overall lightcurve because the events did not have double coverage.

Figure 2 shows a composite lightcurve featuring the rotation period of the primary and mutual events of the binary system. The 0.7 mag deep "W" shape associated with the minimums of the lightcurve were double events (eclipse and occultation) that occurred every 47 hours at relatively large phase angles.

Figure 1 depicts an assumed clockwise (retrograde) system; though we note the sense of revolution is unknown. As the satellite orbits the primary (A), the first part of the double event at phase 0.25 shows the satellite occulting and moving away from the primary (B). The second part of the double event is caused when the satellite casts its shadow on the primary and then moves away from the primary (C). At phase 0.75, the first part of the "W" is when the satellite disappears and then reappears from behind the primary in an eclipse (D) followed by the second part of the "W", which is caused by the disappearance and reemergence of the satellite from the shadow of the primary.

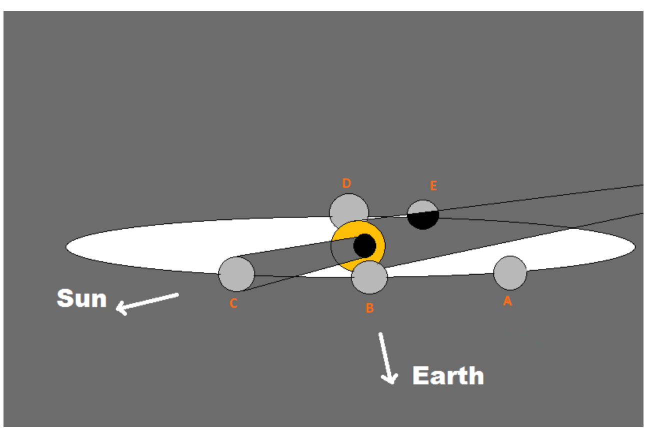

Fig 1. Diagram of the mutual events in 5674 Wolff.

The mutual events were up to 0.70 mag deep and the deepest part of the attenuation in the lightcurve shows no "flat bottom" (Pravec, 2012). This indicated partial mutual events and set the lower limit of the ratio of the satellite diameter and the primary diameter (D_2/D_1) as 0.80. The lightcurve amplitude was 0.52 mag. Since the observations were taken at relatively high phase angles, the amplitude-phase effect could distort (increase) the measured actual amplitude by up to 40%.

The total light curve amplitude was 1.22 ± 0.02 mag. The effective equatorial elongation of the primary+secondary is estimated to be about 1.4. This is likely a fully-synchronous binary system where both the primary and the secondary rotation periods are synchronized with the orbital period of the satellite at 93.7 ± 0.2 h. More observations are needed at future apparitions to further constrain the physical parameters of this interesting binary.

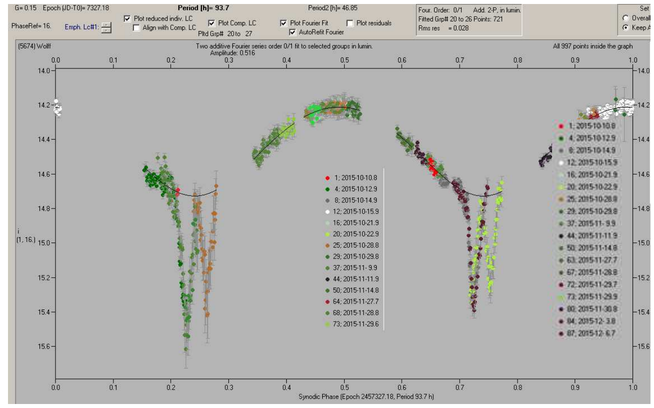

Fig. 2 Light curve plot of binary asteroid 5674 Wolff.

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