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Lightcurve photometry of Didymos in support of NASA's DART mission

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ABSTRACT

On 26 September 2022, NASA's DART (Double Asteroid Redirection Test) spacecraft intentionally impacted the ~170-m asteroid moon Dimorphos. As the world's first full scale planetary defense experiment, this impact changed the orbit period of Dimorphos around its primary body, the asteroid 65803 Didymos. Many years of characterization efforts with ground-based telescopes helped ensure the success of this experiment. We will present the results from a coordinated campaign of lightcurve observations spanning both pre- and post-impact apparitions. We will highlight these results in the context of planetary defense, in particular how ground-based reconnaissance can provide detailed and essential insights into asteroid properties.

Observations prior to impact spanned a baseline of almost 20 years and resulted in extremely high precision for the orbital parameters of Dimorphos around Didymos, making it one of, if not the best characterized binary asteroid in the Solar System. For

example, the pre-impact orbit period of Dimorphos = 11.92147 hr was constrained to a precision of about 70 milliseconds through measurement of mutual events (eclipses and occultations) in lightcurve photometry (Naidu et al. 2022; Scheirich & Pravec, 2022). This is more than two orders of magnitude better than typical constraints for binary asteroids (e.g. Pravec et al. 2006).

Following the DART impact, a world-wide campaign of lightcurve observations determined a new orbit period for Dimorphos equal to 11.371 +/- 0.003 hr, representing a 33-minute change in the period (Thomas et al. 2022). Despite the presence of significant ejecta obscuring the binary system, the first mutual event was detected just 28 hours after impact. Dozens of subsequent events have since been detected and have led to a refinement of the system's orbit solution. Lightcurve observations during this mutual event season are expected to continue through March of 2023.

Aside from contributing to DART's primary mission requirements, this coordinated campaign highlights aspects that are broadly applicable to planetary defense. Despite a favorable apparition in 2022 (Didymos apparent magnitude V<16.5 through December), collecting high quality photometry for mutual event analysis has been a challenge. Systematic biases in all data sets, as well as a wide diversity of observational setups, have resulted in subtle discrepancies that are not easily reconciled. For other targets, this would influence estimations of absolute magnitude (H) and object size, as well as constraints on rotation state. While these issues can be mitigated with data spanning multiple apparitions, that may not be feasible for all targets, e.g. a potential impactor with short lead time. For high priority targets like Didymos, simultaneous observations from multiple sites offer a powerful approach to mitigating uncertainties and systematics. Regardless of these subtleties, the DART lightcurve campaign has been highly successful and highlights the capability of a diverse observing community to quickly and reliably produce mission critical data products.

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Comments:

Preference for oral presentation