THE OBSERVING WORKING GROUP FOR THE ASTEROID IMPACT & DEFLECTION ASSESSMENT (AIDA) A. S. Rivkin[1], P. Pravec[2], N. Moskovitz[3], A. Thirouin[3], P. Scheirich[2], D. Oszkiewicz[3], D. C. Richardson[4], D. Polishook[5], W. H. Ryan[6], C. A. Thomas[7], M. W. Busch[8] , A. F. Cheng[1], P. Michel[9] and the AIDA Observing Working Group[9] [1]JHU/APL (andy.rivkin@jhuapl.edu), [2]Ondrejov Obs. [3]Lowell Observatory, [4]U. of Maryland, [5]Weizmann Institute, [6]Magdalena Ridge Observatory, [7]PSI, [8]SETI, [9]Obs. Côte d'Azur, CNRS [10]Various

Introduction: The Asteroid Impact & Deflection Assessment (AIDA) is a joint ESA-NASA mission concept currently under study [1,2]. AIDA has two components: the Double Asteroid Redirect Test (DART) is the US component designed to demonstrate a kinetic impactor, while the Asteroid Impact Mission (AIM) spacecraft is on station to do a thorough pre- and post-impact survey of the Didymos system.

Members of the DART and AIM Investigation teams have been organized into several joint and independent working groups, including groups addressing the dynamical and physical properties of the Didymos system, modeling the outcome of the impact and fate of the ejecta, proximity operations for AIM, and Earth-based observations of the Didymos system in preparation for, during, and after the 2022 impact. While there is overlap in subject matter and membership between the groups, we focus here on the activities of the Observing Working Group. Current members of the group are listed in Table 1. We welcome additional members from the community.

Purview of the Working Group: The Observing Working Group has two overall goals. First, to characterize the Didymos system pre-impact. The interpretability of the impact outcomes are vastly improved as the characterization becomes more detailed. The presence of AIM is of great utility, but data in the pre-launch period provides additional constraints on variations due to "natural" dynamical conditions. Details of the binary orbit, system composition, and pole of the system are primary goals of this period, along with providing other necessary inputs to the other working groups for their efforts. The abstract by Richardson et al. in this volume [3] and a paper by Michel et al. [1] summarize the best current values for the basic properties of the Didymos system, including work by members of this working group.

Near-term Plans and Results: The first work by the group was undertaken during the spring of 2015, before DART entered Phase A. During this period Didymos made an apparition reaching roughly V~20.5 in brightness, and our top priority was constraining which of two very different pole positions for the Didymos system was correct. Several telescopes in the 2-4m aperture range around the world attempted observations. While smaller telescopes were unable to reach the needed S/N on a short enough cadence, a spate of bad weather at stations with larger telescopes limited good data to an observing run by Moskovitz and Thirouin on the 4.3-m Discovery Channel Telescope at Lowell Observatory in April. An observed mutual event allowed the one pole position to be ruled out. Didymos is now thought to be a low-obliquity, retrograde rotator, similar to many other asteroid binary systems and consistent with expectations from a YORP-driven origin for the satellite.

We have begun planning for the 2017 apparition, occurring in the first half of the year. Didymos will be ~20% brighter at opposition than the 2015 apparition. Scaling from the successful observations with the 4.3-m telescope gives, assuming the sky+background noise dominates, an expected rms photometric error of 0.020 mag with the same telescope and setup and in the same sky conditions. As errors of 0.02 mag or smaller are generally needed for objectives given below, it indicates that we will need telescopes at least 4 m (or larger, for some of the tasks, or at times longer before or after the opposition) in primary diameter for the advanced characterization in 2017.

Currently, we have four goals for this apparition: 1) Confirming the preferred retrograde pole position, 2) Gathering data to allow BYORP-driven changes in the mutual orbit to potentially be determined by later observations [4], 3) Establishing whether or not the secondary is in synchronous rotation with the primary, 4) Constraining the inclination of the satellite orbit.

We look toward the next apparition of Didymos (January to May 2017). To reach goal 1, taking observations on one full night, covering 2/3 of the orbital period (i.e., about 8 hours) with a 4-m telescope between 21 March and 3 April 2017 should be sufficient. To reach the goal 2, we will need to resolve primary vs secondary events, requiring additional observations of one full and one partial night either before 6 March or after 19 April; a 5-m telescope could suffice for these observations. For task 3, we will need to take high-quality observations, which we estimate will require a telescope of 6-m in diameter on two nights between 21 March and 3 April. To reach goal 4, the most demanding of these goals, we will need to cover at least one full mutual event in each of the four dark times (around new moon) around the start of each month February to May 2017. The beginning and end of this interval will require 6-m telescope(s) as Didymos will be particularly faint; 4-5m class telescopes could suffice during dark time closer to the opposition.

Looking forward, we are also considering whether space-based observations in 2017 or beyond will be appropriate for our observations.

We are also conducting a combined analysis of radar measurements from 2003 and lightcurve measurements from 2003 to provide joint constraints.

Near-Impact Observing: The DART impact is currently planned for the fall of 2022. At that time, Didymos will make an excellent apparition for Earth-bound telescopes, reaching apparent V-band magnitude ~14-15. This brightness is within the capability of eyepiece observing at 0.5-m telescopes, common on campuses throughout the world, and potentially observable in many CCD-equipped backyard systems. Didymos reaches 0.07 AU from Earth, putting it within range of operating radar systems, which are an important component of the near-impact campaign. Modeling is underway to understand the debris cloud that will be created, which may have an appearance qualitatively similar to many “main belt comets” (Figure 2).

While analysis is underway, it is already clear that observations with fairly small (2 m and smaller) telescopes will be possible with good accuracy since beginning in June 2022 through the DART impact period in October (from late April 2022 with larger telescopes), which should bring a substantially refined model for the binary, providing backup and some reduncancy for AIM. Observations after the impact (including potential studies of an impact-created coma) will be possible with <~2m telescopes until the end of February 2023 and longer with larger telescopes. A detection of the expected orbital period change caused by the impact, which is estimated to be on an order of a few minutes, will be possible with a few days of mutual-event timing after the coma disperses.

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Table 1: Current membership of the AIM Observing Working Group

References:[1] P. Michel et al. (2016) Adv. Sp. Res. Submitted.. [2] Cheng, A. F. et al. (2016) *P&SS*, accepted [3] Richardson, D. et al. (2016) *LPS XLVII.* . [4] McMahon J. W. et al. (2016) *LPS XLVII*, submitted. [5] D. Jewitt et al. (2015) *Ap. J., 798,* art #109.

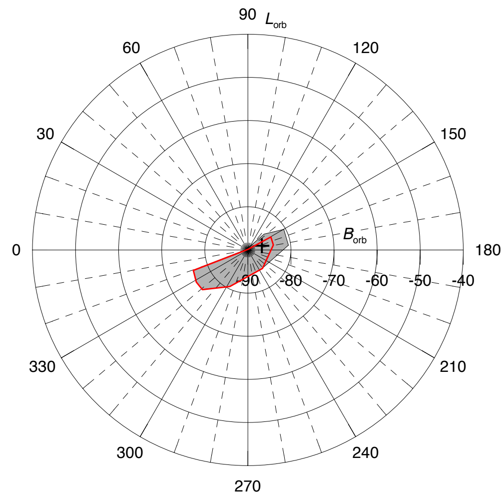

Figure 1: The allowed (3-s) area of the retrograde pole of Didymos’ mutual orbit in ecliptic coordinates. The gray area was derived from the 2003 and 2015 photometric observations. The bold curve is an outline of the area further constrained using the shape model of the primary. The + represents the south pole of Didymos’ heliocentric orbit. Updated from Scheirich and Pravec (2009)

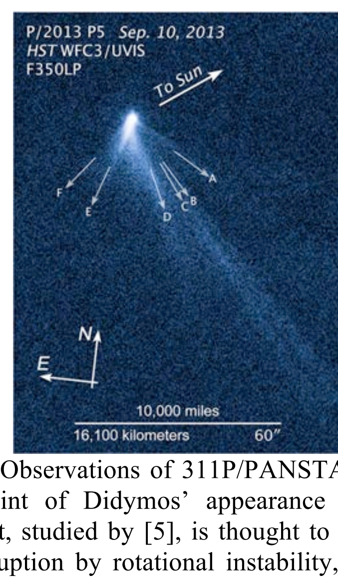

Figure 2: Observations of 311P/PANSTARRS give a possible hint of Didymos’ appearance post-impact. This object, studied by [5], is thought to have experienced disruption by rotational instability, resulting in several impulsive mass loss events. While an impact will only create a single tail, 311P is roughly the size of Didymos’ moon, the target of the DART impact.