THE AFTERMATH OF THE DART IMPACT: A POLARIMETRIC STUDY OF DIDYMOS-DIMORPHOS.

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Introduction: On September 26, 2022, the NASA DART (Double Asteroid Redirection Test) spacecraft struck Dimorphos, the moonlet of Didymos, to test near-Earth object deflection through impact in the context of planetary defense [1]. The impact caused a massive dust cloud to be ejected from the surface [2,3]. Here, we report our findings from imaging polarimetric observations of the Didymos-Dimorphos asteroid system around the time of the DART impact.

Polarimetric observations exploit the fact that sunlight scattered by the surface of astronomical bodies becomes partially polarised. For Solar System objects, linear polarisation measurements may be plotted as a function of the phase angle. The way in which the observed fraction of linear polarisation changes as a function of phase angle depends strongly on the physical properties of the surface layer, including the composition, particle size, packing density and material heterogeneity. The analysis of polarimetric phase curves, combined with photometric and spectroscopic data, provides a unique way to assess the microscopic properties of the surfaces of small solar system bodies [4]. Further, polarimetric maps of extended objects allow one to view the spatial distribution and temporal evolution of the polarisation and may reveal structures that go undetected in intensity measurements [5].

Observations: We monitored the Didymos-Dimorphos system in imaging polarimetric mode from approximately one month before to four months after the DART impact. In this time, we observed the asteroid system in three stages: (1) Pre-impact, when the asteroids were in their 'original' state. (2) Post-impact (days-weeks), when the ejecta dust cloud was present. (3) Post-post-impact (weeks-months), when most of the ejecta had dissipated and/or migrated to the dust tail. These observations were performed at the Very Large Telescope (VLT) and Nordic Optical Telescope (NOT) A number of the VLT observations were made hand-in-hand with spectro-polarimetric observations [6].

Results and Discussion: Our results are summarised as follows. (1) A dramatic drop in polarisation is found immediately (just hours) after the DART impact. We can safely assume that particles with properties different to those present on the surface(s) of the Didymos-Dimorphos before impact were ejected into the system. Importantly, they are characterised by a lower polarisation. Considering this, we suspect fragments smaller than those on the original surface(s) were ejected via the impact. Further, we suspect that these new particles are brighter than those on the pre-impact surface(s) due to the effects of space weathering. In the geometric optics regime, both smaller and brighter particles polarise light less than larger and darker particles [7,8,9], explaining the drop in polarisation.

(2) The polarisation of the post-impact system remains lower than the pre-impact system, even months after the impact. This leads us to believe that some of these new particles settled on the surface(s) of the asteroid(s).

(3) The slope of the post-impact polarimetric phase curve is smaller than that of the pre-impact curve. According to the Umov effect, there is an inverse correlation between an object's maximum degree of polarisation and its geometric albedo, which can be measured from the slope of the polarimetric phase curve at the inversion angle, i.e. the phase angle at which the polarisation switches from negative to positive. A smaller slope of the post-impact polarimetric phase curve confirms that the ejecta particles are brighter than those present on the original surface [10,11].

(4) The polarimetric behaviour of Didymos-Dimorphos is typical of an S-type asteroid. (5) The polarimetric maps show the evolution of the dust cloud and tail, and are comparable to [2] and [3].

Further interpretations of these results will be discussed in the polarimetric models by [12].

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