Las Cumbres Observatory Observing Support for the Double Asteroid Redirection Test (DART) Mission.

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Introduction: The Double Asteroid Redirection Test (DART) mission [1] is a NASA planetary defense and technology demonstration mission that will demonstrate the feasibility of kinetic impactor deflection missions. The spacecraft will deliberately impact Dimorphos, the secondary component of the Near Earth Object (NEO) binary system (65803) Didymos. This will result in a change in the binary orbital period that will be measurable by a number of ground-based telescopes including those of Las Cumbres Observatory (LCOGT). This will enable measurement of the momentum enhancement factor, beta, and the first experimental test of a kinetic impactor as a technique for mitigating potential hazardous asteroids.

The Las Cumbres Observatory Telescope Network: The LCOGT network is a global network (see Figure 1 below) of remote, robotic telescopes which can be dynamically scheduled and has the ability to react to new targets within minutes and is also able to perform long-term monitoring for extended periods of time. The LCOGT network has grown to comprise two 2-meter telescopes, twelve 1-meter and ten 0.4-meter telescopes at sites at Haleakala (Hawaii), McDonald Observatory (Texas), Tenerife (Canary Islands), Cerro Tololo (Chile), South African Astronomical Observatory (SAAO; South Africa) and Siding Spring Observatory (Australia).

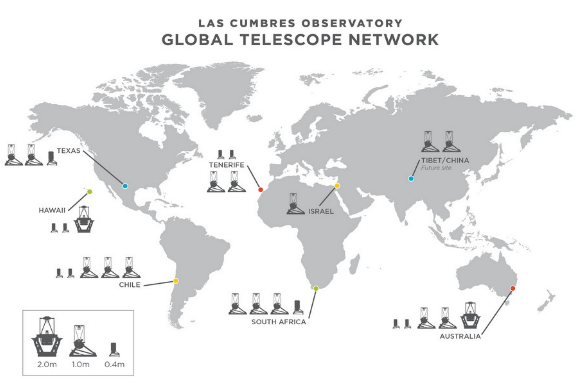

Figure 1: World map showing the distribution of the telescopes of LCOGT network .

The network has been fully operational since 2014 May, and observations are executed remotely and robotically. In addition, all the observatory software to submit, schedule, execute observations and reduce the data is all cloud-based, allowing operations to continue throughout the pandemic (once the telescope sites themselves re-opened). Work is underway to deploy two 1-meter class PlaneWave telescopes to the Ali (Tibet) site in 2022. This will produce a complete Northern Hemisphere ring for continuous coverage in addition to the existing Southern Hemisphere ring.

The twelve 1-meter telescopes each have a *Sinistro* CCD imagers giving a 26'x26' FOV and containing 21 filters including complete Bessell and Sloan/ PanSTARRS sets, including the broad PanSTARRS-*w* filter (equivalent to SDSS g'+r'+i'). In addition to the main imaging cameras, each 1-meter telescope has a 1024 × 1024 FLI CCD camera capable of imaging at up to 0.5 Hz rate.

Planned Observations: Due to the path of Didymos across the sky during the 2022 apparition, pre-impact observations and the impact itself will take place in the southern hemisphere where LCOGT has a large number of telescope resources (see Figure 1). In addition, the actual time of impact of the DART spacecraft with Dimorphos itself will take place during the local night at LCOGT's site at SAAO, South Africa.

Light curve observations: For the measurement of the light curve, observation of the mutual events and determination of the binary orbit period, observations will use the LCOGT 1-meter *Sinistro* imagers and PanSTARRS *w* filter to maximize throughout. Observations are planned to cover several of the ~12 hour binary orbital periods both pre- and post-impact during 2022 August – December.

Observations will be scheduled using the NEOexchange [2], the web-based target selection, scheduling and data reduction system we have developed to confirm NEO candidates and characterize targets of special interest such as radar-targeted known NEOs, close passing NEOs and potential mission destinations.

During early 2022, observations of other NEOs will be undertaken as “Didymos simulants”. These other NEOs will be of a comparable brightness and have similar on-sky motions as Didymos will have during the time following spacecraft impact. These NEO observations will take place using a newly developed semi-sidereal tracking mode for the LCOGT network which uses the orbital elements passed through from NEOexchange to predict the position at the time of observation but halves the differential rates sent to the telescope. This allows observations with a small amount of elongation of both the NEO target and reference stars, compared to the normal tracking on the NEO target but allows for longer exposures and a higher signal to noise ratio. (Use of orbital elements is necessary for moving object submissions to LCOGT rather than a pre-computed ephemeris table for a particular site e.g. from JPL HORIZONS. This is because submitted observation requests can be moved from site to site and to different times within the specified observing window by the LCOGT scheduler which re-plans and reschedules the whole network every ~10 minutes).

High cadence observations at time of impact: Although not part of the mission goals for the DART mission and despite considerable uncertainty on what will be visible from ground-based observatories, we will also take advantage of the multiple 1-meter telescopes and fast frame rate cameras at LCOGT's South African node to attempt multi-telescope imaging of the evolution of the impact plume and ejecta after the DART spacecraft's impact into Dimorphos. Obviously Didymos, Dimorphos and any plume produced after impact will be unresolved from the ground and all that can be monitored is any change in total brightness. Nevertheless given the southern declination of Didymos and the timing of the impact during the nighttime at LCOGT's South Africa node, we will attempt high cadence simultaneous observations using the fast frame rate autoguider cameras during the time of impact and afterwards before it becomes visible to larger aperture and higher resolution assets in Chile. (The LCOGT autoguider cameras are used regularly for very similar high cadence observations for occultations e.g. [3])

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References:

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