International Occultation Timing Association

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Eclipses of Stars by Near-Earth Asteroids Might Be Used to Save Earth and Gain Science

On July 29th, 2019, amateur and professional astronomers swarmed the countryside from California to Colorado to capture the shadow of a small asteroid.

David Dunham, of the International Occultation Timing Association (composed mainly of dedicated amateur astronomers), and Marc Buie, Southwest Research Institute, coordinated the efforts of scores of astronomers to deploy more than 60 telescopes with cameras and recorders in the tightest "fence" ever set up to observe an occultation (eclipse) of a bright star by the mysterious small active asteroid (3200) Phaethon. The geometry of such an event is illustrated with a figure at http://iota.jhuapl.edu/OccultationGeometry.tif. The July 2019 observers precisely measured Phaethon's shadow, pinning down its location in the sky hundreds of times more accurately than standard direct astrometric observations with large telescopes. Since Phaethon's discovery in 1983, it was known to be the source of the Geminid meteor shower, one of the strongest visible each year in mid-December. Phaethon's orbit is extremely elongated, passing less than half Mercury's distance from the Sun at its perihelion (closest point to the Sun), and well beyond Mars' orbit at its farthest, so the solar heating varies by almost a factor of 300 around its 1.43-year orbit. The strong thermal shocks at each perihelion cause Phaethon to shed rocks and pebbles, creating the Geminid meteoroid stream that has been imaged by NASA's Parker Solar Probe. This mass loss exerts a tiny "non-gravitational" force on Phaethon that can be measured by precise observations of its orbit.

The 2019 July occultation observations were used to refine our knowledge of Phaethon's orbit, which permitted the prediction and observation of six more occultations by Phaethon. Analysis of the orbit using all of these occultation observations resulted in a 3-fold improvement in our knowledge of the non-gravitational force acting on the asteroid. This in turn aids the accurate calculation of Phaethon's trajectory for thousands of years. And it will help planning for the Japanese Space Agency's DESTINY+ space probe that plans to fly by and closely observe Phaethon in 2025.

Although the study of Phaethon's long-term orbit shows that it poses no danger to Earth, there are other near-Earth objects (NEOs) rated as potentially hazardous that could. The techniques demonstrated by the Phaethon occultation campaigns can be applied to other NEO's to characterize them and greatly improve their orbits, contributing to an improved assessment of their risk. The pro-am collaborations of future occultation campaigns can inspire and educate future generations of astronomers, as well as help determine the physical and dynamical properties of small bodies, including NEOs, throughout the solar system. Sky observers everywhere are invited to participate with IOTA and SwRI in this exciting work; the opportunities are frequent and ubiquitous.

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Reference:
This result was presented as oral presentation 412.10, "(3200) Phaethon, First Successful Observations of Occultations by a small Near-Earth Object," at the American Astronomical Society's 52nd Division for Planetary Sciences meeting online, Oct. 29, 2020. Preparation has started for a formal paper that will be submitted to the Astronomical Journal about a year from now.

Marc Buie acknowledges support from NASA, from their New Horizons and Lucy programs. We thank all the observers, most of whom travelled to the occultation paths with their own resources and with their own equipment.

Please visit our website at http://PhaethonLinksAndGraphics.htm for more information, especially our press Power Point presentation with direct link http://412p01PhaethonOccultationsDunhamForPressLatest.pptx.