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NEAR EARTH ASTEROID CHARACTERIZATION VIA STELLAR OCCULTATION: THEORY AND OBSERVATION

Abstract

This paper describes a technique to detect and characterize Near Earth Asteroids (NEAs), using a formation of ground or space-based telescopes that observe the intensity patterns of stellar occultations. Advanced optical processing of the recorded intensity data is employed to deduce the size, shape, and albedo of detected NEAs. The technique greatly extends conventional occultation technology to produce sharp silhouettes of NEAs even when their shadows in starlight are heavily diffracted. The work concentrates on asteroids that are small enough that only a small fraction have been detected, yet are large enough to cause significant destruction in the event of an Earth impact. Conventional characterization of NEAs via stellar occultation is well known and widely practiced among both amateur and professional astronomers. An array of observers note the times at which a star apparently disappears due to occultation by an asteroid and the times when it reappears. Processing of this data allows one to draw a set of parallel chords across the shadow region, thereby determining the asteroid's size and shape. But the above approach assumes that the NEA is able to cast a sharp shadow. That is, the shadow must have Fresnel number much larger than unity. Consider, however, NEAs with diameters between 140m and 40m. It is estimated that only about 1Fortunately, it is still possible to reconstruct the sharp silhouette from measurement of the time histories of the light intensities observed by an array of telescopes, using high bandwidth photon counting detectors. The paper describes how the sharp silhouette as well as size and some orbit parameters are recovered from the intensity time histories using a novel phase retrieval algorithm. Calculations of the signal-to-noise ratio are summarized and the expected frequency of appropriate occultation events is estimated. To illustrate the technique, the paper includes observational results involving four 400mm diameter telescopes.