PhAst: Accelerated Asteroid Characterization Through Novel Photometric Integration Using Ground and Space-Based Sky Surveys

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The pace of asteroid discovery surpasses the rate at which their physical properties can be analyzed. To date, phase curves, which are crucial for asteroid characterization, have been generated for a few thousand of the 1.3 million known asteroids as they necessitate observations from multiple phase angles over several years. This hinders our planetary defense capabilities against near-Earth asteroids and limits our understanding of the solar system's evolution. My novel methodology PhAst combines several years of sparse photometry of serendipitous asteroid observations from ground and space-based all-sky surveys with dense photometry from professional and citizen scientists. The algorithm generates phase curves whose linear component yields the asteroid's geometric albedo and composition while the non-linear brightness surge at small angles determines the absolute magnitude. This allows the creation of folded lightcurves to measure the asteroid's rotation period and, for binary asteroids, their mutual orbital period. PhAst was tested on asteroid Didymos, the target of NASA's DART planetary defense mission, and accurately determined its albedo, rotation period, mutual orbital period, strength, size, and taxonomy. Additionally, PhAst was used to generate phase curves for over 2100 asteroids in 100 hours on a home computer, determining their physical properties, and submitting the analyses to the binary asteroid working group. Moreover, the taxonomical distributions of carbonaceous, siliceous, and metallic asteroids in the main belt were compiled, gaining insights into their migration during the solar system evolution. Open-source PhAst training modules have been developed for citizen scientists to accelerate asteroid characterization and strengthen planetary defense.