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Asteroid Phase Curves Seen by Pan-STARRS 1

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Abstract

The Pan-STARRS survey made 19 million optical observations of more than half a million main-belt asteroids in 2010–2016. We use the phase curves of the $H_r > 13$ sample to derive the absolute magnitudes and slope parameters of more than half a million asteroids, and map these to the dynamical populations of the main belt.

Introduction

Phase curves provide critical information about the surface reflectance properties, shapes, and sizes of minor planets (Bowell et al., 1989; Oszkiewicz et al., 2012), which are typically unresolved in observations. Two parameters defining the physical properties of a minor planet can be derived from a phase curve. The absolute magnitude H_{filter}, as measured within a given wavelength range, provides a luminosity, often used as an albedo-independent proxy for size. The slope parameter, G, does not necessarily imply a specific lithology or morphology, but encodes bulk information about an unresolved minor planet's reflectivity. On the scale of populations, the relationships between H_{filter}, G and orbital parameters can provide insight into the formation and evolution of minor planet populations (Oszkiewicz et al., 2012).

1 Pan-STARRS1 observations

Obtaining H and G measurements for a large sample of asteroids has only been possible with the advent of systematic wide-field surveys. The Panoramic Survey Telescope and Rapid Response System 1 Survey (PS1) has created an exceptionally rich imaging dataset. PS1 has made two wide-field Northern sky surveys: the 3π survey (Chambers et al., 2016) and the ongoing Solar System survey (hereafter, S3). The PS1 imager is equipped with six filters: a Sloan-like $grizy$ set and a wide-band w filter, which approximates the gri passband (Tonry et al., 2012). The photometry from the first fifteen months of the 3π survey was considered by Vereš et al. (2015), who obtained H and G parameters for 250,000 asteroids.

We consider the asteroid photometry from both the 3π and the S3 datasets of PS1. The 3π observations we use were acquired after the telescope was refit and the software overhauled, from 2010 through to its end in mid-2014. The S3 observations were made between 2012 June and 2016 October.

We provide phase curve information sampled over this seven-year span for more than half a million asteroids, double that of the Vereš et al. (2015) set. We derive H and G parameters for all available asteroids with well-determined orbits, and map these against the precisely-known dynamical populations of the main belt.

Asteroids with $m_r < 16$ will saturate in the imaging of the upcoming LSST survey; thus, this dataset of physical parameters will remain useful in that era, complementing the phase curves that will be measured with *Gaia* (Oszkiewicz et al., 2017).

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