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Near-Simultaneous Spectroscopy and Polarimetry of Main Belt Asteroids

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Abstract

We present rotationally resolved optical spectra of several main belt asteroids of SMASSII spectral type S, in near-simultaneous conjunction with rotationally resolved linear and circular polarimetry. We discuss the presence or absence of correlations between optical spectral features such as band shapes and depths and spectral slopes, and polarimetric features as a function of rotation phase. The characterization of these asteroid surfaces will provide constraints on the properties of S-type asteroids and will serve as a proof of concept for the use of this technique to study potential targets of future small bodies missions of both scientific and commercial utility.

1. Introduction

Individually, spectroscopy and polarimetry are useful tools for characterizing the surface of small bodies. Implemented simultaneously, they can paint a detailed picture of the properties of asteroid surfaces and how those surfaces interact with incident light. Spectroscopy can reveal the presence of specific minerals and volatiles on the surface, while linear polarization can provide insight into the size of the regolith particles [2] and circular polarization can be used to detect surfaces that are both rough and high in metal content [1]. Each of these measurements will show variation throughout the duration of the target's rotation if its surface properties are not homogenous. Rotationally resolved spectroscopy is a more commonly used diagnostic tool than rotationally resolved polarimetry, which does not exist for as many asteroids. The goal of this work is to demonstrate that polarimetry is a useful complement to spectroscopy by using the two techniques to compare asteroids of the same spectral type and to identify correlations between observed features as the asteroid rotates. If physical surface properties (grain size and metal content) can be linked to specific substances, the combination of these measurements has the potential to characterize surfaces to a level of detail that has not previously been achieved from a remote sensing standpoint.

2. Observations

Two observing sites were used to carry out this study, as this maximized our ability to perform near-simultaneous observations.

2.1 Apache Point Observatory

The Dual-Imaging Spectrograph (DIS) on the Astrophysical Research Consortium (ARC) 3.5m telescope at Apache Point Observatory is a medium dispersion optical long-slit spectrograph that has two channels (Blue and Red) spanning roughly 0.4- 0.9 μm. In its default low resolution mode, it achieves resolving powers of R = 400 in the blue channel and R = 300 in the red channel, making it an ideal instrument for obtaining low resolution optical spectra of asteroids. We expect to be able to readily confirm target spectral types by examining the overall shape of the spectra, as outlined in [4], while also doing more in-depth analysis of the variations of spectral shape, slope, and other features that may change with rotation.

The ARC 3.5m is also equipped with a cross-dispersed near-infrared spectrograph, TripleSpec, covering roughly 0.9- 2.5 μm with R= 3500. We plan to utilize this instrument in the future to explore NIR spectral features associated with asteroid metal content, as demonstrated in [3], also in conjunction with rotationally phased polarimetry.

2.2 The Aerospace Corporation

The Aerospace Corporation, located in El Segundo, CA, is home to a 1m telescope, Aerotel. We expect to perform polarimetric observations using Aerotel and the PHALANX polarimeter, which is designed to achieve 1 ppm (0.0001%) sensitivity on bright targets. This new instrument is a significant upgrade of the POLISH2 polarimeter, which has performed rotationally resolved polarimetry of Main Belt asteroids [5]. Observations of linear and circular polarization of light were taken at similar rotation phases of the targets we observed with DIS in order to determine whether or not there is a link between the observed spectral and polarimetric features.

3. Summary and Conclusions

We discuss comparative signatures to identify correlations between spectral and polarimetric features and make inferences about what these correlations can tell us about the surface properties of asteroids. If the physical properties of asteroid surfaces can be connected to the spectral properties of specific substances, this will add another layer of information regarding the characterization of such surfaces.

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