Spectral Variations of D-Type Asteroids

Do Variations Correlate to Distance?

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Introduction & Objectives

D-type asteroids present one of the most complex puzzles in asteroidal science. Their origin, dynamic evolution, and mineralogical makeup remain unknown. They are dark, difficult to detect, have never been visited by spacecraft, and no confirmed meteorite samples of D-types exist. They could be related to comets, Trans Neptunian Objects (TNO), Kuiper Belt Objects (KBO) or icy outer planet moons.

The purpose of the research is to understand how D-type asteroids differ spectrally at varying heliocentric distances. New ground based spectral observation of 49 selected D-types from different regions of the Solar System, obtained specifically for this work, will be compared to spectra of known meteorite types to establish a possible connection with D-types. Compositional modelling will be applied to the new asteroid spectra, and selected meteorite spectra, to estimate possible surface composition. Finally, the research will attempt to develop a model of spectral gradient of D-types by heliocentric distance.

What is a D-Type Asteroid?

D-type asteroids represent ~2% of the mass of all asteroids [1]. They are mostly in the outer regions of the Main Asteroid Belt with one large cluster located between ~3.0 - 3.2AU and the largest cluster at the Jupiter L4 and L5 Trojan points [1, 2]. Several hundred D-types are estimated to reside in the middle and inner belt with a few dozen recently detected in near Earth space [3, 4].

The term D-type originates from taxonomic classification of observed characteristics [5-7]. D-type spectra are characterized by low albedo (~0.025 - 0.10) and are relatively featureless, exhibiting a steep, almost linear, red slope across the visible spectrum, with a decrease in spectral slope often observed longward of 0.8μm with a slight curvature or gentle kink around 1.5μm [1, 5, 6]. Ambiguity exists between D-types and asteroids of other taxonomic classes (Figure 1) [6]. Spectral reddening of D-types appears to increase with increasing heliocentric distance [8] and decrease with increasing diameter [9, 10]. Observations of Trojan D-types, suggest possible correlations between reddening, inclination, and formation location [11].

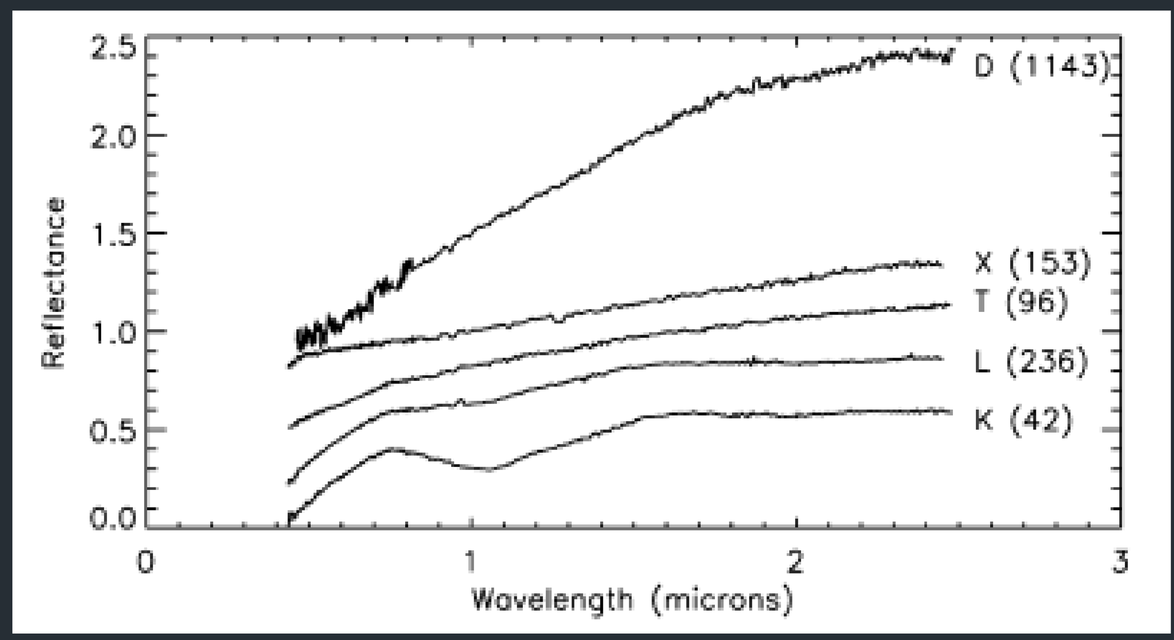

Figure 1: Example of Prototypical D-type Spectrum Compared to Other Types (DeMeo et al., 2009)

Methodology

Spectra will be obtained from observations conducted at the NASA Infrared Telescope Facility (0.8-2.5μm), The Thailand National Observatory (0.3-1.0μm), and the Subaru Telescope (2.8-5.6μm). Data reduction will be accomplished with SpeXtool, Matlab, SARA, and Excel routines [12]. Laboratory samples of the Tagish Lake Meteorite, one of only two meteorite samples with possible connection to a D-type parent body, will be compared to the obtained spectra [13]. Shkuratov modeling, a mathematical technique for estimating surface composition of small bodies, will be applied to find plausible models of surface mineral composition [14]. Detailed analysis of spectra may yield a set of constraints related to variations in heliocentric distance.

Early Results

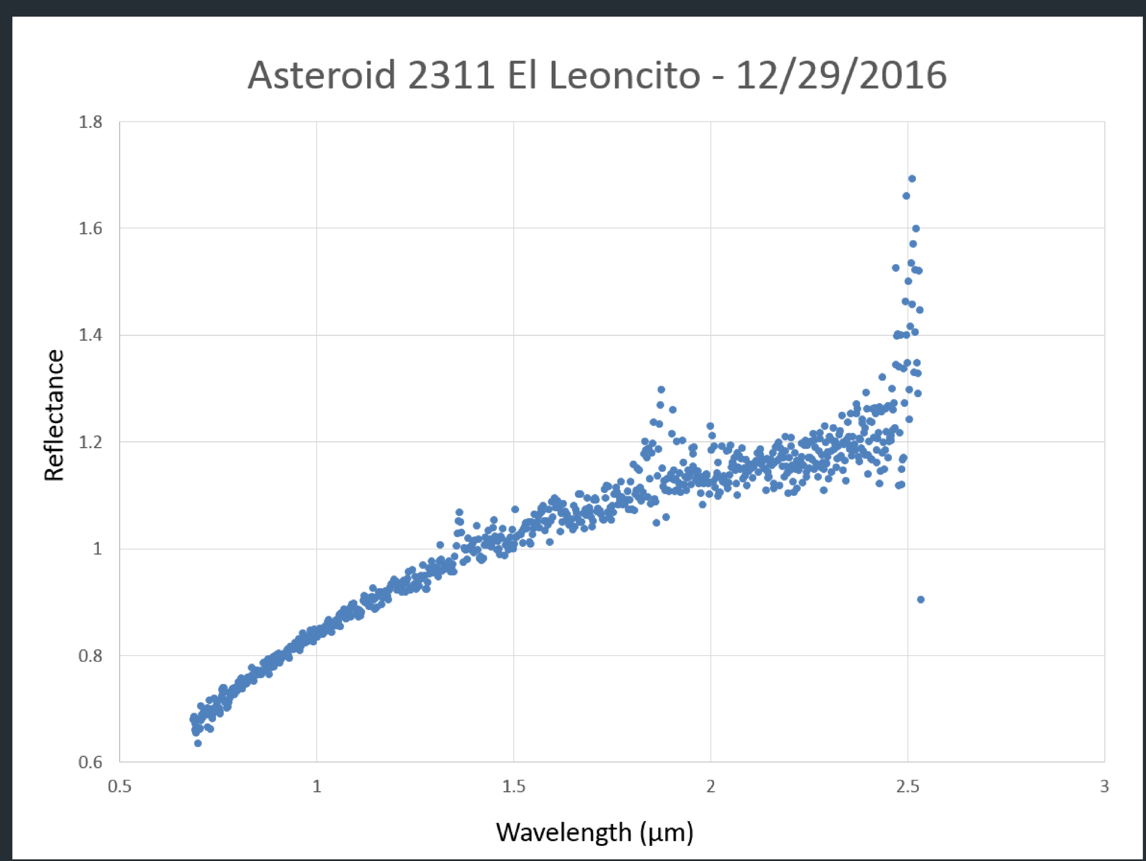

Figure 3: NIR Reflectance Spectrum of 2311 El Leoncito

A spectrum (0.8-2.5μm) of asteroid 2311 El Leoncito (α = 3.6AU) was obtained from observations at NASA IRTF in December 2016 using a 200s integration time (Figure 2). Each author reduced the same data set separately and achieved consistent results. Although no apparent mineral absorption features have been discerned from this initial data, work is ongoing to obtain additional spectra from other targets.

Next Steps

There are four key focus areas going forward: 1) Securing adequate telescope time for acquiring spectra; 2) Understanding how potential variations in spectra correlate to heliocentric distance; 3) Developing modeling code for applying the Shkuratov equations to reduced spectral data; 4) Developing analysis procedures for laboratory comparison of spectra, meteorite samples, and terrestrial material analogs as input to surface compositional modeling.

References

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