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Ultraviolet Spectroscopy of Jupiter Trojans Patroclus and Leucus Using the Hubble Space Telescope

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Abstract

Interest in the Jupiter Trojans, a population of small bodies that orbit in Jupiter's L4 and L5 Lagrange points, has increased in recent years, particularly with the selection of the NASA Discovery class mission Lucy, which will visit five Jupiter Trojans in the late 2020s to early 2030s. Despite this, the spectra of the Trojan population remains enigmatic due to a relative paucity of features in the visible and infrared regions. We present the ultraviolet spectra (>200 nm) from the Hubble Space Telescope of the two Trojan asteroids (617) Patroclus and (11351) Leucus. Both these targets will be visited by the upcoming Lucy mission.

1. Introduction

Jupiter's Trojan asteroids are a population of small bodies that share Jupiter's orbit, concentrated into leading and trailing swarms near the Sun-Jupiter L4 and L5 Lagrange points. Due to the dynamical stability of their orbits over billion year timescales, the Jupiter Trojans represent a population of primitive objects whose physical and chemical properties have remained relatively unchanged since their emplacement within Jupiter's Lagrange points. Various models of solar system formation, including the Nice model [4] and the more recent Jumping Jupiter model [5] have identified potential source populations and capture mechanisms for the Trojans. The composition of the Trojan source population varies with its location within the primordial disk, thus the study of the physical and chemical properties of the Trojan population has the potential to differentiate between competing dynamical models of solar system formation and yield insight into the process of planetary formation and migration in the very early solar system.

However, the chemical composition of Trojan asteroids remains mysterious due to their relatively featureless spectra. In the visible and near infrared (VNIR), Trojan asteroids display a broad increase in reflectance towards longer wavelengths, resulting in reddish spectral slopes. In visible-near infrared spectral slope, the Trojan population is bimodal, with two spectral groups called the "red" and "less-red" populations [7]. At longer wavelengths, in the thermal infrared, an emission feature at 10 microns has been observed [1]. This feature is interpreted to be due to fine grained silicates in a fairy castle structure or suspended in a transparent matrix. The ultraviolet region of the spectrum is also useful for investigating space weathering on small bodies. Recent ultraviolet spectra of six Jupiter Trojans have found that the trend in spectral slopes in the visible and near infrared is reversed in the ultraviolet: objects with steeper slopes in the VNIR tend to have shallower slopes in the UV, while objects with shallower slopes in the VNIR have steeper UV slopes, a trend that has been interpreted as due to space weathering [6]. Using the Hubble Space Telescope, we examine the ultraviolet spectra of two additional Trojan asteroids, (617) Patroclus and (11351) Leucus, two asteroids that will be visited by the upcoming Discovery class mission Lucy.

2. Procedure

Spectra of Patroclus and Leucus were obtained using the G280 grism on the Wide Field Camera 3 (WFC3) aboard the Hubble Space Telescope. Spectra were extracted from the images using the aXe reduction pipeline for slitless spectroscopy [2]. Outliers were rejected from the extracted spectra at 5-sigma using a moving mean box average with a width of 20 points. The resulting spectra were divided by an interpolated, Gaussian smoothed solar spectrum based on the SOLAR-ISS spectrum [3] fitted to a small (< 10 nm) wavelength shift and overall scaling factor. This was done to align each asteroid spectrum to the solar spectrum in case of sub-pixel wavelength shifts in the instrument and ensure the proper alignment of narrow solar spectral lines. Each spectrum was then divided by the best fit shifted and scaled solar spectrum

to produce a relative reflectance. A wavelength array was created by consolidating all the wavelength points sampled by each measurement. For each object, spectra were interpolated and relative reflectance was determined at every point in the wavelength array. Then, for each object, the spectra for all observations were combined by taking the mean of the interpolated reflectance values at each point in the wavelength array.

3. Results

Ultraviolet spectra normalized to the solar spectrum for Patroclus and Leucus are shown in Figure 1. In particular, we note a change in concavity towards the shorter wavelengths in the spectrum of Patroclus, which may be indicative of a spectral feature in the ultraviolet. We will discuss the significance of these spectra and how they compare to the known visibile spectra of these objects. We will also compare our results to the recent ultraviolet observations of six other Trojans [6].

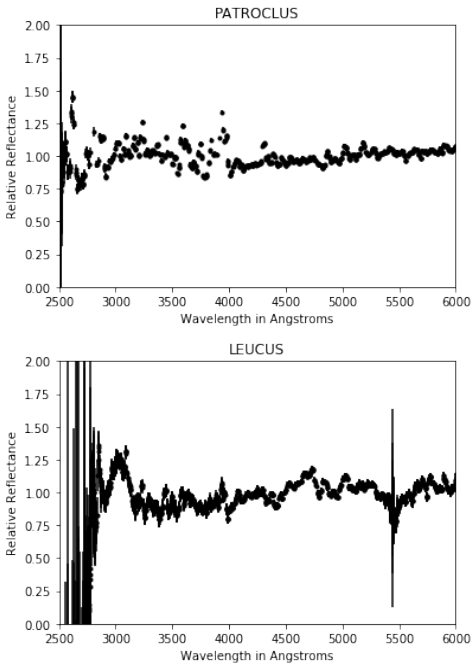

Figure 1: Ultraviolet spectra of Trojan asteroids Patroclus and Leucus obtained by the Hubble Space Telescope WFC3.

4. Future Work

Additional spectra of the Trojans (3548) Eurybates and (21900) Orus will be taken by the Hubble Space Telescope during Cycle 26. Along with the spectra presented here, our sample will span four of the five Trojans that will be visited by the Lucy mission and include both "red" and "less-red" spectral types as well as objects representing the C, D, and P taxonomic classes.

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