VISIBLE ANALYSIS OF NASA's LUCY MISSION TARGETS 3548 EURYBATES, 15094 POLYMELE, 21900 ORUS AND 52246 DONALDJOHANSON.

A. C. Souza-Feliciano[1,2], M. N. De Prá[2], A. Alvarez-Candal[1], N. Pinilla-Alonso[2] , E. Fernández-Valenzuela[2], J. De León[3,4], P. Arcoverde[1], E. Rondón[1], D. Lazzaro[1], [1]Observatório Nacional. Gal. José Cristino St, 77. São Cristóvão. Rio de Janeiro. Brazil. E-mail: carolofisica@gmail.com, [2] Florida Space Institute/Univeristy of Central Florida. 12354 Research Parkway, Orlando, FL 32826, U.S.A. Suite #214. [3]Instituto de Astrofísica de Canarias. C/Vía Láctea s/n, E-38205 La Laguna, Tenerife, Spain. [4] Departamento de Astrofísica, Universidad de La Laguna. E-38206 La Laguna, Tenerife, Spain.

Introduction: Jupiter Trojans (JTs) are primitive small bodies of the Solar System that share Jupiter's orbit around the Sun, residing in two equilibrium points, known as L4 and L5 Lagrange regions [1]. Understanding the origin and composition of these bodies could provide us insights into the composition of the solar nebula that gave birth to the Solar System [2,3]. In the past few years, there is growing momentum for determining the nature of primitive small bodies, with missions such as OSIRIS-Rex, Hayabusa 2, and NASA's Lucy mission.

NASA's Lucy mission will visit five JTs and one main belt asteroid between 2027 and 2028. The observations conducted by this spacecraft will help decipher the history of the Solar System, and perhaps the origins of life and organic material on Earth. In order to provide valuable information for mission planning and maximizing the scientific return, we performed rotationally resolved spectroscopy observations in the visible, looking for inhomogeneities on the surface of the Jupiter Trojans (3548) Eurybates, (15048) Polymele and (21900) Orus with the Goodman High Throughput Spectrograph at the 4-m SOAR Telescope. Additionally, we conducted unprecedented analysis on the main belt asteroid (52246) Donaldjohanson from data obtained at the 10.4m Gran Telescopio Canarias (GTC) in order to extract the first spectral information from this body.

Objective: The main goal of this work is to study how the surface properties of these bodies change with the rotation by visible rotational spectroscopy.

Observations and Data reduction: We observed 3 JTs that will be visited by the Lucy mission at the SOAR Telescope, and observed the main belt asteroid at the GTC, all in the visible wavelength range. We applied standard reduction techniques: images were bias and flat-field corrected. Next, the sky background was subtracted and the spectra, extracted. The spectra were wavelength calibrated with specific lamps. This procedure was repeated for the three sub-exposures of each target. The spectra were then averaged to produce a final object spectrum, integrating 4 spectra for (21900) Orus (covering 48% of its rotational period), 3 for (3548) Eurybates (covering 63% of its rotational period), 3 for (15094) Polymele (coverings 85% of its rotational period) and one spectrum of (52246) Donaldjohanson

Analysis: While the spectra of primitive bodies are typically considered featureless at visible wavelengths, our analysis was directed toward the search for slope variations, which may indicate inhomogeneities on the surfaces.

To calculate the spectral slope we used the concept of the spectral gradient (S') [4]. Unlike the other spectra, the spectrum of (52246) Donaldjohanson displays a clear drop of reflectance below 0.5 μm. For the characterization of JTs spectra we evaluated the visible slope, the presence of a turn-off point [5] around 0.5 μm, and the near-ultraviolet slope. The slopes of all JTs spectra with the error-bar of 2-sigmas for (3548) Eurybates, (15048) Polymele and, (21900) Orus, are shown in the Figure 1.

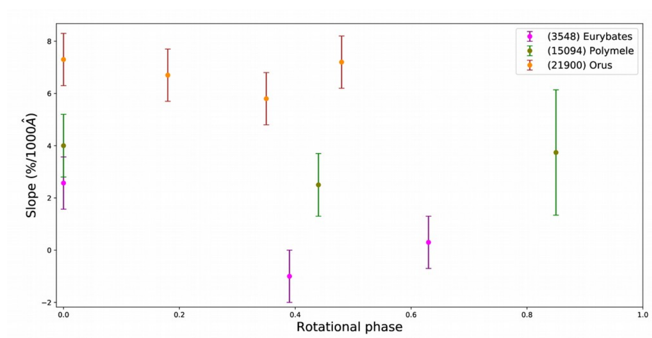

Figure 1: Spectral slope of the observed objects versus rotational phase. Each dot represents the slope of an object with the errorbar of 2-sigmas levels for Eurybates (pink), Polymele (green) and Orus (orange). The spectra slopes are in units of %/1000Â and the values of the rotational phase are arbitrary with 0 representing the beginning of the observation and 1, the end of the rotational period of the object.

Results: Our analysis suggests that there are heterogeneity on the surface of (3548) Eurybates (Fig. 1). In an effort to confirm this heterogeneity, we performed time-resolved visible photometry for 2 nights at the 1-m OASI (Brazil) telescope, in the **r** and **i** filters. Detailed analysis of the photometric data is in-progress. We did not find strong statistical evidence of heterogenity in the data of (15048) Polymele and (21900) Orus. In contrast to the other spectra, (522246) Donaldjohanson showed a decrease in reflectance towards lower wavelengths. This feature is commonly associated with iron-bearing phyllosilicates in the surface of primitive asteroids. While this feature is associated with aqueous alteration, we did not find any structure to confirm it.

Discussion: Although there has been no evidence of ices on the surface of JTs [6,7,8], the theories of formation for this population suggest that ices should exist [2,3]. The current paradigm is that the ice-rich interior of JTs is obscured by a refractory crust, produced over the solar system history by steady space weathering [8,9]. In such a scenario, occasional impacts could expose the underlying volatiles, such as water ice [10]. Then, to find spectral variations in the slopes of these objects, could be an indication that we are observing a partion of the surface that was recently exposed. The fact that (3548) Eurybates is a member of a collisional family, makes it a strong candidate to have collided in its recent past, which may have exposed some sub-surface material [11]. However, there are other mechanisms that can affect the spectral slope, such as different compositions, distinct regolith sizes, surfaces with different ages that were differently affected by space weathering [12] or a combination of all these effects.

Conclusion: We obtained visible rotational spectra of targets of the Lucy mission, including 3 JTs with the Goodman SOAR spectrograph and, one main belt asteroid with the OSIRIS camera at GTC. In this work, we show for the first time a rotational spectrum analysis in the visible for these JTs. For the main belt asteroid, it was not possible to do a rotational spectrum analysis; however, we performed the first spectral analysis in the visible for it. Our results will support the Lucy mission by providing unprecedented results of this peculiar population of primitive bodies and will establish the broader framework and maximize the value of the spacecraft results.

References: [1] Szebehely, V. (1967). AJ, 72, 7.
[2] Marzari F. et al. (2003). Icarus, 162, 453.
[3] Morbidelli A. et al. (2005). Nature, 435, 462.
[4] Jewitt, D.C. (2002). ApJ, 123, 1039.
[5] De Prá., M. et al. (2018). Icarus, 311, 35.
[6] Dotto E. et al. (2006). Icarus, 183, 420.
[7] Fornasier, S. et al. (2007). Icarus, 190, 2, 622.
[8] Emery J. P., et al., 2015, in Asteroids IV. Univ. Arizona Press, Tucson, AZ, p. 203.
[9] Gradie J. & Veverka J. (1980) . Nature, 283, 840.
[10]Guilbert-Lepoutre A. (2014). Icarus, 231, 232.
[11] Perna, D. et al. (2018). MNRAS 475, 974.
[12] De Luise, F. et al. (2010). Icarus, 209, 586.