Project ESPRESSO: Optical Constants for Quantitative Spectral Analysis. M. H. Yant[1], S.M. Hörst[1], A.H. Parker[2], S. Protopapa[2,3], K. Nowicki[2], C.A. Thomas[4], J. Hanley[5], and W.M. Grundy[5], and the Project ESPRESSO Team. [1]Department of Earth and Planetary Sciences, Johns Hopkins University, Baltimore, MD 21218. [2]Space Sciences division, Southwest Research Institute, Boulder, CO 80302. [3]University of Maryland, Department of Astronomy, College Park, MD 20742. [4]Northern Arizona University, Department of Physics & Astronomy, Flagstaff, AZ 86001. [5]Lowell Observatory, Flagstaff, AZ 86001. (marcella.yant@jhu.edu).

Introduction: With the imminent launch of the NASA James Webb Space Telescope (JWST; *Figure 1*), planetary astronomers will soon have reliable access to a far greater range of wavelengths for remote spectroscopic characterization of Near-Earth Objects (NEOs) than ever available before.

In order to accurately and quantitatively interpret in situ and ground-based reflectance measurements to assess surface's composition a complete set of optical constants for potential constituent materials must be available over the wavelength range of interest. These optical constants are the real (n) and imaginary (k) indices of refraction as a function of wavelength. With a library of optical constants of relevant materials, the equations of radiative transfer can be applied (often in the form of Hapke modeling or similar) to accurately model the reflectance spectra of complex mixtures in a variety of states and geometries, permitting quantitative estimates of composition and material scattering properties.

However, for many materials over many valuable wavelength regions, optical constants have not yet been measured in the laboratory, making truly quantitative assessments of some target body compositions from remote spectroscopy impossible. This leads to the common adoption of more limited methodologies, such as approximating compositions with analyses of spectral band widths, band depths, and band centers. The necessity of measuring optical constants of a broad range of minerals in order to recover compositions of the resource-rich C- and M-type asteroids is stated in [1] the "Mineralogy and Surface Composition of Asteroids" chapter of *Asteroids IV*.

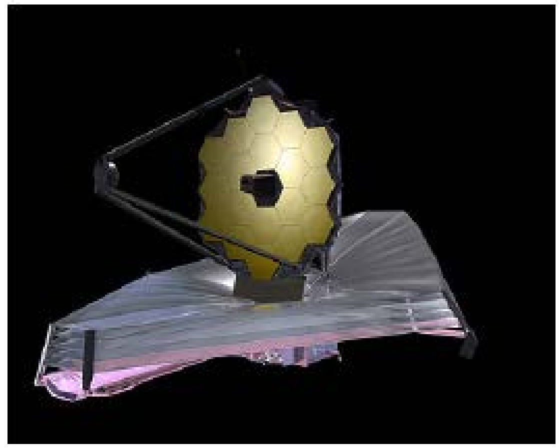

Figure 1: JWST, to launch in 2019, will provide astronomers with unprecedented spectral characterization of target bodies, such as NEOs. To leverage these and other near-term observing capabilities, we will provide the community with an expanded library of optical constants for materials relevant to asteroid and lunar surfaces. Image credit: NASA/GSFC.

In this work, we describe how we will respond to this need by expanding the library of critical optical constants. The Project ESPRESSO[1] (Project for Exploration Science Pathfinder Research for Enhancing Solar System Observations) node of the SSERVI (Solar System Exploration Research Virtual Institute) program will be measuring optical constants of lunar and asteroid constituent materials for

[1] https://www.espresso.institute

quantitative compositional analysis of these target bodies.

Methods: At Johns Hopkins University, our team is in the process of implementing a facility to provide SSERVI and the planetary community with reliable access to rapid, responsive measurements of optical constants over the wavelength range 0.175–28.5 μm, well-matched to several current and upcoming telescopic facilities including JWST. The facility's primary instruments are two reconfigurable spectrophotometers that together cover the range 0.175–28.5μm. There is a region of overlap between the two spectrophotometers' wavelength ranges (1.2–3.3 μm), where optical constants can be computed from spectral measurements acquired with *both* devices and all available methods for calibration and cross validation purposes will be applied.

Our proposed effort focuses on materials sorely needing optical constants characterization in the 0.6-5 μm range in order to interpret existing IRTF/SpeX spectral measurements of NEOs [e.g., 2], as well as JWST observations of NEOs planned to occur in parallel with ESPRESSO as Guaranteed Time Observations. In these analyses, we are placing an emphasis on characterizing the 3-μm spectral complex to quantify hydration.

We will use a wide variety of methods to recover optical constants, including

1) diffuse reflectance spectra of powdered samples,
2) transmission spectra of transparent samples,
3) specular reflection spectra of polished pure mineral samples,
4) and variable phase angle reflectance spectra of variable grain size powdered samples.

This will permit cross validation and confirmation of results across different methodologies, identification of materials and spectral regions for which standard radiative transfer modeling methods break down, and ensure that for the vast majority of mineral types at least one method will be viable for extracting optical constants.

We will use the optical constants recovered at the JHU laboratory to analyze the new JWST observations of Near-Earth Objects with mature, sophisticated radiative transfer models developed within our team that have been successfully applied to other solar system targets [3-6]. The results of these observations and modeling will in turn adjust the priorities of material types to be characterized in the Johns Hopkins University lab in later years of the program.

Furthermore, in order to enhance these JWST observations, the ESPRESSO optical constants laboratory team will refine selections of materials for analysis in response to the results of the observational team. Timed to coincide with the launch of JWST and the arrival of OSIRIS-REx at Bennu, we will host a community workshop to develop a community-wide strategy for selecting and processing materials relevant to NEOs for optical constants measurement.

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References: [1] Reddy, V., et al. (2015) *Asteroids IV*, pages 43–63. [2] Rivkin, A. S., et al. (2016) Publications of the Astronomical Society of the Pacific, 128(959):018003. [3] Protopapa, S., et al. (2008) Astronomy and Astrophysics, 490, 365–375 [4] Protopapa, S., et al. (2009) Astronomy and Astrophysics, 501, 375–380. [5] Protopapa, S., et al. (2014) Icarus, 238, 191–204. [6] Protopapa, S., et al. (2017) Icarus, 287, 218-228.