A FIBER-COUPLED PLASMONIC SPECTROMETER FOR IN SITU CHARACTERIZATION OF ASTEROIDS. N. J. Chanover1, S.-Y. Cho2, D. G. Voelz2, P. A. Abell3, C. Dreyer4, and D. Scheld2 1Astronomy Department, New Mexico State University, Box 30001/MSC 4500, Las Cruces, NM 8803, nchanove@nmsu.edu, 2Klipsch School of Electrical and Computer Engineering, New Mexico State University, Box 30001/MSC 3-O, Las Cruces, NM 8803, sanyeongcho@gmail.com, davvoelz@nmsu.edu, 3NASA Johnson Space Center, Mail Code KR 2101 NASA Parkway, Houston, Texas 77058, paul.a.abell@nasa.gov, 4N-Science Incorporated, 1113 Washington Ave, #210, Golden, CO 80401, christopher.dreyer@gmail.com, dscheld@nsicorp.org.

Introduction: We discuss the development of a novel plasmonic spectrometer for the in situ characterization of asteroid surface and subsurface environments. This instrument will be used to distinguish between various asteroid types (ordinary chondrites, carbonaceous chondrites, metallic, and basaltic) using optical and near-infrared (NIR) reflectance spectra, as well as to examine surficial deposits of potential interest for in situ resource utilization (ISRU). The spectrometer will be coupled to a probe via optical fibers, and thus can be used for surface measurements as well as the study of compositional variations with depth.

Technology Description: We are considering a multifaceted approach where we explore illumination and light gathering strategies for on- or near-surface studies of asteroids using optical fibers. The gathered light will then be sent to a plasmonic spectrometer designed using the principles of extraordinary optical transmission. This design enables the transmission of light through subwavelength apertures that have been patterned in a metallic film with a regularly repeating periodic structure. The interaction of light with the metal surface results in excitation of electrons and the formation of a surface plasmon. The regularly spaced structure on the surface enables much higher transmission efficiency as a result of constructive interference due to the presence of surface plasmon resonances. An array of these apertures will be used for wavelength discrimination and the acquisition of a spectrum (Fig. 1). We will explore both the optical and near-infrared spectral regions in order to fully characterize an asteroid surface spectrum with a resolving power (\(\lambda/\Delta\lambda\)) of greater than 2000.

Using a nanoscale optical/NIR spectrometer on a probe will enable the identification of volatiles, organics, and metals of interest for ISRU. Furthermore, depending on the porosity of the asteroid’s surface, such a probe could be used to make measurements on and below the surface to explore the variation of volatile composition with depth. A NIR version of our proposed plasmonic spectrometer could cover 1.5 to 3.5 \(\mu\)m to provide access to organic absorption features. Water and OH also have absorption bands in this spectral region (OH stretch at 1.4 \(\mu\)m, H\(_2\)O bend at 1.9 \(\mu\)m, and a fundamental vibrational overtone of H\(_2\)O at 3 \(\mu\)m, which is the strongest of the three). Until fairly recently water ice was not thought to exist in large quantities in the Asteroid Belt. However, 2.2 – 4.0 \(\mu\)m spectra of 24 Themis are well fitted by a mixture of ice-coated pyroxene grains and amorphous carbon [1], suggesting that water ice is more prevalent in the Asteroid Belt than previously thought. Obtaining signatures of OH and/or H\(_2\)O ice or admixtures is critical for ISRU applications, and will be enabled with this proposed technique.

Results: We will present numerical modeling results showing the anticipated sensitivity levels of a plasmonic spectrometer as related to asteroid reflectance spectra. We will also present a mission scenario with a notional concept of operations to demonstrate the utility and functionality of such an instrument for ISRU interests.


![Figure 1. Schematic drawing of the plasmonic spectrometer. At lower right is an SEM image of a 2D grating fabricated by co-author Cho’s group for photon-SPP conversion. Additionally, two transmitted-light-microscope (TLM) images of the fabricated nanostructures show wavelength-selective optical transmission.](image-url)