Study of Barnard’s Star B as an Analog for Titan-like Exoplanets. Ryan Felton¹,²(26felton@cua.edu), Shawn Domagal-Goldman², Giada Arney², Peter Gao³, Juan Lora⁴, Geronimo Villanueva², ¹Catholic University of America, ²NASA Goddard Space Flight Center, ³UC Berkeley, ⁴Yale University

Introduction: Titan is currently unique in many ways: it is a rocky/terrestrial planet outside the snow line of the solar system but with a thick atmosphere; that atmosphere exhibits cycles of evaporation and precipitation, an optically thick haze, and a reducing chemical composition. As such, Titan serves as an example of potential exoplanets that are dissimilar from Earth in many ways, and as we improve our studies of Titan it will be necessary to apply what we have learned to potential “Titan-like” exoplanets to provide context for our search for potentially “Earth-like” worlds.

Recent radial velocity measurements of Barnard’s Star [1] have shown the potential for there to be a planet – Barnard’s Star b – with a minimum mass of 3.2 Me, and an orbiting with a semimajor axis near the snow-line of the system. In other words, the size and orbital properties of Barnard b are somewhat Titan-like in nature: Barnard b is a potentially rocky planet with a thick atmosphere above it, orbiting at a distance at which methane and ethane could condense. Further, Barnard’s Star is 1.8 parsecs from the Sun, which is close enough to allow direct-imaging of this world with a large space-based telescope such as LUVOIR-A.

In this presentation, we present simulations of the observational features of Titan, as an exoplanet, using the known properties of Barnard b and the performance of LUVOIR’s coronagraph (ECLIPS). These simulations were done using the Planetary Spectrum Generator (PSG) [2] to produce synthetic reflectance spectrum of a Titan-like Barnard’s Star b. First, we discuss our efforts to validate PSG against previous Titan observations for transit and reflection spectroscopy [3]. We discuss some of the validation issues encountered and how they were mitigated. We then present simulations for Barnard’s Star b, pointing out the observable features of that planet, and top-level conclusions we could make based on those simulated observations. We increased the complexity of the simulated atmosphere by adding hydrocarbon gas abundance profiles that were calculated by the Titan Atmospheric Model (TAM) and the photochemical models KINETICS [4] and Atmos. We highlight which of these gases can be detected in the spectra and also discuss how uncertainties on Barnard b’s radius could influence these conclusions. Figure 1 shows the synthetic direct imaging spectra of a Titan-like Barnard’s Star b being observed with LUVOIR-A.

The results of this study tell us that potentially Titan-like exoplanets are characterizable with a large space-based telescope. Our next goal is to study a wider range of planetary properties, including planet size, chemical composition, and orbital semimajor axis.

Figure 1. Synthetic spectra of Barnard’s Star B assuming a minimum mass of 3.2 Me and a corresponding radius of 11053 km. A portion of the UV, all of the visible and a section of the near-infrared is observable when noise is considered.

References: