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DEVELOPMENT AND SUBORBITAL VALIDATION OF TECHNOLOGIES FOR DIRECT IMAGING OF NEARBY EXOPLANETARY SYSTEMS IN REFLECTED VISIBLE WAVELENGTHS

Abstract

Primarily through indirect observational techniques, we have confirmed the existence of almost 5,000 exoplanetary systems. However, we still do not have an image of an exoplanetary system at reflected visible light. Indeed, the recently released Decadal Report (nap.edu/astro2020) noted, “to examine the atmospheres of potentially Earth-like planets around Sun-like stars will require further development of a specialized space telescope for high-contrast imaging to measure a reflection spectrum that could show oxygen, methane, water vapor, and carbon dioxide”.

For the past decade, our research group has transitioned key technologies that are necessary for direct imaging of exoplanets and their environments from laboratory to near space using suborbital platforms. Two of our sounding rocket experiments, called PICTURE and PICTURE-B, carried a 0.5m dia Gregorian telescope, a Visible Nulling Coronagraph (VNC) operating in 600 − 750 nm, a 1024 channel Deformable Mirror (DM) and our own fine pointing system. The rocket flights demonstrated the suitability of these enabling technologies for space applications.

Following up on these rocket experiments, in 2019 we flew a high-altitude balloon called PICTURE-C. It carried a telescope employing a 0.6m dia off-axis parabolic primary mirror, a Vector Vortex Coronagraph (VVC), a 97-channel low order DM and a 1024 element high order DM with a five-band imager providing coarse spectral information in the 540 − 660 nm wavelength range. Like the rockets, the balloon flight demonstrated a 5 milli-arcsecond fine pointing capability and the space worthiness of the above-mentioned coronagraphic subsystems.

PICTURE-C is awaiting its second flight, scheduled for August/September 2022. We are hopeful that this flight will obtain the first high-contrast image of the epsilon Eridanis b system at optical wavelengths. It will gather information on the scattering properties and physical structures of its debris disk, a circumstellar ring produced by the sublimation of cometary material and collisions among asteroids, comets and Kuiper-belt analogs.

Future missions aboard Ultra Long Duration Balloons (ULDB) using telescopes having larger collecting areas and fitted with essentially the same coronagraphic optics and supporting subsystems should be able to simultaneously image in reflected light Jupiter-like exoplanets such as epsilon Eridanis b and their debris disks. Data from such a mission would significantly mature most technology necessary to firmly

put us on the road to achieving the exciting exoplanetary science program outlined in the Astro 2020 Decadal Report.

In this presentation we will describe results from our past work and outline our future plans.