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IR Photometric Survey for Transiting Exoplanets around Nearby Stars

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Response to NASA/SMD Planetary Science Division, Artemis Science Definition Team (SDT), **Call for White Papers**

Science Objectives

The search for Earth-like planets orbiting nearby stars is among the most compelling scientific endeavors of the 21st century. Using the transit method for exoplanet detection and characterization, NASA's Kepler and TESS missions have been crucial for revolutionizing our understanding of the prevalence and variety of planetary systems throughout the Milky Way. Yet the detection of Earth-size planets in Earth-like orbits around nearby sun-like stars remains fertile ground for discovery using state-of-the-art transit and radial-velocity techniques. Precise photometric lightcurve measurements for identifying rocky planets transiting sun-like stars requires exquisite pointing and thermal stability that the lunar surface environment can enable. The sensitivity to small transiting exoplanets can also be improved by observing at IR wavelengths to reduce photometric noise and limb-darkening effects from the stellar photosphere below what is normally experienced at optical wavelengths.

Table 1:
Bright southern sun-like stars.

Star Name	*Sp Type*
β Hydri	G2 IV
τ Ceti	G8 V
δ Pavonis	G8 IV
ε Eridani	K2 V
82 Eridani	G6 V
40 Eridani A	K0.5V
ε Indi A	K5 V

We propose an intensive southern hemisphere observing campaign targeting (1) sun-like stars brighter than V = 5 (Table 1) and (2) known exoplanet host stars in order to detect small, rocky planets and to improve characterization of known exoplanet physical properties and orbital parameters. The transit signature of an Earth analog orbiting a solar type star is ~80 ppm, thus the investigation has the goal of achieving 20 ppm (4σ detection) precision for individual stars. We believe that highly stable pointing, strict thermal management and long dwell times during each lunar day will allow improved ingress and egress characterization and phase curves.

The analysis of the legacy data set will be performed in conjunction with citizen scientists through the crowd sourcing platform, Planet Hunters [1]. The Planet Hunters project uses human's ability for pattern recognition to discover exoplanets, as well as other unusual astrophysical phenomena in time series data (e.g., the first transiting circumbinary exoplanet in a quadruple system, PH1-b [2], and the mysterious dipper, Boyajian's Star [3].

Payload Description. The AstronetX Lunar-based Infrared Camera (L-IRC) reference payload uses a ~60-80 mm aperture telescope configured to image at near-IR wavelengths (~1100-1700 nm). The imager is steered by an alt-az gimbal mount, and performs slews to different targets and achieves fine guiding through periodic rapid centroiding of a bright target star in the science field. The imager has an aperture cover to protect it from dust and debris during launch, lunar landing, astronaut deployment, etc. The imager and gimbal mount to a stand that also houses power, thermal management and communications components. The major technical challenge of this project is thermal management, to leverage the polar environment for achieving low detector temperatures

and thus low readout and dark noise. The ~30 kg package can be deployed within ~1 km of the landing site by astronauts and will operate autonomously through lunar daytime and hibernate at night.

Strategic alignment & partnerships. The search for Earth-like planets around nearby stars aligns with the 2018 NASA Strategic Plan, the Artemis Science Plan and Priority 1, Strategy 1.3 of the 2020 NASA Science Plan. We are also seeking interest in the data among U.S. government national security units interested in cislunar space situational awareness data, consistent with Strategy 1.4 of the Science Plan.

References:

[1] Fischer, D.A., et al. MNRAS, 419, 2900 (2012) “Planet Hunters: the first two planet candidates identified by the public using the Kepler public archive data”

[2] Schwamb, M. E., Orosz, J. A., Carter, J. A., et al. ApJ, 768, 127 (2013) “Planet Hunters: A Transiting Circumbinary Planet in a Quadruple Star System”

[3] Boyajian, T. S., et al. MNRAS, 457, 3988 (2016), “Planet Hunters IX. KIC 8462852 - where's the flux?”