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PALE POLARIZED DOTS: SPECTROPOLARIMETRY OF THE EARTH AS AN EXOPLANET WITH LOUPE

Abstract

We present LOUPE, the Lunar Observatory for Unresolved Polarimetry of the Earth, a compact snapshot spectropolarimeter designed to observe the Earth from the Moon as if it were an exoplanet. Viewing the Earth as it would be seen by a faraway observer will offer novel insight into the spectropolarimetric signatures of planets harboring life, as well as a chance to refine algorithms for the retrieval of exoplanetary properties such as the presence of liquid water, clouds, vegetation, and more.

LOUPE boasts a novel solid-state optical design based on patterned liquid crystal optics built atop the cosine HyperScout, a flight-proven hyperspectral imager. Uniquely to LOUPE, a microlens array creates a two-dimensional grid of unresolved Earth-images on the detector, resulting in an array of "pale (blue) dots" filtered spectrally along one direction, with polarization modulation applied in the perpendicular direction. The clever use of custom-patterned liquid crystals as a passive modulator thus replaces the need for classical dispersion elements and polarization modulation optics. This pioneering approach enables LOUPE to simultaneously obtain spectral and Stokes measurements for the entire Earth, whilst the position of the Earth-dots also has the benefit of providing input for angle-dependent spectral and polarization calibration.

Here we discuss our detailed design process and the challenges involved in creating a unique spectropolarimeter with no moving parts and no bulky optics, whilst maintaining flexibility for different usage scenarios: rovers, landers, orbiters, and more. We present a performance trade-off, optical design informed by ray tracing with polarization effects, and the development of methods for spectral and polarimetric demodulation of simulated Earth observation data.