
PSI-Red v1.0 (SCALES)

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Abstract

The Planetary Systems Instrument (PSI) for the Thirty Meter Telescope (TMT) is comprised of 3 key modules: 1) an Adaptive Optics (AO) bench consisting of a large stroke, high actuator count ‘woofer’ Deformable Mirror (DM) and Wavefront Sensor (WFS) that is common to both the Red and Blue arms; 2) PSI-Red, covering 2-5 microns with a sophisticated suite of modular components based around a lenslet IFS coronagraph; and 3) PSI-Blue, covering 0.6 to 1.8 microns with its own suite of modular components including a ‘tweeter’ DM with its own WFS. An additional module is PSI-10, an 8-13 micron suite of modular components based around a lenslet IFS. The precursor to PSI-Red is currently being developed by UC Observatories, the Indian Institute for Astrophysics, and Durham University as SCALES (Slicer Combined with an Array of Lenslets for Exoplanet Spectroscopy). SCALES will operate in the mid-IR from 2 to 5 microns at the WM Keck Observatory where it will share a pyramid wavefront sensor with the HiSPEC instrument before being integrated with the remainder of PSI at TMT. Its fully cryogenic optical train uses a custom silicon lenslet array, selectable coronagraphs, and dispersive prisms and gratings to carry out integral field spectroscopy over a 2 arcsec field of view with low spectral resolution (50 to 200). A slicer module with a smaller field of view sits behind the lenslet array, allowing for medium spectral resolution (5000 to 10,000), which has not been available at the diffraction limit with a coronagraphic instrument in the mid-IR before. The opto-mechanical design takes advantage of modern diamond-turning materials and machining techniques with minimal risk and cost while delivering diffraction-limited performance both at Keck and TMT. Unlike previous IFS-based exoplanet instruments, SCALES is capable of characterizing cold exoplanet and brown dwarf atmospheres (< 600 K) at bandpasses where these bodies emit most of their radiation while capturing interesting molecular spectral features. We will discuss some of the technical challenges of designing a TMT-ready instrument that will first be deployed at Keck.

Keywords: exoplanets, thermal infrared, coronagraphs

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