Multi-Objective Diffraction-limited High-resolution Infrared Spectrograph (MODHIS)

MODHIS is a first-light high-dispersion (R~100,000) near-infrared [0.95 - 2.4 µm] spectrograph that uses single mode fibers, which are fed AO-corrected wavefront by TMT's Narrow Field InfraRed Adaptive Optics System (NFIRAOS). The blue and red spectrographs provide simultaneous full wavelength coverage and a velocity precision of 30 cm/s.

Principal Investigator: Dimitri Mawet
California Institute of Technology
Caltech - USA

MODHIS Project Manager: Hiroshi Terada (TMT)

For questions, email: inquiry@tmt.org

Notes

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MODHIS

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MODHIS will provide powerful windows of investigations, from exoplanets to distant galaxies.

One of the first-light TMT instruments, the Multi-Objective Diffraction-limited High-resolution Infrared Spectrograph (MODHIS) will provide diffraction limited, high spectral resolution capabilities with high-velocity precision. The high angular resolution and enhanced contrast returned by TMT's NFIRAOS adaptive optics system will enable studies from exoplanets (transit and direct spectroscopy, precision radial velocity, atmospheric characterization), to circumstellar disks and exoplanet formation processes. MODHIS' fields of investigation will also include solar system, stellar physics and extra-galactic science.

Illustration of the striped cloud pattern on the brown dwarf Luhman 16A. MODHIS will allow doppler tomographic mapping of the surfaces of exoplanets and brown dwarfs.

Credit: Caltech/R. Hurt (IPAC)

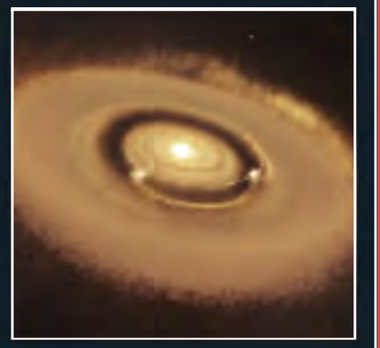
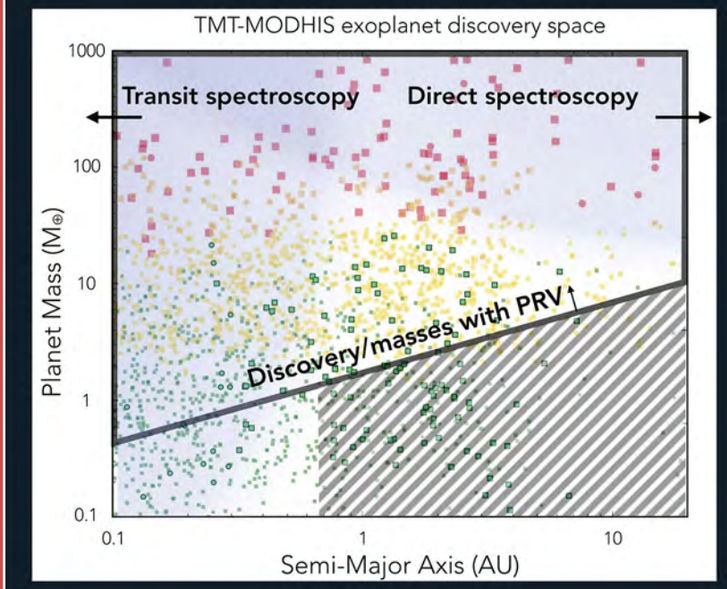


Illustration of two giant newborn planets in the PDS 70 system. MODHIS will be able to measure the characteristics of exoplanets embedded in their protoplanetary disk.

Credit: W. M. Keck Observatory/Adam Makarenko



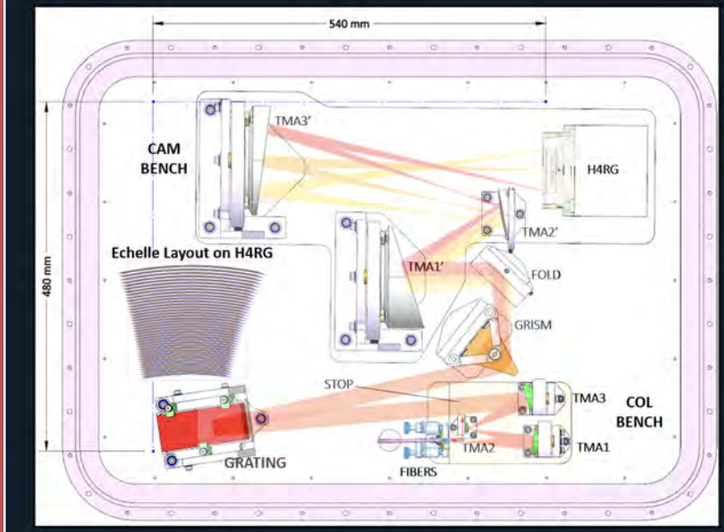
Simulation of MODHIS' exoplanet discovery and characterization space for a planet population within 27 pc (Kopparapu et al. 2018), covering giant planets to temperate super-Earth and Earth-size planets. Diagonal line is for 20 cm/s RV precision.

Spectral resolution	>100,000
Wavelength coverage	[0.95 - 2.4] µm (yJHK) simultaneously
Single science target with sky and calibration fibers	1-9 channels, including object, sky, calibration
Angular resolution at y band / K band	7 mas / 20 mas
Field of regard	>4x4 arcsec square patrol area
High contrast capabilities	10^{-3} raw contrast at the diffraction limit λ/D
Point-source limiting mag (1 hr, S/N = 10 per spectral channel)	19^{th} mag
Calibration	Laser Frequency Comb, Etalon, Gas cells
Instrumental stability	30 cm/s

Thanks to its diffraction limited input beam, MODHIS features a compact and cost-effective design optimized to fully exploit the future TMT-NFIRAOS infrastructure and boost the scientific reach of TMT Observatory.

MODHIS Specifications

At this early stage of design, MODHIS plans to use the natural and laser guide star modes offered by TMT's Narrow Field InfraRed Adaptive Optics System. This design choice, combined with the use of single mode fibers, make MODHIS an extremely compact instrument. With a spectral resolution R~100,000 obtained simultaneously across the [0.95 - 2.4] µm range, MODHIS will uniquely complement IRIS's near-infrared diffraction-limited imaging and integral-field spectroscopic capabilities, opening new windows of research to the community of TMT partners.



Schematic of MODHIS' red-channel spectrograph opto-mechanical layout. The blue channel will have similar components.

MODHIS design is based on diffraction-limited single-mode fiber injection and precise wavelength calibration technologies. A laser frequency comb is used to achieve high-accuracy wavelength calibration down to ~30 cm/s.

MODHIS Overview