From the Rise of Metals to Water for Habitable Worlds

National Aeronautics and Space Administration

Origins Space Telescope: Planet-forming Disks and Exoplanets

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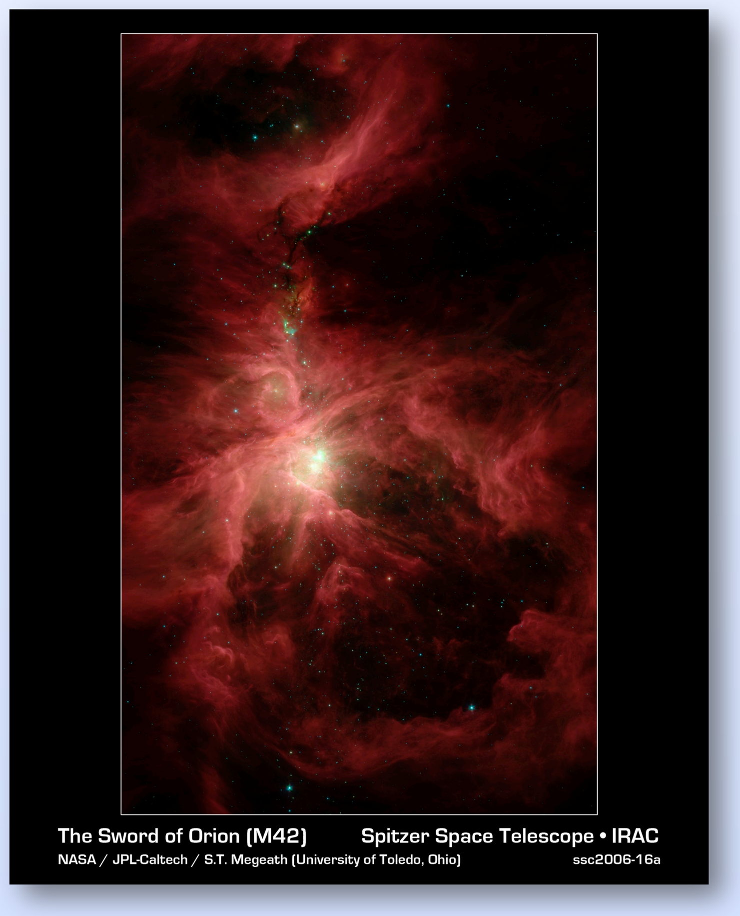
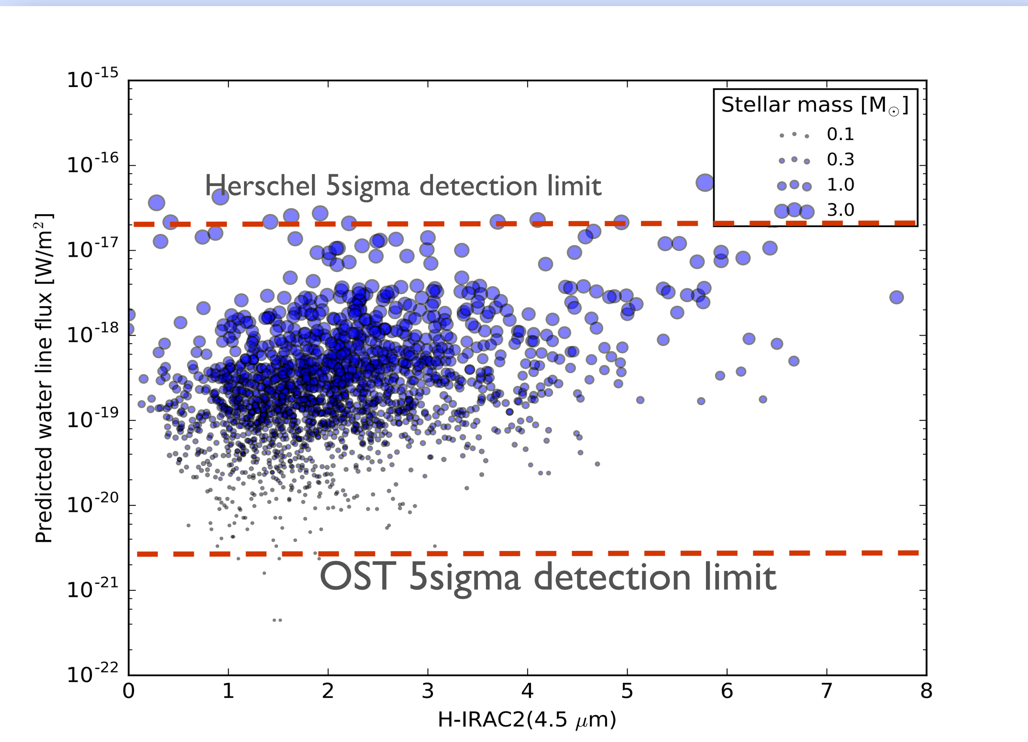
A census of water vapor in planet-forming disks

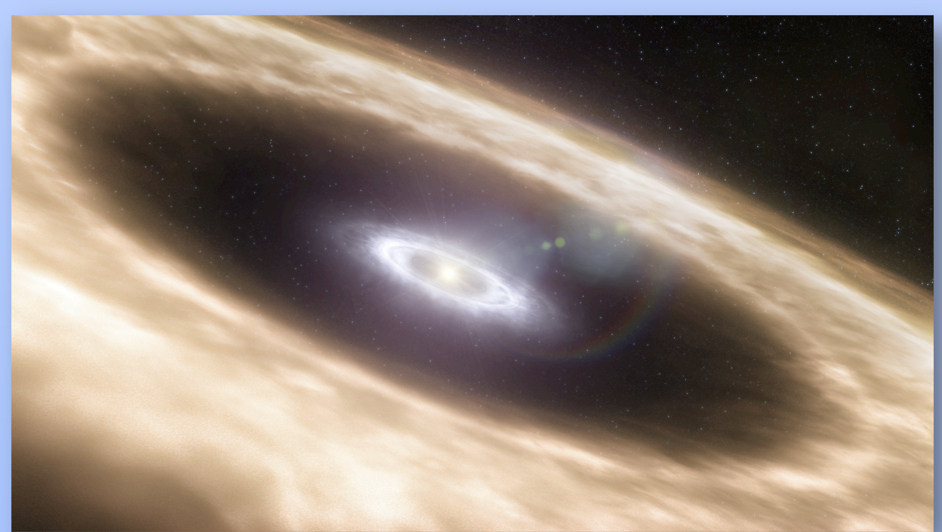
Are planet-forming disks universally able to seed their planets with water and other volatile species? While we know that many disks have abundant water, a full census will place the Solar Nebula into a broad Galactic context.

Using sensitive, high-resolution mid- to far-infrared spectroscopy, the Origins Space Telecope will create a comprehensive Galactic census of the water content in up to 1000 planet-forming disks around young stars of all masses at disk radii of 1-100 AU. This goal will address whether water is universally abundant and available as an ingredient for habitable planets.





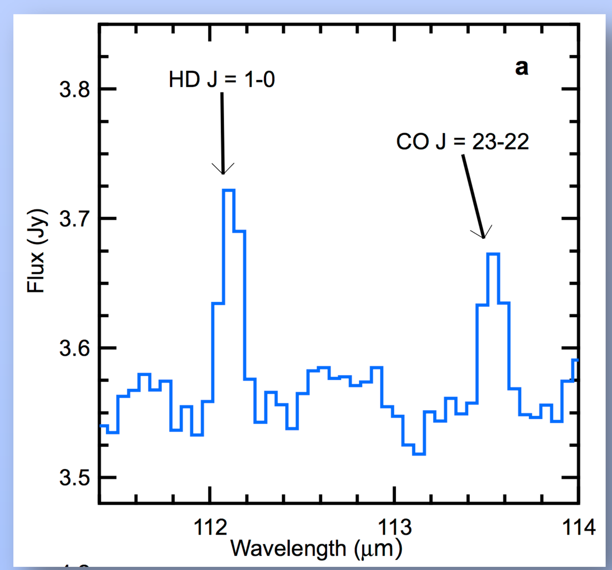
Predicted line fluxes for the Orion cluster for a representative far-infrared water line (321-212) at 78.4 micron. The line fluxes are scaled by luminosity and distance to match observed infrared photometry (Megeath et al. 2012). Sensitivity to lines in the 10^{20}-10^{21} W/m² range will allow for complete water inventories of disks out to 500 pc.



Measuring disk gas masses

What is the planet-forming disk gas mass? Previous estimates of disk masses use the thermal continuum emission of the dust grains or rotational lines of CO as indirect, and highly uncertain, tracers. The Herschel Space Observatory, demonstrated that the fundamental rotation transition of HD at 112 μm can be used as a direct tracer of disk mass in a few cases.

A survey of HD emission with the Origins Space Telescope can expand measurements of accurate disk masses from the current ~3 systems up to 1000 disk systems. This will determine the disk gas lifetimes as well as the efficiency with which disks convert their masses into planetary systems

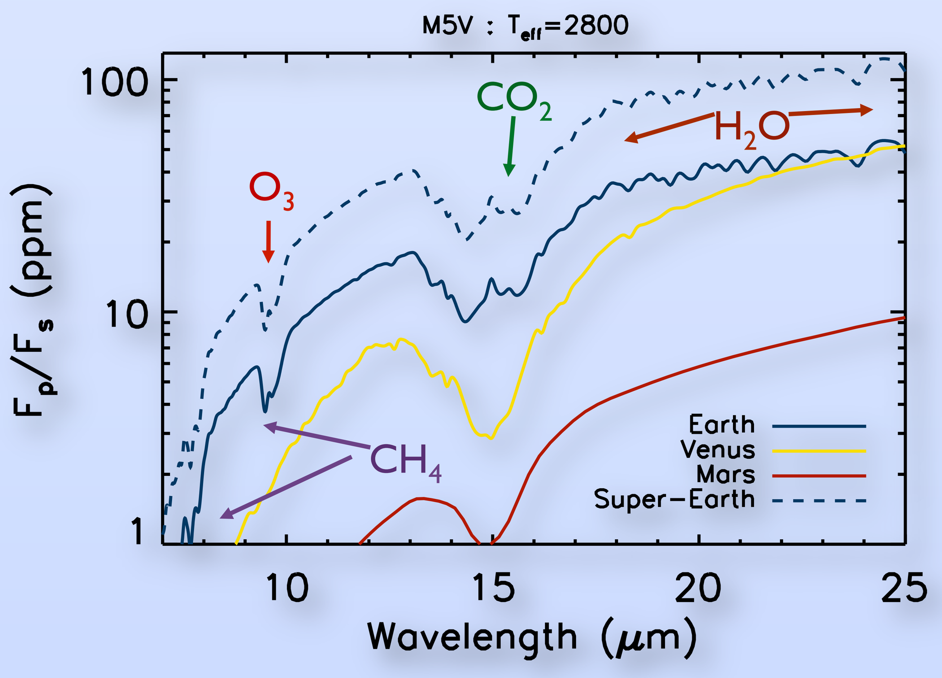


Detection of the HD ground-state line in the TW Hya protoplanetary dis. Bergin et. al. 2013

Climates and biosignatures of super-Earths

Habitability is typically defined as the ability of a planet to sustain liquid water on its surface, which is a function of orbital distance and atmospheric composition. Spectroscopic characterization of terrestrial planetary atmospheres will provide constraints for climate models to assess habitability. This remote characterization may also provide evidence of spectroscopic biosignatures.

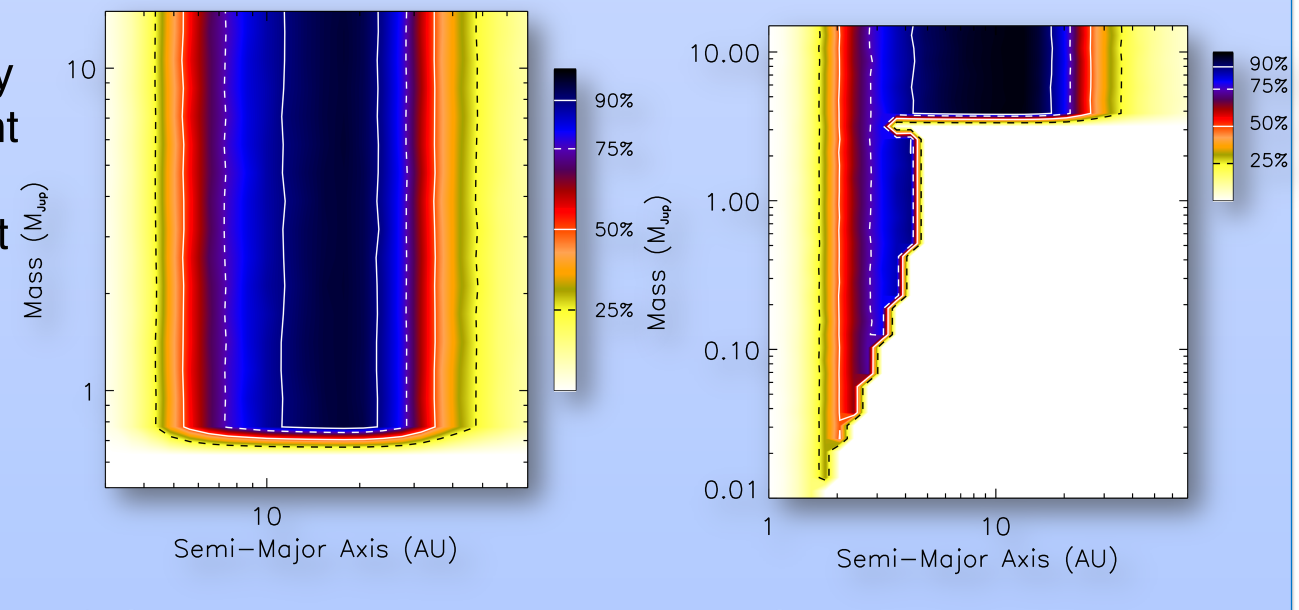
The Origins Space Telescope will measure the atmospheric composition of low-mass (1-3 $R_\oplus$) rocky planets orbiting M dwarfs in the habitable zone using absorption thermal emission transit spectroscopy and phase curves. Mid-infrared transit emission spectroscopy of exoplanet atmospheres allows for detection of the prominent 9.7 micron ozone, 15 micron CO_2 bands and H_2O vapor continuum at ~18 micron. These features alone can distinguish wet Earth-like planets from those that are more Venus-like with dry, dense CO_2 atmospheres, or Mars-like with thin CO_2.



Relative intensity of emission as a function of mid-infrared wavelength for three modeled terrestrial planets. Credit: Tyler Robinson

Characterizing Jupiter Analogs

Jupiter analogs have proven to be difficult to detect. They are cool, so they have low contrast relative to their parent star at short wavelengths (<10 micron), and their orbits are too wide for efficient radial velocity detections. The Origins Space Telescope with a high contrast coronagraph will be able to directly image such cool planets with masses less than 1 MJup orbiting at 5 AU around stars within 10 pc, and will be able to measure the molecular composition of their atmospheres.



Left: Completeness to giant planets around a 1 Gyr M-star at 10 pc. Right: Completeness to Jupiters, Neptunes, and Super-Earths orbiting a G0 at 7.5 pc. Credit: Erik Nielsen.

The **Origins Space Telescope** is the mission concept for the **Far Infrared Surveyor**, a study in development by NASA in preparation for the *2020 Astronomy and Astrophysics Decadal Survey*.

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Secret OST Word: biosignature