Model Spectra of the First Potentially Habitable Super-Earth - Gl581d

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OVERVIEW

Developed Gl581d has a min. mass of 7 M_{Earth} and is the first detected potentially habitable rocky Super-Earth. Our models confirm that a habitable atmosphere can exist.

Model the observable spectra: We derive spectroscopic features for atmospheres, assuming an Earth-like composition for this planet, from high oxygen atmosphere analogous to Earth's to high CO_2 atmospheres with and without biotic oxygen concentrations.

MAIN POINTS

Habitable: We find that a minimum CO_2 partial pressure of about 7 bar, in an atmosphere with a total surface pressure of 7.6 bar, are needed to maintain a mean surface temperature above freezing on Gl581d.

Observables: We model synthetic transmission and emergent spectra from 0.4μm to 40μm and show where indicators of biological activities in such a planet's atmosphere could be observed by future ground- and space-based telescopes (Fig. 1).

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http://adsabs.harvard.edu/abs/2011arXiv1103.2953K

OBSERVABLES IN SPECTRA - A ROCKY Gl581d

Emergent spectra: the larger surface area of a Super-Earth makes the direct detection and secondary-eclipse detection of its atmospheric features and biosignatures easier than for Earth size planets. In the infrared region of the emergent spectrum, CO_2 also dominates the atmospheric features (Fig. 1). In the visible part of the emergent spectrum, biomarkers could be detected even for high CO_2 concentrations .

Transmission spectrum: dominated by CO_2 down to 1μm and Rayleigh scattering below that wavelength, not providing information about the habitability of a rocky planet with a dense CO_2 atmosphere (Fig. 2).

Testing our concept of the Habitable Zone: Our concept of the habitable zone is based on the carbonate-silicate cycle, predicting high CO2 levels on a geological active Super-Earth (model for a habitable Gl581d.) This concept can be probed by observing detectable atmospheric features by future ground and space-based telescopes like E-ELT and JWST.

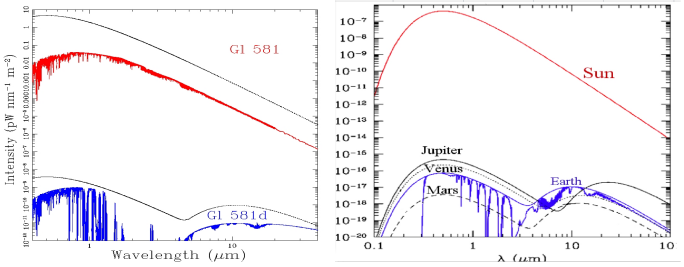

Fig. 1 Planet-star contrast ratio for emergent spectra (assuming 1/2 illumination of the planet) from 0.4 to 40 μm for a clear atmosphere (left) B2 model atmosphere (green indicated the Earth-Sun system level)), (right) Sun and Earth (adapted fromTraub & Jucks 2002).

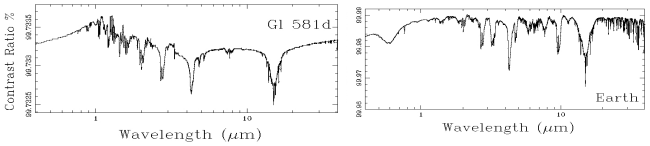

Fig. 2 Planet-star contrast ratio for transmission spectra from 0.4 to 40 μm for a clear atmosphere (left) B2 model atmosphere (right) Earth (adapted from Kaltenegger & Traub 2009).

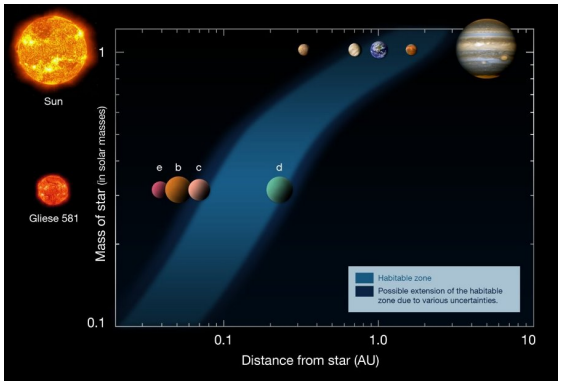

Fig. 3 Artist impression of the HZ indicating the planets in our Solar System as well as in the Gl581d system (F. Selsis et al, 2007, press release)

FUTURE GROUND- & SPACE-BASED OBSERVATIONS

Transmission and emergent spectra of terrestrial exoplanets may be obtained in the near future with the same techniques that have successfully provided spectra of Earth and extrasolar giant planets (EGP).

Emergent spectra of rocky planets in the HZ are dominated by reflected starlight in the visible to near-IR and thermal emission from the planet in the mid-infrared, while transmission spectra result from starlight that is filtered through the planet's atmosphere. Such spectroscopy provides molecular band strengths of multiple transitions (in absorption or emission) of a few abundant molecules in the planetary atmosphere.

Spectra of Super-Earths like Gl581d which can characterize a planet and explore indicators of biological activities in the planet's atmosphere may be observed by future ground- and space-based telescopes such as the Extremely Large Telescope (E-ELT) and the James Webb Space Telescope (JWST) in the near future.

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