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Detectability of Atmospheric Features of Earth-Like Planets in the Habitable Zone around Cool Host Stars

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Abstract

Terrestrial extrasolar planets around low-mass stars are prime targets in the search for habitable surface conditions and biosignatures with current and near-future instruments like the James Webb Space Telescope (JWST). Therefore, investigating potential atmospheres of terrestrial planets in the Habitable Zone (HZ) around M-dwarfs is one main challenge when searching for atmospheric biosignatures on exoplanets. Here we use a 1D coupled climate-chemistry-model to simulate atmospheric composition and temperature profiles of Earth-like planets in the HZ around early-to-late M-dwarfs. For most of the stellar input we use spectra from the MUSCLES database. Especially the UV Spectral Energy Distribution (SED) is crucial for the photochemical processes in the atmosphere which would e.g. impact the signals from a potential biosphere or cause false positive biosignatures. Due to weak stellar UV emissions at wavelengths higher than 0.2 μm, planets orbiting M-stars show an increase in the abundance of certain biomarkers and bioindicators like methane (CH_4) or water (H_2O) compared to the Earth around the Sun [1, 2, 3]. This effect is enhanced for late-type M-dwarf planets compared to planets around hotter M-dwarfs. Due to the increased abundances, the absorption features of CH_4 and H_2O in the near-IR are more pronounced compared to the Earth, specially for Earth-like planets around late M-dwarfs. This could lead to potentially detectable features in transit spectra of such planets with near future instrumentation. We therefore develop an S/N model to calculate the potential detectability of absorption features with the JWST. Due to saturation limits, planets around early M-dwarfs are not observable with NIRSpec at a distance below about 10 pc. Earth-like planets around late-type M-dwarfs are favourable targets for the detection of atmospheric features due to the lower saturation limits and longer duty cycle [3]. We calculate the detectability of selected absorption features with JWST for hypothetical Earth-like planets around all 915 M-dwarfs within 15 pc taken from the TESS input catalogue. We identify 36 stars where hypothetical planets could have at least one detectable spectral feature with a single transit observation. We furthermore find that for 267 of the TESS low mass stars Earth-like planets would have an SNR of at least 3 for a single spectral feature [3]. Hence, we conclude that atmospheric features of Earth-like terrestrial planets around cool host stars in the solar neighbourhood could be detectable with JWST.

References

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