Modeling the Atmospheric Evolution of Exoplanets in the Habitable Zone of M-Dwarfs

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The abundance of M-dwarfs, combined with the relative ease of detecting Earth-sized planets around them, has made them prime targets for finding and characterizing planets in their ‘habitable zone’ (HZ). However, terrestrial exoplanets are often born with voluminous H/He envelopes. If these planets retain such envelopes over Gyr time scales, they will not be ‘habitable’ even within the HZ, due to pressures incompatible with liquid water and the lack of volatiles necessary for a great percent of life-as-we-know-it. By improving current stellar wind and EUV radiation models, I study whether the H/He envelope of 34 HZ planets could be removed, making them candidates for secondary atmospheric revival. I find that: (1) Stellar wind can only remove a small fraction of the H/He envelope of Earth-sized exoplanets in the HZ of early-type M dwarfs, therefore photoevaporation is essential for removing significant amounts of H/ He. (2) Planets in the inner and 'Earth' HZ regions that are <2 earth masses can be stripped of their initial H/He envelopes. (3) Planets in the outer HZ region can not be stripped of a primordial envelope due to the stellar wind or EUV radiation. (4) GJ 1061 c, GJ 1061 d, K2-72 e, Kepler-1649 c, Proxima Cen b, Ross 128 b, and TRAPPIST-1 (d-f) could have lost their primordial envelope. My results will help contextualize the atmospheric data taken by the James Webb Space Telescope. Further, understanding atmospheres through these evolutionary models will greatly help guide the search for life on exoplanets.

Awards Won:

Third Award of $1,000