Atmospheric Escape From TOI-700 d: Venus versus Earth Analogs

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The recent discovery of an Earth-sized planet (TOI-700 d) in the habitable zone of an early-type M-dwarf by the Transiting Exoplanet Survey Satellite constitutes an important advance. In this Letter, we assess the feasibility of this planet to retain an atmosphere – one of the chief ingredients for surface habitability – over long timescales by employing state-of-the-art magnetohydrodynamic models to simulate the stellar wind and the associated rates of atmospheric escape. We take two major factors into consideration, namely, the planetary atmospheric composition and magnetic field. In all cases, we determine that the atmospheric ion escape rates are potentially a few orders of magnitude higher than the inner Solar system planets, but TOI-700 d is nevertheless capable of retaining a 1 bar atmosphere over gigayear timescales for certain regions of the parameter space. The simulations show that the unmagnetized TOI-700 d with a 1 bar Earth-like atmosphere could be stripped away rather quickly (< 1 gigayear), while the unmagnetized TOI-700 d with a 1 bar CO₂-dominated atmosphere could persist for many billions of years; we find that the magnetized Earth-like case falls in between these two scenarios. We also discuss the prospects for detecting radio emission of the planet (thereby constraining its magnetic field) and discerning the presence of an atmosphere.