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# Study of atmospheric ion escape from exoplanet TOI-700 d

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The recent discovery of Earth-sized planets in the habitable zones (HZ) of M dwarfs has focused attention on whether liquid water and life exist on these planets. M dwarfs have lower temperatures and luminosities, and the HZ is much closer to the host star than Sun-like stars. Terrestrial planets around M dwarfs in the HZ are easy to observe because of frequent transits and their relatively large ratio of cross-sectional areas for the planet and the host star. Since close-in exoplanets are also suitable for characterizing their atmospheres using transmission spectroscopy methods, exoplanets around M dwarfs provide our first opportunity to seek potentially habitable worlds. However, close-in exoplanets around M dwarfs are expected to experience strong ion loss because the X-ray and EUV (XUV) radiation from M dwarfs is substantially larger than that of Sun-like stars.

We focused here on exoplanet TOI-700 d, which is the Earth-sized planet in the HZ of M dwarf. In this study, we assessed the feasibility for atmospheric retention on a Venus-like exoplanet at the TOI-700 d location using multi-species magnetohydrodynamics (MHD) simulations model, REPPU-Planets [1]. Simulations were conducted under different conditions for the interplanetary magnetic field (IMF) orientation, the planetary intrinsic magnetic field, and the XUV radiation to investigate their effects on atmospheric escape. We assumed a Venus-like atmospheric composition that depends on the stellar XUV flux as the input neutral atmosphere [2]. The similar stellar wind conditions to previous studies [3] were used in the simulations.

The results suggests that unmagnetized TOI-700 d would have difficulty to retain its atmosphere over a few billion years under strong XUV condition above 30 times of the current Earth (Figure 1). However, the strong intrinsic dipole magnetic field of 1000 nT at equatorial surface drastically reduces the escape rate and helps the exoplanet to retain its atmosphere. It means a intrinsic magnetic field plays a crucial role to retain an atmosphere of exoplanets in the HZ around active M dwarfs.

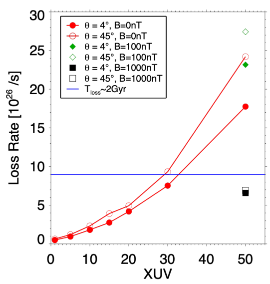


**Figure 1.** The dependence of $O^+$ escape rate on the XUV flux for all cases.

## References

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[3] Dong, Chuanfei, Meng Jin, and Manasvi Lingam, "Atmospheric escape from TOI-700 d: Venus versus Earth analogs," *The Astrophysical Journal Letters*, **896**, 2, June 2020, pp. L24, doi:10.3847/2041-8213/ab982f.