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B 会場 ：11/24　PM2 （15:30-18:15）
17:15〜17:30

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Effects of hot oxygen corona on the ion escape from Venus-like planets

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Since Venus has no substantial planetary magnetic field, the fast-flowing solar wind plasma interacts directly with its upper atmosphere. Venusian extended oxygen corona in the exosphere, as well as thermal atomic oxygen in the thermosphere, is a source of the ion loss. Ionized oxygen loss is thought to be the main mechanism of atmospheric escape at current Venus. Therefore, to understand the atmospheric evolution of a Venus-like planet, it is important to understand how much hot oxygen corona contributes to the ion escape. Venusian exosphere has been studied based on spacecraft observations and numerical simulations for many years (e.g., Nagy et al., 1981; Gröller et al., 2010). These studies focus on current Venus, but it is important to note that the structure of Venusian upper atmosphere is strongly influenced by X-ray and extreme ultraviolet (XUV) radiation from the host star (Sun). In the past, the Sun is thought to be emitted XUV radiation that was tens of times stronger than it is today. Similarly, close-in exoplanets in the habitable zones (HZ) around M dwarfs are expected to be exposed to extreme levels of XUV radiation. This could mean that the contribution of the oxygen corona to ion escape in such extreme XUV environments was different from current Venus.

In this study, we investigated the effect of the hot oxygen corona on the ion escape from Venus-like planets under various XUV environments and stellar wind conditions. We combined a Monte Carlo code for calculating hot oxygen transport in the thermosphere with the multi-species MHD simulation model REPPU-Planets (Terada et al., 2009; Sakata et al., 2022). The hot oxygen density above the exobase is calculated by using Liouville's equation (Schunk and Nagy, 2009). We assumed a Venus-like atmospheric composition that depends on the stellar XUV flux as the input neutral atmosphere based on Kulikov et al. (2007). The stellar XUV flux is set between 1 and 100 times the current Venus value. As stellar wind conditions, number density and velocity were varied from 4.5 to 450 cm^{-3} and from 470 to 4700 km s^{-1}, respectively, and the temperature was fixed at 1.3×10^6 K, by referring to previous studies (Nishioka et al., 2023; Dong et al., 2020). Interplanetary magnetic field (IMF) was assumed to be a Parker spiral with an angle of 45 degrees and a magnitude of 12 nT.

We first confirmed a good agreement of the model results for the current Venus with the observations of the hot oxygen corona by the Pioneer Venus Orbiter. The results of the parameter surveys show that the contribution of the oxygen corona decreases under high-XUV environment or low-density stellar wind. This is because increased XUV radiation causes the thermospheric component to dominate over the nonthermal component, and reduced stellar wind density decreases ionization of the corona through charge exchange and electron impact ionization. This study reveals that the hot oxygen corona plays a crucial role in the ion escape from close-in exoplanets in the HZ around inactive M dwarfs. In the presentation, effects of the stellar wind number density, velocity, and XUV radiation on the ion escape mechanism will be also reported in detail.