R009-26
B 会場 ：11/7　AM2 （10:45-12:30）
12:15〜12:30

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Study of plasmasphere formation at terrestrial exoplanets around M-Dwarf stars and its detectability

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Many terrestrial exoplanets or super-Earth have been found around low mass stars such as M dwarfs. A red dwarf (M type star) has comparatively narrow habitable zone, which is very close to the host star, and exoplanets are considered to be exposed to extreme levels of X-ray and ultraviolet (UV) radiation [e.g., France+, 2016]. Classic equilibrium tide theories predicts that K or M-type stars induce strong tidal effects on potentially habitable exoplanets, and tidal locking is possible for most planets in the habitable zones of K and M dwarf stars [e.g., Barnes, 2017]. When a planet has dipole magnetic field and rapid rotation, superposition of the stellar wind induced and corotation electric fields results in the tear-drop-shaped region of the closed drift, where planetary ionized atmosphere can fill the magnetic flux tubes along the field lines. The region is characterized with cold dense planetary plasma and called as the plasmasphere. In this study, a simple estimation method of the size of terrestrial exoplanetary plasmasphere is shown based on the knowledge of the solar system planets.

First, we considered the role of rapid rotation of the atmosphere (superrotation) in the formation of the plasmasphere of tidally-locked exoplanets. Many GCMs of exoplanets show that the circulations of typical tidally locked terrestrial exoplanets can become superrotation [e.g., Showman+, 2013]. However, the horizontal circulation in the thermosphere is far from understood [e.g., Machado+, 2017]. As for the planetary atmosphere, we assumed the Venus-like composition and thermospheric and ionospheric density altitude profiles of various species are estimated based on newly developed 1-D thermosphere model [Nakayama and Seki, in preparation]. As a representative stellar radiation input of M dwarf stars, we used XUV radiation of the Proxima Centauri (PC) [France+, 2016]. As a result, the model estimates ionospheric densities for CO2+, CO+, O2+, N2+, O+. N+, and C+ for imaginary exoplanets with the intrinsic dipole strength as strong as that of Earth and Venus-like atmospheric composition with two planetary mass cases, i.e., Venusian mass or 2 times of Earth mass.

The results indicate that the main ion species in the ionosphere and plasmasphere is C+, and it is different from current Venusian ionosphere whose main ion species is O+. The results of plasmasphere estimation show that Earth/Venus-like magnetized exoplanet can have a plasmasphere with a size of 4-6 times of the planetary radius. The size of the plasmasphere depends on the superrotation speed of the thermosphere, ionospheric conductance, stellar wind dynamic pressure, and IMF cone angle. Estimation of the transit depth of C+ line around 1334-1336 Angstrom indicates that the FUV absorption of plasmaspheric C+ ions can cause a few to several percent of the transit depth depending on the planetary size and plasmaspheric C+ density, which might be observable by space telescopes. Since the plasmasphere formation requires the existence of both the thick atmosphere and global intrinsic magnetic field, the observation of plasmasphere can provide possible evidence and clues of the exoplanetary atmosphere and intrinsic magnetic field.

References:
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