R009-19
A 会場 ： 11/25　AM1（9:15-10:45）
9:45〜10:00:00

#アサ サティアグラハ [1], 木村 智樹 [1], 藤井 友香 [2], 垰 千尋 [3], 原 亮太 [1]
([1] 東京理科大学, ([2] 国立天文台, ([3] 情報通信研究機構

Development of a Simplified Analytical Model for Exoplanetary Auroral Radio Emission

#Satyagraha ASA[1], Tomoki KIMURA[1], Yuka FUJII[2], Chihiro TAO[3], Ryota HARA[1]
([1]Tokyo University of Science, ([2]National Astronomical Observatory of Japan, ([3]National Institute Of Information And Communications Technology

Planetary auroral radio emissions are considered a promising tool for the direct detection of planetary magnetic fields and atmospheres. Their circular polarization (Wu & Lee, 1979) allows them to be distinguished from other radio sources, and their emission frequency is theoretically proportional to the magnetic flux density at the source region. Therefore, auroral radio observations can directly constrain the magnetic field strengths without relying on complex model assumptions. However, auroral radio emissions have not yet been observationally detected from any exoplanet, except for a marginal detection (Turner et al., 2021). Previous modeling efforts have focused on magnetosphere-ionosphere (M-I) coupling (Nichols, 2011) and star-planet interaction (SPI) mechanisms (Saur et al., 2013), but these models have not successfully explained emissions across diverse exoplanetary systems simultaneously.

We present a newly developed simplified analytical model of the M-I coupling that predicts the auroral radio power across various star-exoplanet systems, based on the pioneering exoplanetary M-I coupling model by Nichols (2011). The model uses only magnetospheric velocity distribution, excluding parameters difficult to constrain observationally, such as flux function and mass loading rate. Plasma velocity profiles are used to calculate the dynamo electric field and latitudinal currents, from which total Joule heating is then estimated. Validation against Jupiter and Saturn shows that our model accurately estimates the total auroral energy dissipated via Joule heating in their ionospheres—approximately 450 TW for Jupiter and 15 TW for Saturn. These values agree with observational estimates within an uncertainty of one order of magnitude and are consistent with previous modeling studies. Assuming a 0.01% conversion efficiency from auroral Joule heating to radio emission, our model predicts radio powers of ˜10 GW for Jupiter and ˜1 GW for Saturn, consistent with observations (Cowley et al., 2004; Zarka, 2007). When applied to ultracool dwarfs (UCDs), the model suggests that their observed radio emissions—up to ˜1 TW (Hallinan et al., 2008; Kao et al., 2023)— indicate weak atmospheric ionization, with electric conductance estimated between 0.1 and 10 mho (cf. ˜0.5 mho at Jupiter; Nichols et al., 2016). We also applied our model to the tentative LOFAR detection of the hot Jupiter Tau Boö b. According to our modeling, the magnetospheric size of Tau Boö b must be approximately 3 – 23 planetary radii to reproduce the observed signal of 10^{14} - 10^{16} W (Turner et al., 2021). This is significantly more compressed than Jupiter's magnetosphere (extends from 42 planetary radii; Kivelson et al., 2006), which is plausible given Tau Boö b's close orbital distance of 0.0462 AU (Butler et al., 1997). These results support the validity of our model. We plan to apply it to a broader range of UCDs and hot Jupiters, with the ultimate goal of extending it to Earth-like planets. Here, we summarize the current status of our model development and validation.