R009-18
B 会場 ：9/27　AM1 （9:00-10:30）
10:00〜10:15

#堺　正太朗 [1,2), 中山　陽史 [3), 関　華奈子 [4), 寺田　直樹 [1), 品川　裕之 [5), 坂田　遼弥 [1),Leblanc　François[6),Brain David[7), 田中　高史 [8)
[(1] 東北大・理・地球物理,[(2] 東北大・理・PPARC,[(3] 立教大・理・物理,[(4] 東大・理・地球惑星,[(5] 情報通信研究機構,[(6]LATMOS/CNRS, Sorbonne Université,[(7]LASP, University of Colorado Boulder,[(8] 九州大・i-SPES

Effects of stellar XUV spectra on atmospheric escape from a Mars-like planet orbiting inactive low-mass stars

#Shotaro Sakai[1,2)],Akifumi Nakayama[3)],Kanako Seki[4)],Naoki Terada[1)],Hiroyuki Shinagawa[5)],Ryoya Sakata[1)],Leblanc Francois[6)],David A. Brain[7)],Takashi Tanaka[8)]
[(1]Department of Geophysics, Graduate School of Science, Tohoku University,[(2]Planetary Plasma and Atmospheric Research Center, Graduate School of Science, Tohoku University,[(3]Department of Physics, Graduate School of Science, Rikkyo University,[(4]Department of Earth and Planetary Science, Graduate School of Science, University of Tokyo,[(5]National Institute of Information and Communications Technology,[(6]LATMOS/CNRS, Sorbonne University,[(7]Laboratory for Atmospheric and Space Physics, University of Colorado Boulder,[(8]International Research Center for Space and Planetary Environmental Science, Kyushu University

Atmospheric evolution is one of the key parameters in answering the question of how Earth was able to maintain a thick atmosphere and yield a habitable environment. A universal understanding of atmospheric evolution, including that of exoplanetary systems, is essential to explain how planets have evolved to their current state. In particular, atmospheric escape is strongly linked to atmospheric evolution. It is dependent on the planetary size, the existence of an intrinsic magnetic field, its intensity, the stellar activity, and stellar wind conditions. The variation in stellar activity affects both thermal escape and nonthermal escape. Ancient Mars, when the solar activity was more active than at present, had a very high atmospheric escape rate, the magnitude of the X-ray and extreme ultraviolet (XUV) irradiance being one of the parameters to determine the ion escape rate.

Many exoplanets have been discovered in recent years, and among them, M and K dwarfs are of particular interest because they might have habitable environments. The habitable zones of these stars are located very close to the main stars within 0.1 AU. Exoplanets in the habitable zones of these stars must therefore be exposed to intense XUV radiation and stellar winds. Numerical simulations suggested that the ion escape rate from Proxima Centauri b, orbiting at 0.049 AU, is three orders of magnitude greater than at the present Mars, with a value of ~10^{27} s^{-1} (Dong et al., 2017). The previous study assumed an XUV intensity several tens of times that of the Sun to determine the ion escape rate, but in fact, the shape of the XUV spectrum determines the thermospheric profile, controlling the ion escape rate.

The XUV spectrum is quite important in determining the thermospheric profile, controlling the ion escape as well as the ionospheric distribution. The current study focuses on the stellar XUV spectrum, and after investigating thermospheric profiles under various XUV spectra using a thermosphere model, the impact of the stellar XUV spectrum on ion escape is presented using a multispecies magnetohydrodynamic model (REPPU-Planets). The target stellar systems are Sun, HD85512, and GJ581. Note that these stars are somewhat inactive XUV environments compared to Proxima Centauri. The planets are of Mars type and located at 1.52, 0.622, and 0.174 AU, respectively, in order to keep the same irradiance as that of the Martian orbit in the present solar system. Mars under 10 times XUV irradiance at 1.52 AU is also investigated to understand the effects of the shape of the XUV spectrum on ion escape. According to the thermosphere model, the thermosphere of the HD85512 system is the most extended, followed by the GJ581 system. The ion escape rates are estimated by REPPU-Planets simulations using these thermospheric profiles as input. Ion escape is also the most intense for the HD85512 system, followed by the GJ581 system. The XUV irradiances between 40 and 100 nm are one of the most important parameters to determine the atomic ion escape rate. The O_2^+ escape rate is smaller in the high XUV environments because of the larger dissociative recombination, associated with decreasing the O_2^+ density. The C^+ escape rate, meanwhile, is higher in high XUV environments due to greater photodissociation of CO_2 and CO, and the associated charge exchange.

Reference:
Dong, C., et al. (2017). Is Proxima Centauri b habitable? A study of atmospheric loss. ApJL, 837, L26.