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Development of multi-fluid MHD simulation code of interaction between the solar wind and unmagnetized planets

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Draping of the solar wind magnetic field can form the induced magnetosphere around a planet, even when the planet does not possess any intrinsic magnetic field. It has been pointed out that the solar wind induced escape processes such as the ion acceleration in the draped magnetic field and the ionospheric ion scavenging by penetration of the solar wind magnetic field into the ionosphere play important roles in the atmospheric escape from such an unmagnetized planet. The escape of the planetary atmosphere is an important phenomenon related to evolution of the atmosphere, and numerical simulations are an effective method to understand the global atmospheric escape processes. While there have been many previous studies of the interaction between the solar wind and the upper atmosphere of unmagnetized planets based on hybrid or MHD simulations, these models have not yet succeeded to well reproduce the actual observations, such as a large amount of heavy of molecule ion escape observed by Mars Express [Carlsson et al., Icarus, 2006] and difference of velocity between O+ and H+ [Lundin and Dubinin, ASR, 1992]. In order to reproduce the dynamics of multi-species plasmas around the unmagnetized planet, multi-fluid MHD approximation, in which each ion species is treated as an individual fluid, is effective. Particularly, it is an advantage of the multi-fluid MHD code that it can include ion-ion collisions and assess their effects on the ionospheric convection numerically. Combining the virtue of existing multi-species [Terada et al., JGR, 2009] and multi-fluid [Najib et al.. JGR, 2011] simulations, we have formulated a new multi-fluid code to simulate the solar wind-unmagnetized planet interaction. In this presentation, we report on the formulation and initial results of the multi-fluid MHD simulation code under development.

Keywords: unmagnetized planet, ionosphere, multi-fluid simulation