Dense cold ion outflow observed in the Martian induced magnetotail by MAVEN

*Shogo Inui[1], Taku Namekawa[1], Kanako Seki[1], Shotaro Sakai[1], Kazunari Matsunaga[1,2], David A. Brain[3], James P. McFadden[4], Jasper S. Halekas[5], David L. Mitchell[4], Jack E.P. Connerney[6], Bruce M. Jakosky[3]

1. Graduate School of Science, University of Tokyo, 2. Graduate School of Science, Nagoya University, 3. Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, 4. Space Sciences Laboratory, University of California, Berkeley, 5. Department of Physics and Astronomy, University of Iowa, 6. NASA Goddard Space Flight Center

Geological studies have suggested that Mars had a warm climate and liquid water on surface about 4 billion years ago. Now, Mars has a cold surface temperature and little water on surface. Escape of greenhouse gases such as CO_2 to space is considered as the plausible reason to cause the drastic climate change. On one hand, mechanisms enabled the large amount of the CO_2 loss is far from understood. The planetary ion escape through interaction between the solar wind and the Martian upper atmosphere is one of the candidate mechanisms to achieve the atmospheric escape. To understand atmospheric loss from Mars, MAVEN (Mars Atmosphere Volatile EvolutioN) has observed the ion escape from Mars as well as space environment around Mars since November 2014. In this study, we investigate detailed characteristics of a dense cold ion outflow event observed in the Martian induced magnetotail based on the MAVEN observations.
From 14:55 to 15:35 UT on December 4, 2014, MAVEN traversed the wake region and observed cold ions in the induced magnetotail of Mars. Around 15:01 UT, it crossed the current sheet from the dusk-southern to dawn-northern quadrants of the magnetotail. The former (latter) corresponds to the downward (upward) electric field (E) hemisphere in the MSE (Mars-Sun-Electric field) coordinates, since the direction of the solar wind electric field was directed roughly to Z axis of the MSO coordinates. In the wake region, the negative spacecraft charging enable us to detect ambient cold ions. The observation shows a clear asymmetry both in the cold ion density and composition against the current sheet crossing: In the southern downward-E hemisphere, the density is high (>100 1/cc) and heavy ion rich, where the main component is O_2^+ with O_2^+/O^+ ratio of ~2.6. However, in the northern upward-E hemisphere, the heavy ion density drops more than 1 order of magnitude and proton becomes the main component. It should be noted that the high heavy ion density was observed also at high altitudes (>2000km).
At the time of the cold dense heavy ion observation, the strong crustal magnetic fields located on the dayside of Mars. Therefore, the MAVEN observed the cold dense heavy ion outflow in the magnetotail region which corresponds to the downward-E hemisphere as well as most likely the downstream of the mini-magnetosphere formed by interaction between the solar wind and the strong crustal magnetic fields. The result might mean that the combination of the mini-magnetosphere and the downward-E hemisphere facilitates the cold ion escape from Mars. We also tried to precisely estimate the number density of CO_2^+ ions by eliminating the O_2^+ contamination using a fitting method based on the data from The Supra-Thermal And Thermal Ion Composition (STATIC) instrument onboard MAVEN. The preliminary result of the CO_2^+ density estimation will be shown.

Keywords: Mars, Atmospheric escape, MAVEN

