R009-21
Zoom meeting D ：11/1 PM2 (15:45-18:15)
16:30〜16:45

A technique for retrieving the Martian hot oxygen exosphere from O+ pickup ion measurements in the magnetosheath

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Mars has lost its atmosphere to space over billions of years. The atmospheric escape takes place above exobase where collisions are not important (i.e., exosphere). Studying the atmospheric escape processes leads to expand our understanding on the atmospheric evolution of Mars and to understand why present Mars possesses such a dry environment. However, measuring tenuous atmospheric particles in the exosphere is challenging due to their small density and flux.

Mars does not have a global intrinsic magnetic field, and thus its exosphere is directly exposed to the solar wind. Once the exospheric particles are ionized by the solar UV radiation, charge exchange, or electron impact, they are accelerated by the solar wind motional electric field. The “ion pickup” by the solar wind is known as a common ion escape process from Mars. Pickup ions are widely observed in the solar system and their nature is well studied (e.g., Coates, 2010; Cravens et al., 2002).

In the collisionless plasma, pickup ions exhibit cycloid trajectories (i.e., the E x B drift). In the velocity space, the E x B drift is described as the ring distribution. Because ring distributions potentially own information of ionization locations and densities of exopheric neutral particles, they are a useful tool to probe the Martian exosphere. Recent studies have shown that very tenuous hydrogen and oxygen exospheres (altitude of $>$3000 km) can be retrieved by H^+ and O^+ pickup ion ring distributions observed in the solar wind (Rahmati et al., 2015, 2017, 2018).

In this study, we have established another method to retrieve hot oxygen exosphere around Mars, using the O^+ pickup ion ring distributions in the magnetosheath observed by the SupraThermal And Thermal Ion Composition (STATIC) instrument aboard the Mars Atmosphere and Volatile EvolutioN (MAVEN) spacecraft. In the magnetosheath, although the shocked solar wind has fluctuations in velocity and magnetic field, the motional electric field typically points outward or planetward depending on the interplanetary magnetic field orientation. Because O^+ pickup ion gyroradii are typically much larger than the Mars radius, pickup ions in the magnetosheath are nearly accelerated along the motional electric field of the magnetosheath, meaning that they are typically on the initial phase of the ring distribution. Using measured ion fluxes in the first quadrant phase of the O^+ ring distribution, we successfully retrieved ionization locations and densities of hot oxygen atoms in ˜1000-5000 km altitude range. In this presentation, we will show typical oxygen exosphere profiles in different local times and their dependences on the solar wind, solar EUV radiation, and seasons.

In near future, the Martian Moons eXploration (MMX) spacecraft will carry multiple scientific instruments to investigate Mars and Martian moon environments and return samples from Phobos. One of the instruments is the Mass Spectrum Analyzer (MSA) instrument that measures ion velocity distributions and magnetic fields. The high mass resolution ($M/\Delta M>100$) of MSA will allow us to study ion isotopes such as $^{18}O^+$ and $^{13}C^+$ as well as their major ion elements ($^{16}O^+$ and $^{12}C^+$). Using our retrieval method in the future observations of MMX/MSA, we aim to retrieve Martian exospheric density profiles of multiple components, including isotopes, with the MSA’s pickup ion measurements around Mars. Such information will be crucial for understanding the evolution history of Mars through atmospheric escape.