MAVENの火星磁気リコネクション観測

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MAVEN observations of magnetic reconnection signatures at Mars

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It has been speculated that magnetic reconnection could occur frequently in the near-Mars space, given the complex magnetic field configuration resulting from interaction between crustal and interplanetary magnetic fields. However, definitive identification of in-situ reconnection signatures has been elusive due to the lack of comprehensive particle and field instrumentation on the past Mars missions. Here we investigate the occurrence and characteristics of magnetic reconnection in the Martian magnetosphere by utilizing ion, electron, and magnetic field measurements by the Mars Atmosphere and Volatile EvolutioN (MAVEN) mission. We identified current sheet crossing events with a collection of reconnection signatures including (i) Alfvenic ion flows within current sheets, (ii) Hall magnetic fields, (iii) nonzero normal fields, and (iv) closed field topology on both the dayside and the nightside of Mars. Many reconnection events observed by MAVEN exhibit mass-dependent ion flows, highlighting two important aspects of the plasma environment of Mars: (i) the presence of heavy ions (predominantly atomic and molecular oxygen ions) along with protons and (ii) the smallness of the system size with respect to the ion scale length. Statistical investigation of Hall magnetic fields and accelerated ion flows in nightside magnetotail current sheets suggests that magnetic reconnection operates for at least ~1-10% of the time in tail current sheets. Furthermore, analysis of magnetic topology inferred from electron energy and pitch angle distributions revealed that the coexistence of trapped electrons of solar wind and ionospheric origins on the same closed field line, which is indicative of recent closure of open field lines by reconnection, is observed relatively frequently with ~1-10% occurrence rates in the nightside magnetosphere. Taken together, these MAVEN observations demonstrate that magnetic reconnection is not uncommon in the near-Mars space. This result has important implications for the formation and dynamics of the Martian magnetosphere such as the twisted magnetotail configuration, formation of magnetic flux ropes, and electron injection on closed crustal field lines.