Effects of an intrinsic magnetic field on the ion escape from Mars

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Mars has experienced a large amount of atmospheric escape from the past through the present. This is due to the fact that recent space missions provided some evidences for existence of thick atmosphere and liquid water in the past. Therefore, present-day Mars only leaves the thin atmosphere and does not have liquid water at the surface. One of the important mechanisms of atmospheric escape is the ion loss. The ion escape is largely controlled by the magnetic configuration, solar wind and solar XUV (X-ray and extreme ultraviolet) irradiances. Terada et al. (2009) focused on the ion escape rate under the ancient solar condition, and the ion escape rate was at most five orders of magnitude higher than for the present one. The planetary magnetic field is also an important factor in determining the ion escape mechanism. The present Mars does not have intrinsic global magnetic field, but it is leaving the magnetism in its crust, which is called as the crustal magnetic field. The intrinsic magnetic field could affect the mechanism of atmospheric escape from the planet. It is actually known that the aspect of interaction between the solar wind and terrestrial-types planet significantly depends on the strength of intrinsic magnetic field of the planet. The terrestrial intrinsic field also repeated the inversion and intensity change and affected the climate and surface environment. Therefore, it is important to know how the intrinsic magnetic field affects the atmospheric escape in estimating the atmospheric composition and surface environment of the planet.

The ion escape mechanism of Mars is investigated under only the interplanetary magnetic field (IMF) and both a weak intrinsic magnetic field and IMF using a magnetohydrodynamics modeling. Existence of the weak dipole field results in enhancement of the tailward flux of heavy ions through the four escape channels. Two of them are associated with the open field lines from the cusps, and the others originate from the open field lines yielded by a reconnection between the dipole field and IMF around the magnetosheath. The escape rate of heavy ions such as O_2^+ is particularly greater than with the IMF only. It is suggested that the intrinsic magnetic field encourages escape of heavy ions that are mostly present in the lower ionosphere.

Reference

Terada, N., et al. (2009), Atmosphere and water loss from early Mars under extreme solar wind and extreme ultraviolet conditions, Astrobiology, 9, 55-70, doi:10.1089/ast.2008.0250.

Keywords: Mars, Atmospheric escape, Intrinsic magnetic field

