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周回機2機構成で挑む火星大気散逸科学

Atmospheric escape science by two Mars orbiters

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The next Japanese Mars exploration working group (MELOS WG) has studied possibility of a mission to achieve a synergetic Martian science with a focus on its climate change. Combination of remote sensing and in-situ measurements from the two orbiters and isotope measurements from the lander(s) is an ideal candidate configuration for the purpose. In this presentation, the scientific objectives as well as the strategy for atmospheric escape science using two orbiters are reported.

Mars is known to have no global intrinsic magnetic field and has the radius about a half of that of Earth. The lack of the magnetic barrier allows the solar wind (a supersonic plasma flow from the sun) to interact directly with Martian upper atmosphere and facilitates various atmospheric escape processes that are a characteristic of non-magnetized planet. It is now almost certain that Mars once had duration of warm and wet climate. The aim of the "atmospheric escape" observation is to get a clue of how and why the atmosphere and climate of Mars have evolved with time. The Martian atmosphere has been subject to the external forcing by the solar wind and sun's radiation, which exhibits from short (seconds) to long (billions of years) term variations. The cumulative effect of the atmospheric erosion due to this external forcing is regarded as one of the plausible candidates of the drastic climate change from warm and wet to cold and dry environment, which Mars is believed to have undergone in the past. Our target is to elucidate non-thermal escape processes, in particular, solar wind-induced escape processes, which are pointed out to involve substantial uncertainties by previous measurements and theoretical studies.

This target was one of the main scientific objectives of Nozomi (launched in 1998), the Japanese first mission to Mars. Recent progress made by MGS and Mars Express has given us partial view of current atmospheric escape, and the motivation is now taken over by the upcoming MAVEN mission of NASA. MAVEN is planning to carry out a comprehensive in-situ observation of the atmospheric escape, which will unveil the current state of upper atmosphere and its escape during solar minimum. Taking account of the past and ongoing missions, we consider that the following combination of remote sensing and in-situ measurements from two orbiters is essential to get key information to deepen our understanding of escape processes and their response to solar activity variations to the level of an extendable one to the past to discuss atmospheric evolution. Simultaneous observations from the "high-altitude orbiter", which will grasp a global (planet-wide) structure of escaping ions and neutrals by UV/EUV imaging, and from the "low-altitude orbiter", which will investigate the escape processes by in-situ measurements (plasma and neutral particles, magnetic field, etc.), enable us to identify many essential escape processes which otherwise are

difficult to observe. In addition, the UV/EUV imaging as well as the high-mass-resolution in-situ particle measurements can identify ion and neutral compositions of escaping atmosphere, such as C, CO, C+, CO+, and CO2+. Thus it will be possible to study how and how much the greenhouse gas has escaped from Mars. The "high-altitude orbiter" provides another key observation: solar wind monitoring. The solar wind monitoring is crucial to precisely understand present escape processes/fluxes as well as their dependences on the external conditions of the solar activity (solar wind parameters, EUV flux, X-rays, and so on), which are necessary to reconstruct the evolutional history of atmospheric escape with geological timescale. Deep dips of the "low-altitude orbiter" as low as the exobase (170-230 km) or possibly the homopause altitude (125 km) would allow us to explore connection between the atmospheric escape and the upper atmospheric conditions.

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