

## Atmospheric Escape Science by Mars Exploration Mission MELOS

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MELOS, the next Japanese Mars exploration mission, is expected to consist of two orbiters and one (or more) lander. Combining remote sensing and in-situ measurements from the two orbiters and isotope measurements from the lander, we plan to achieve a synergetical atmospheric science at Mars, which will unveil the present and past atmosphere and climate of Mars. Our multi-spacecraft mission is based on the heritages and experience gained in the JAXA's past and ongoing missions, such as Nozomi, Planet-C, Kaguya, and BepiColombo. It will extensively explore the entire atmosphere of Mars, including the upper atmosphere, middle and lower atmospheres, and their interconnection with the planetary surface/subsurface and solar conditions, which are essential to understand the evolution of the planetary environment (hence habitability of life). In this presentation the scientific objectives as well as the strategy of atmospheric escape science by MELOS are presented.

One of the primary scientific objectives of MELOS is 'atmospheric escape'. 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, which Mars is believed to have undergone in the past. However, there has been no comprehensive observation of the solar wind erosion of the martian atmosphere, so there is no consensus view as to what processes are responsible for the erosion and what are the impacts on the evolution of the planetary environment. 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 (incomprehensive) measurements and theoretical studies. This target was one of the main scientific objectives of Nozomi (launched in 1998), the Japanese first mission to Mars. However, this does not necessarily mean that we plan a mere 'Nozomi-recovery' mission. We have refined our scientific objectives based on the recent progress made by MGS and Mars Express. Simultaneous observations from the 'meteorological orbiter', which will grasp a global (planet-wide) structure of escaping ions and neutrals by UV/EUV imaging, and from the 'atmospheric escape 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<sup>+</sup>, CO<sup>+</sup>, and CO<sub>2</sub><sup>+</sup>. Thus it will be for the first time possible to study how and how much the greenhouse gas has escaped from Mars. The 'meteorological 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 (solar wind parameters, EUV flux, X-rays, and so on), and thus necessary to reconstruct the evolutionary history of atmospheric escape with geological timescale.