Investigations on the origin of Mercury's sodium tail by a numerical calculation: A suggestion from a newly observed tail shape

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Mercury has the surface bounded exosphere similar to that of the moon and one of the exospheric components, sodium, was discovered by the ground-based observation [Potter and Morgan,1985]. Mercury's sodium exosphere should be extended toward the antisolar direction, due to the solar radiation pressure. Potter et al. [2002] actually identified the extended sodium exosphere for the first time, and the antisolar region was named sodium tail. In this study, we calculated extended distribution of sodium atoms by a numerical simulation with the Monte Carlo method in order to investigate source mechanisms of sodium atoms in the tail region. In this simulation, we have considered the following four source processes; i.e., thermal desorption, photon-stimulated desorption, meteoroid vaporization and solar wind sputtering. As the result, it is shown that most of sodium atoms in the tail are released from the surface of Mercury by solar wind sputtering, and the production rate by solar wind sputtering is more than ten times higher than the proposition by Killen et al. [2004]. These results suggest that the production efficiency of the sodium atoms might be much larger and/or the size of the observed tail reflects the existence of some transient solar activities like CME and flare.

Recently, Mercury's sodium tail was newly observed by a research group of Univ. Tokyo and Tohoku Univ. at the Haleakala observatory, Hawaii. Characteristics of emission shapes of the tail are as follows: the north-south width is narrow (about 6 Hermean radii(Rm)) near Mercury, and the width is spread (about 10Rm) in the far tail region (about 8Rm from Mercury's center). As the result of comparison between the observation and calculation, it is shown that solar wind sputtering is the dominant source process of the sodium tail. However, it is also shown that the variation in the north-south width cannot be explained by a steady source rate and variation in source rate is required with the time scale of about 1 hour, which infers that the width of the sodium tail changes in short time by responding to variation of the solar wind. Considering these features of the sodium tail were confirmed under the low solar activities, it is plausible that the production efficiency of the sodium atoms by solar wind sputtering is much larger than the present expectation.