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Investigation of Local Time dependence of Mercury's sodium exosphere based on a numerical simulation

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Mercury has the surface bounded exosphere similar to that of the moon. One of the atmospheric species, sodium, was discovered by the ground-based optical observation as the most prominent component [Potter and Morgan,1985]. According to several ground-based observations, various characteristics about the spatial and temporal distribution of Mercury's sodium exosphere have been identified. One of these has been called as local-time (LT) dependence of Mercury's sodium exosphere [Sprague et al.,1997; Barbieri et al.,2004; Schleicher et al.,2004; Potter et al., 2006]. This is non-uniformity of sodium exosphere for LT at low-latitude regions, for example, it is suggested that sodium column density at the dawn side region is larger than that at the dusk side region and amount of sodium exosphere is largest at not the noon region but the morning region. However, so far, there have been few researches that quantitatively discuss causalities of the LT dependence.

We have investigated the origin of Mercury's sodium exosphere based on a numerical simulation. This time, we have focused on the local-time dependence of Mercury's sodium exosphere in order to understand production and loss processes for the exosphere near Mercury's surface in the dayside low-latitude region. As a concrete method of the investigation, we have compared a model sodium exosphere simulated from the Monte Carlo method with observation results [Sprague et al.,1997]. In this investigation, we discussed origin of the LT dependence mainly for the dawn side region, because most observations are made for the dawn side region (06~12LT).

In this simulation study, the motion of atmospheric atom is resolved as the restricted three-body problem (Sun, Mercury, and a sodium atom) and time evolution of atoms released from Mercury's surface is calculated using the four-order Runge-Kutta method. Release speed of sodium atoms is determined according to the velocity distribution function of each release mechanism (e.g. desorption, sputtering, etc.) and release direction is determined with the Monte Carlo method. We adopted the photon-stimulated desorption process and thermal desorption process as the release mechanisms, because these release processes are considered to contribute mostly to the exosphere of near Mercury's surface in the dayside low-latitude region.

As the result of comparison between observed results and model exospheres calculated by adopting the source rate considered as before (here after 'the initial source rate'), the model could not meet with the observations. This means that the other source rates are required for forming the observed LT dependence. We, then, have surveyed suitable source rate which meet with the observations. As the results, the model meet with the observations when the initial source rate decreases gradually from morning to noon, particularly, with the rate of more than one order. This variation of source rate can be converted to that of the surface sodium density. Therefore, the source rate decrease corresponds to the decrease of the surface sodium density from morning to noon. This means non-uniformity of surface density for LT. Moreover, considering the value of surface density, this suggests that sodium atoms are accumulated at the morning region and depleted at the noon region. The difference of density at morning region and at noon region is about two orders. It is also suggested that the degree of the accumulation and the depletion has dependence of distance between Sun and Mercury, or True Anomaly Angle (TAA).