Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

PCG033-09 Room:101 Time:May 24 10:45-11:00

Long-term variability in sodium on Mercury

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Mercury has a very thin atmosphere. The surface pressure is less than 10^{-12} atm. Since its scale height is greater than the mean-free-path near the surface, Mercury's atmosphere is called Surface-bounded exosphere. The Mariner 10 UV spectrometer detected the emission from H, He, and O atoms, which are thought to be the solar wind origin. Subsequently, the emission from Na, K, and Ca atoms were detected by the ground-based telescope. These alkali atoms are thought to be released from the surface by photon-stimulated desorption, thermal desorption, chemical sputtering, solar wind ion sputtering, and micrometeoroid vaporization.

In the detected species, sodium has been most investigated because its emission is brightest and it can be relatively easily observed by ground-based telescopes. Though many observations have been done since its discovery in 1985, the source process of exospheric sodium atoms is still unclear. In this paper, we show the past results of ground-based observations and discuss its source process.

Most remarkable feature of Mercury's sodium exosphere is the concentration at high latitudes and its temporal variability.

The planetary magnetic field of Mercury is strong enough to sustain the solar wind magnetic fields and form a magnetosphere. The cusp region, where the planetary magnetic field connects to the interplanetary field, is formed at high latitudes. Solar wind protons and other heavy ions precipitate more frequently at the cusp region than near equator. However, Kameda et al. (2007) shows that the temporal variability of average sodium density is less than ~10%. This issue is still to be clarified.

In this study, we compare the observed sodium density with Solar EUV flux, Solar wind flux, and the distance from the ecliptic plane. Photon-stimulated desorption is caused by solar photons, whose energies are higher than UV energy. The relationship between the solar EUV flux at the wavelength from 0 to 200 nm and the Na density will be shown. We used the data obtained by SEE on TIMED. Solar wind flux also changes with time, which possibly causes temporal variability in the sputtered Na concentration. We compared the Na density with the solar wind proton flux. We used the data obtained by SWEPAM on ACE and estimated the solar wind flux. As a result, the Na density is not correlated with the solar EUV flux or the solar wind flux. Therefore these observations do not support the theory that photon-stimulated desorption or solar wind ion sputtering is the dominant source process of Na.

Assuming that interplanetary dust (IPD) is concentrated on the ecliptic plane, IPD density should be dependent on the distance from the ecliptic plane. We have developed an IPD distribution model to investigate further the relationship between atmospheric Na density and IPD distribution. We assume that the average Na density in Mercury's atmosphere is proportional to the IPD density at Mercury. The inclination (i) and ascending node (omega) of the symmetry plane of IPD are also free parameters. We searched the most relevant values for these four parameters using the least square method. The correlation coefficient can be more than 0.6 for -104 $<$omega$<$ 57 and i $>$ 1.9. Our results do not correspond completely with the past results, mainly because of the difference in the position of the observed IPD. In this presentation, we discuss the source process of sodium exosphere including the effect of solar tides.

Keywords: Mercury, Sodium, Planetary Atmosphere, Ground-based observation, Exosphere