The Effect of Magnetic Anomalies on the Detection of Moon Originating Ions

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Introduction: The Moon has neither thick atmosphere nor global intrinsic magnetic field, which enables solar wind to directly reach the lunar surface. Although ions around the Moon consist mainly of solar wind ions for this reason, the existence of heavy ions around the Moon has also been known by the Apollo series and ground-based observations since the second half of the 20th century. Though the generation / transportation processes of the ions originating from the Moon have long been discussed, they have not been sufficiently understood yet. At present, it is supposed that ions are generated by multiple processes including ionization of neutral exosphere by solar wind, processes at the lunar surface such as thermal desorption, photon / charged-particle / chemical sputtering, meteoric impact, and interior release. The generated ions are accelerated by surface potential / convection electric filed in the solar wind, and then released to space[1],[2].

IMA (Ion Mass Analyzer) of MAP-PACE on Kaguya (SELENE) that was facing the Moon surface measured energy and mass of the ions from the Moon. IMA made in-situ observation of heavy ions originating from the lunar exosphere / surface. Yokota et al [3] identified heavy ions such as C+, O+, Na+, K+, Ar+ in the mass spectra obtained by integrating the ion counts observed by IMA when the Moon was in the solar wind. They showed that in general the energies of the ions could be explained assuming ions were accelerated by convection electric filed in the solar wind.

Objective and Analysis: To take some clue to know how electromagnetic field around the Moon affects lunar originating ions, we investigated how Moon originating ions are affected by convection electric field and magnetic anomalies (localized strong magnetic fields on the lunar surface).

We calculated the correlation coefficient between number flux of the Moon originating ions (< 250eV) and each component (nowthward, eastward, and radial directions) and absolute value of the convection electric field $E = - V_{SW} \times B_{SW}$. The convection electric field was calculated at the position of Kaguya using the data obtained by MAP-LMAG and MAP-PACE-IEA. In order to understand the effect of the lunar magnetic anomalies on the ions originating from the Moon, we used data when Kaguya did and did not fly above magnetic anomalies (the strength of magnetic field at 10km aktitude was greater than 20nT and less than 5nT, respectively), using the model made by Tsunakawa et al[4].

Results and Discussion: At ~100km altitude, the observed number flux showed no correlation with northward and eastward component of the solar wind convection electric field while there were relatively good correlation with the radial component, which means the convection electric field is dominant transportation process. When the orbit of Kaguya was as low as ~50km altitude, the correlation between the observed number flux and the radial component became worse. This is probably because ions at higher altitude were more affected by the electric field since the ions travel longer, and/or the effect of the convection electric field is relatively lower near surface due to surface potential field.

Taking into account that the observed number flux has good correlation with convection electric field, we investigated whether there were any variations above the strong magnetic anomalies which could not be explained by the variation of electric field. We found that there were a couple of such examples. Since we calculated only the number flux of ions whose energy was less than 250eV, there exist two possibilities; (i) there were few ions above magnetic anomalies, and (ii) the ions were accelerated to have energies higher than 250eV. In the former cases, the results indicate the following three possibilities; 1) Since the magnetic anomaly prevented the solar wind from reaching the lunar surface, there was no solar wind sputtering (difference in the generation processes), 2) Ions were generated at the lunar surface but they were trapped by magnetic anomalies (difference in the transportation processes), and 3) Electric field was substantially different between the ~100km altitude and low altitude near lunar surface.

Conclusion: We confirmed that the convection electric field is the dominant transportation process. The variation of detected number flux above magnetic anomalies suggests the existence of the following two possible effects; there were few Moon originating ions or they were accelerated to have energies higher than 250eV above magnetic anomalies.

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