Non-gyrotropic Electron Velocity Distribution Functions near the Moon

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We have analyzed non-gyrotropic electron velocity distribution functions (VDFs) obtained near the lunar surface. Electron VDFs, measured at ~10–100 km altitude by Kaguya in the Earth's magnetosphere, exhibit non-gyrotropic empty regions associated with the 'gyro-loss' effect; i.e., electron absorption by the lunar surface combined with electron gyromotion (FIgure 1). Particle-trace calculations allow us to derive theoretical forbidden regions in the electron VDFs, thereby taking into account the modifications due to nonuniform magnetic fields caused by diamagnetic-current systems and lunar-surface charging. Comparison between the observed empty regions with the theoretically derived forbidden regions suggests that various components modify the characteristics of the non-gyrotropic electron VDFs depending on the ambient-plasma conditions. On the lunar nightside in the magnetotail lobes, negative surface potentials slightly reduce the size of the forbidden regions, but there are no distinct effects of the diamagnetic current (Figure 2). In the terrestrial plasma sheet, both of these mechanisms can substantially modify the characteristics of the forbidden regions (Figure 3). Analysis of non-gyrotropic VDFs associated with the gyro-loss effect near solid surfaces can promote a better understanding of the near-surface plasma environment and of plasma–solid-surface interactions.



Figure 1. Schematic illustration of the gyro-loss effect (not to scale).



Figure 2. Electron angular distribution for different energies in satellite coordinates obtained in the period of 20:10:17–20:10:33 UT (16 s) on 5 June 2009, when the Moon was in the magnetotail lobe. Angles with little or no sensitivity are indicated in gray. Note that ESA-S1 and ESA-S2 have different sensitivities. The white contours represent the pitch angles. The red solid lines indicate the forbidden regions derived from particle-trace calculations for the energies of ESA-S1 and ESA-S2 shown in each panel, assuming a uniform magnetic field and no electric field. The red dashed lines indicate the modified forbid- den regions for an electrostatic potential of the lunar surface of -50 V.



Figure 3. Electron angular distribution obtained during 23:06:33–23:07:21 UT (48 s average) on 18 April 2008, when the Moon was in the Earth's magnetosphere, in the same format as in Figure 2. The red lines indicate the forbidden regions for a uniform magnetic field and no electric field, the orange solid lines indicate the modified forbidden regions under the diamagnetic-current effect, and the orange dashed lines indicate those affected by the diamagnetic-current effect and an electrostatic potential of the lunar surface of -1000 V.