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Numerical experiment of formation of the lunar wake using Vlasov-Maxwell model

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Due to the direct interaction between the solar wind plasma and the moon's body, very low density region called as 'wake' is formed behind the moon. It has been suggested that the hot plasma component plays an important role for plasma dynamics in the lunar wake region observed by the Wind satellite. This result proposes that the kinetic approach is necessary for understanding of the formation of the lunar wake. Based on the above observation result, the simulation of the plasma dynamics in the lunar wake region has been made. However, in the PIC [e.g., Farrell et al., 1997] and hybrid [Travnicek et al., 2005] simulations, a real plasma condition can not be adapted. In the present study, we performed the simulation of the formation of the lunar wake using the Vlasov code, which can be adapted for relatively larger scale than where the PIC code can be treated.

In this study, we try to simulate the formation process of the lunar wake behind the moon body by using the Vlasov code. The advanced point of the present study is that the real value of the ratio of electron to ion is used in this simulation.

As a result of the one-dimensional electrostatic Vlasov simulation (Vlasov-Poisson model), the solar wind particles show penetration into the inner region of the lunar wake. This mechanism of the ion injection is due to the acceleration under the action of the polarization electric field associated with the charge separation. This mechanism has been verified in the present numerical simulation. Moreover, comparing with the observation result of the Wind satellite, it is revealed that the ions penetrate deeper into the lunar wake than the observation point. On the other hand, periodic electric field perturbations are found outside the lunar wake. The perturbations seem to be generated by plasma instability near the wake boundary.

As a next step, we have performed the other type of the numerical simulation using the Vlasov-Maxell model. It is shown that the particle motion along the magnetic field line is more dominant than that of the perpendicular direction. This fact also implies the existence of the magnetic shadow pointed out by the previous works.