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A Test Particle Simulation of Jovian Magnetospheric Electrons Precipitating into Europa's Oxygen Atmosphere

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Europa has a tenuous atmosphere composed mostly of molecular oxygen. Roth et al. [2016] found north-south asymmetric morphology of the oxygen 135.6 nm emissions when Europa is far from the plasma sheet center. The observed north-south brightness ratio is up to 5 on the trailing hemisphere and below 2 on the leading hemisphere. Since the main source of the 135.6 nm emissions is the electron impact dissociative excitation of O2, they concluded that the asymmetry is the result of an inequality of electron energy flux from the Jovian magnetosphere into Europa's atmosphere.

The electron energy flux into Europa's atmosphere depends on (a) the bounce period of magnetospheric electrons moving along a field line, (b) the velocity of the corotating plasma flow, and (c) the magnetic latitude of Europa. Retherford et al. [2003] explained that when the corotating plasma flow slows down by the moon-plasma interaction, most electrons in an intersecting flux tube collide with Io: the electrons above the moon precipitate into the northern hemisphere and those below the moon precipitate into the southern hemisphere. This creates a pronounced asymmetric electron energy flux into the atmosphere when the moon is far from the plasma sheet center. The theory, however, has never been evaluated for the case of Europa quantitatively.

To derive the electron flux into Europa's surface, we use a test particle simulation and trace the motion of magnetospheric electrons around Europa. We assume that Jupiter has a tilted dipole magnetic field and a corotational electric field. The motion of each electron is treated as a superposition of the cyclotron motion around a field line, the bounce motion along the field line and the longitudinal convection in the Jovian magnetosphere. We don't consider the field perturbation around Europa, but electron's longitudinal convection assumingly slows down from the corotating velocity (Ip [1996]). We acknowledge that the applicability of dipole field and the decelerated plasma flow alone is limited. To reduce the computational costs, we trace the trajectories backward in time (e.g., Cassidy et al. [2013]).

We calculate the spatial distribution of the electron number flux to Europa's surface and evaluate the 135.6 nm brightness excited by the derived electron flux. We found that the corotating velocity relative to Europa, 100km/s at Europa's orbit, is required to be decelerated to below 5km/s to create a north-south ratio of electron flux larger than 2. Under this condition, the north-south brightness ratio is estimated at 2.82 on the trailing hemisphere, and 5.56 on the leading hemisphere. However, the estimated north-south brightness ratio is inconsistent with the observation results: the ratio should be larger on the trailing hemisphere than the leading hemisphere. This suggests that the simple dipole field cannot generate the exact morphology of the 135.6 nm and we must consider the perturbed field around Europa and the induced field.

We're now working on the test particle simulation with more realistic field scenarios. In this presentation, we will show how the perturbed field and Europa's induced field affect the trajectories of electrons and the distribution of electron flux and the 135.6 nm brightness.