Test particle simulation of 1keV electron energy loss by ionization with water molecule around Enceladus

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1 Introduction

Enceladus (~3.95 Rs) is the dominant source of the water neutrals in the inner magnetosphere. Over time, the ejected H_2O molecules spread out and produce the other water group neutrals (OH, and O) through chemical reactions. The water group neutrals play the dominant role in loss of plasmas [e.g., Paranicas et al., 2007; 2008, *Sittler et al.,* 2008]. The previous studies suggested that the neutrals contribute to loss processes of plasma in the inner magnetosphere. However, little has been reported on a quantitative study of the electron loss process due to electron-neutral collisions. *Tadokoro and Katoh* [2014] examined the time variations of equatorial pitch angle distribution and electrons within loss cone through 1 keV electron pitch angle scattering due to electron-H_2O elastic collisions around Enceladus. Above several hundred eV, ionization cross section for electron electron-H_2O collision is greater than elastic collision. In this study, conducing one dimensional test particle simulation, we examine the electron energy loss rate through ionization interaction between 1keV electron and H_2O.

2 Simulation model

Following the method of *Tadokoro and Katoh* [2014], we use one dimensional test-particle simulation code for monoenergetic electron along Saturn's dipole magnetic field line around Enceladus. Trajectories of the electrons are computed by considering under a dipole magnetic field.

$$m\,dv/dt = q\left(\vec{E} + v \times \vec{B}\right),$$

where B is the magnetic field. We assume that the electric field (E) is zero in this study. In this study, we assume that the initial pitch angle distribution is isotropic distribution. The number of electrons used in this simulation is 500,000. A trajectory trace is terminated when a calculation time is over ~380s. The end of calculation time corresponds to the time scale of the co-rotating flux tube passing through the region of the dense H_2O around Enceladus.

In this study, we assume that the product ion after ionization is H_2O^+ as

$$H_2O + e(1^{st}) \rightarrow H_2O^+ + e(1^{st}) + e(2^{nd})$$

where $e(1^{st})$ shows the incident electron, $e(2^{nd})$ shows the secondary electron. We trace the trajectory of the incident electron.

The collision is solved by a Monte-Carlo procedure. The collisional frequency, f_{col}, between an electron and H_2O molecule can be given by

$$f_{col} = n\sigma v,$$

where n is the neutral H_2O density, σ is the ionization cross section, and v is the relative velocity between an electron and neutral H_2O. The H_2O density model used in this simulation is the same as the model based on observations used in *Tadokoro and Katoh* [2014]. The ionization cross section based on the experimental data is given by *Itikawa and Mason* [2005]. If the ionization occurs, then we conduct a calculation of electron energy loss. We assume that the incident electron energy after ionization impact decreases by 12.6eV (ionization energy) and secondary electron energy. The secondary electron energy is solved by a Monte-Carlo procedure using singly differential cross section [*Itikawa and Mason,* 2005].

3 Result and Summary

It is found that the calculated 1keV electrons of ~72 % (~9 %) show energy loss in 380s (60s). In case of taking no account of secondary electron energy loss, the calculated 1keV electrons of ~54% (~3 %) show energy loss in 380s (60s). The 1keV electron energy loss rate is estimated to be ~0.19[%/s]. In case of taking no account of secondary electron energy loss, the 1keV electron energy loss rate is estimated to be ~0.14[%/s]. The energy loss rate considering secondary electrons is ~1.3 times larger than that in case of taking no account of secondary electrons.

Our future work is required for code development by addition of other ionization process.

References

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