Influence of 500eV-50keV electron elastic collision with H_2O originated from Enceladus: test particle simulation

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1 Introduction

Water group neutrals (H_2O, OH, and O) in Saturn's inner magnetosphere play the dominant role in loss of energetic electrons and ions. The observations of energetic electrons and ions in Saturn's inner magnetosphere suggest that these plasmas do not survive very long time due to the neutral cloud originated from Enceladus (~3.95 Rs) [e.g., Paranicas et al., 2007; 2008]. These abundant neutrals in the inner magnetosphere play the dominant role in a loss process of energetic plasmas [e.g., *Paranicas et al.,* 2007; *Sittler et al.,* 2008]. Conducting one dimensional test-particle simulation, *Tadokoro et al.* [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 when the electron flux tube passes the region of the dense H_2O molecules in the vicinity of Enceladus (~380 sec). The result showed that the electrons of 11.4 % are lost in ~380 sec. The time corresponds to the time scale of the co-rotation of the flux tube passing through the region of the dense H_2O in the vicinity of Enceladus. Assuming the uniform azimuth H_2O density structure in the Enceladus torus, they estimated the electron loss rate of 33% during one co-rotation. Next remaining issue is the survey of energy dependent electron loss rate. We examine the loss rates of electrons with 500 eV – 50keV due to elastic collisions.

2 Simulation model

Following the method of *Tadokoro et al*. [2014], we conduct one dimensional test-particle simulation for monoenergetic electron along Saturn's dipole magnetic field line around Enceladus (L=3.95). We assume that the boundary condition is in the magnetic latitude range of -10 – 10 degrees and the loss cone angle at the equator is 7.3 degrees. A trajectory trace is terminated when a pitch angel of each article at the boundary is smaller than the loss cone angle. We assume that the electrons precipitate into the atmosphere since the collisional frequency at the boundary is smaller than the bounce frequency. Trajectories of the electrons are computed by considering under a dipole magnetic field.

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

where B is the magnetic field. We assume that the electric field (E) is zero in this study. In this study, we consider only elastic collisions and focus on the variation of electron pitch angle distribution. To examine the variation of pitch angle distribution we assume that the initial pitch angle distribution is isotropic distribution. The number of electrons used in this simulation is 500,000. We calculate by each monoenergetic electron (500 eV, 700 eV, 1 keV, 5 keV, 10 keV, 20 keV, 30 keV, 40 keV, 50 keV). We make a calculation of 5 times each monoenergetic electron.

The collision is solved by the Monte-Carlo method. 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 total cross section, and v is the relative velocity between an electron and neutral H_2O. If the elastic collision occurs, then we conduct a calculation of scattering angle based on the differential cross sections. The total and differential cross sections for elastic collisions based on the experimental data are given by *Katase et. al.* [1986].

3 Result and Summary

Figure 1 shows the electron loss rate in ~380 sec as a function of electron energy in the range from 500 eV to 50 keV. The red (blue) line shows the electron loss rate due to elastic collision with high H_2O density in the vicinity of Enceladus (with low H_2O density in the general neutral torus). The error bars are obtained from error by calculation of 5 times. It is found that the loss rates in the vicinity of Enceladus decrease with electron energy. On the other hand, the energy dependence of the loss rates in the torus is not clear due to elastic collision by low H_2O density.

For comparison with observations, we need to develop simulation code adding ionization.

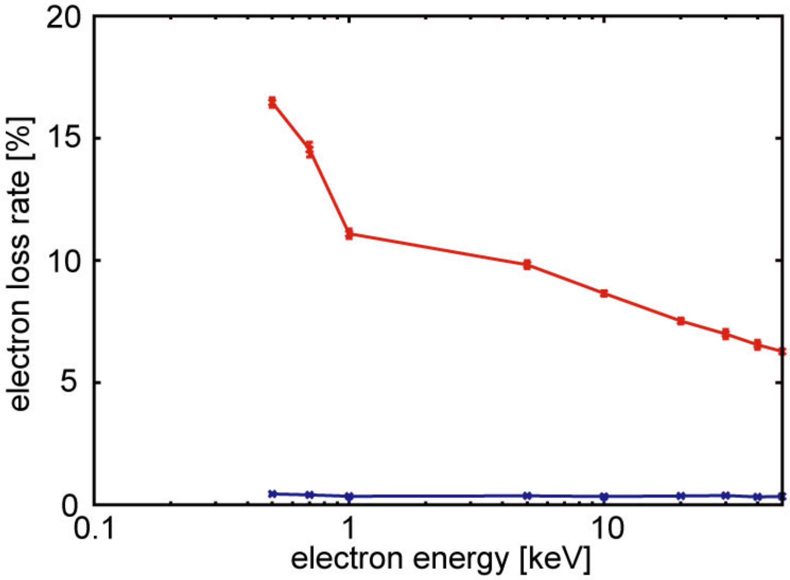

Figure 1. Electron loss rate into the loss cone in ~ 380 sec as a function of electron energy. The red line indicates the loss rate in the high H_2O density region in the vicinity of Enceladus. The blue line indicates the loss rate in the low H_2O density region in the Enceladus torus.

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