エンケラドス衛星近傍における磁気圏電子(500eV-50keV)と水分子の弾性衝突の数値実験

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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 [e.g., *Paranicas et al.,* 2007; *Sittler et al.,* 2008]. The observations of injected plasmas (electrons and ions) in Saturn's inner magnetosphere suggested that these particles do not survive very long time due to the neutral cloud originated from Enceladus (~3.95 Rs) [e.g., Paranicas et al., 2007; 2008]. However, little has been reported on a quantitative study of the electron loss process due to electron-neutral collisions. Conducting one dimensional test-particle simulation along Saturn's dipole magnetic field line, *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. Assuming the uniform azimuth H_2O density structure in the neutral torus, they also estimated the electron loss rate of 33 % during one corotation. Next remaining issue is a survey of energy dependent electron loss rate. We show the loss rate of electrons with 500eV-50keV and the comparison of the loss rate between the high (in the vicinity of Enceladus) and low (in the Enceladus torus) H_2O density regions.

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). The number of electron used in this simulation is 500,000. 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.

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

where B is the magnetic field. We assume that the electric field (E) is zero in this study. To examine the variation of pitch angle distribution we assume that the initial pitch angle distribution is isotropic distribution.

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 cross section, and v is the relative velocity between an electron and neutral H_2O. The total and differential cross sections for elastic collisions based on the experimental data are given by *Katase et. al.* [1986]. For details of simulation method, see *Tadokoro et al.* [2014].

3 Result and Summary

Figure 1 shows the time variation of equatorial pitch angle distribution at 500eV-50keV. It is found that the normalized electron near the loss cone decreeses with time through pitch angle scattering due to elastic collision. It can be seen that electron near the 90 degrees show signify scattering because of abundance of H_2O density.

Figure 2 shows the loss rate of electrons with 500 eV - 50 keV in ~380 sec.. The red (blue) line shows the electron loss rate in the plume (outside the plume). N_{lc} is the amount of electrons into the loss cone, N_{0eq} is the total number of equatorial electrons at the initial condition. We assume that the electrons precipitate into the atmosphere since the collisional frequency at the boundary is smaller than the bounce frequency (For details of simulation method, see *Tadokoro et al.* [2014].).

It is found that the loss rate in the plume is greater than that outside the plume because of the difference of H_2O density. The electron loss rate decreases with electron energy.

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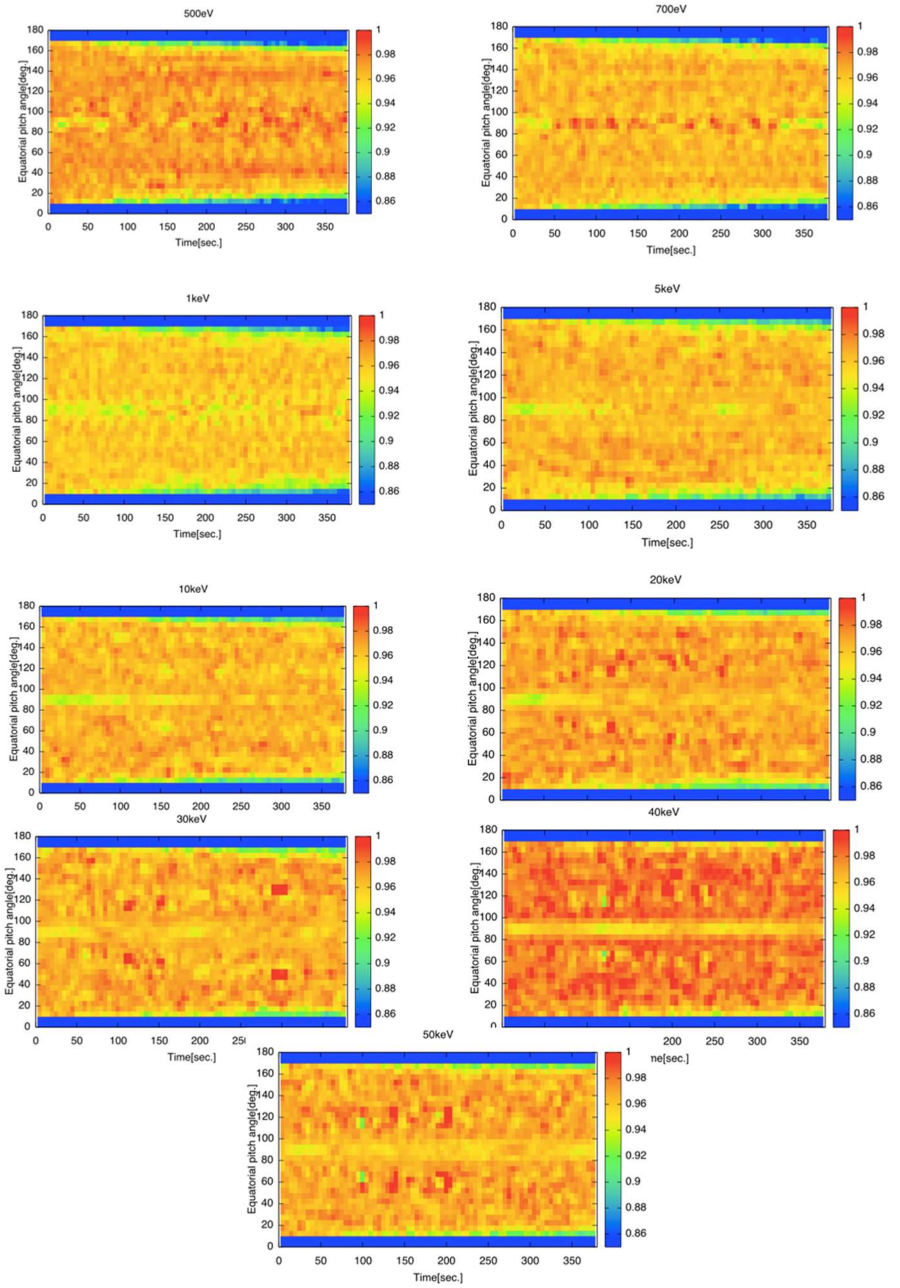

Figure 1. Time variation of equatorial electron (500eV-50keV) pitch angle distribution.

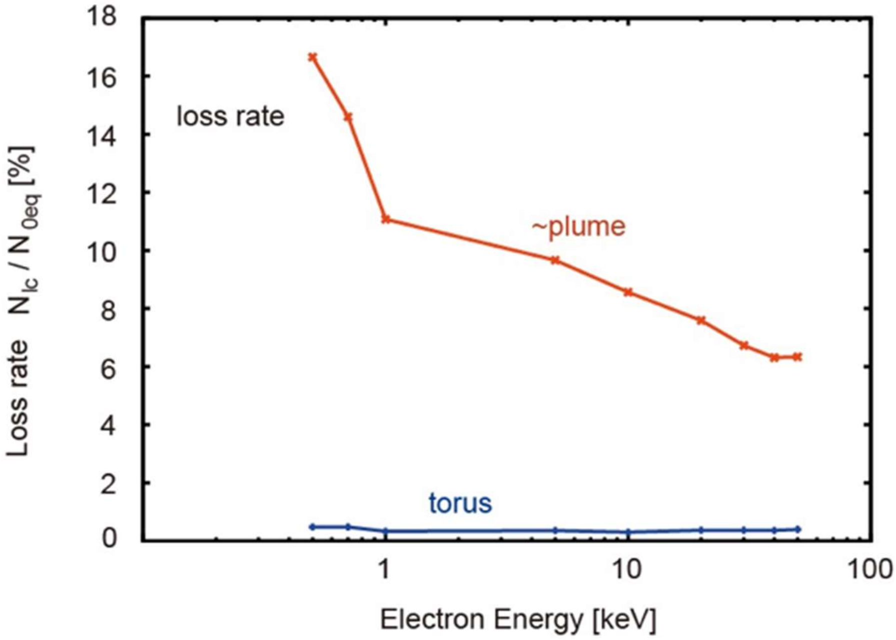

Figure 2. Loss rate as a function of electron energy. N_{lc} is the number of electrons into the loss cone. N_{0eq} is the total number of equatorial electrons at the initial condition. N_{slc} is the small equatorial pitch angle electrons (<20 and >160 degrees) at the initial condition into the loss cone. The red (blue) line indicates the electron loss rate in the plume (torus).