9th Asia-Pacific Conference on Plasma Physics, 21-26 Sep, 2025 at Fukuoka

Numerical Modeling of Particle Dynamics during Dipolarization Events in Substorm Time

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Abstract
We developed a hybrid test particle simulation code to examine particle dynamics during three dipolarization events observed by the THEMIS mission during substorm periods in 2008 and 2009. The code evaluates the trajectories of 20 keV electrons, protons, and oxygen ions, considering various initial pitch angles and *L*-shells. It integrates two particle tracing methods: the Tao-Chan-Brizard guiding center model and full Lorentz motion, along with an assessment of the adiabaticity criterion.
To model the time-varying magnetic field, we incorporated the Tsyganenko TS05 model and the IGRF-12 model, along with the corresponding inductive and polarized electric fields. In this phase of the project, we investigate the effects of including pitch angle scattering and the substorm current wedge model in our simulations.
Preliminary results confirm that particle energies are enhanced in the nightside magnetosphere during dipolarization events. In particular, we found that accelerated oxygen ions in the magnetotail due to dipolarization events can reach the inner magnetosphere and may contribute to the ring current population. Additionally, 10-20% of the total implemented electrons and protons were injected into the outer radiation belt region due to the inclusion of the pitch angle scattering effect and the substorm current wedge model, respectively, during the dipolarization event. These findings highlight the potential and significant role of the substorm-accelerated particles from the magnetotail in populating the inner magnetosphere.

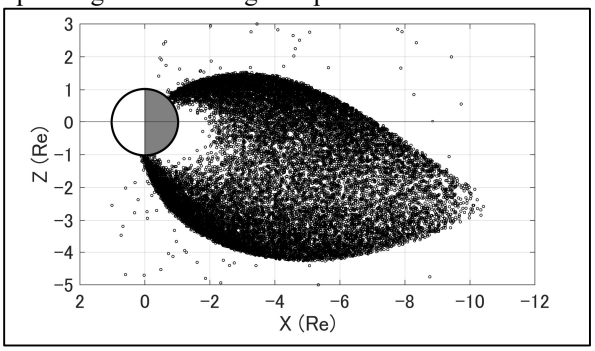

Fig. 1: This figure illustrates an example of the initial particle distribution in the nightside region.

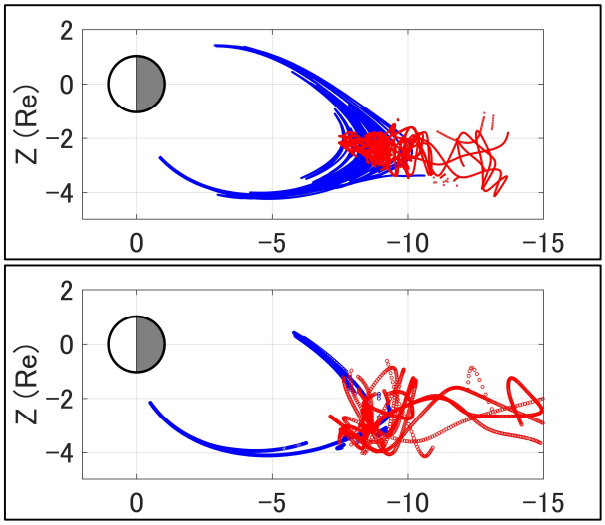

Fig. 2: The top and bottom panels display the trajectories of 20-keV protons and oxygen ions, respectively, in the nightside region. Blue lines represent the guiding center trajectories, while red lines indicate the full Lorentz trajectories.

References

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