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Stochastic Fermi acceleration in the Earth's magnetotail current sheet: a numerical study

Antonella Greco (1), Silvia Perri (2), and Gaetano Zimbardo (1)

(1) University of Calabria, Physics, Rende, Italy (greco@fis.unical.it), (2) International Space Science Institute, Bern, Switzerland

A numerical study has been carried out in order to investigate the effects of model time–dependent electromagnetic fields along with stationary, constant electric and magnetic field components on the ion dynamics. In the Earth's magnetotail, the trajectories of thermal protons are integrated in a 2D model where they can experience a Fermi–like acceleration process by interacting with synthetic oscillating electromagnetic clouds, randomly positioned within the xy plane. Besides the time–dependent fluctuations, a dawn–dusk electric field component E_0y is present, as well as a constant out–of–plane magnetic field component B_n. When the size of the electromagnetic clouds is small compared to the simulation box sides, the proton acceleration is mostly due to the dawn–dusk electric field; increasing B_n causes a reduction of the obtained energies, reduction which decreases when B_n is further increased. For larger sizes of the electromagnetic blobs, Fermi acceleration becomes more efficient, and proton energies up to 100 keV are obtained. In such a case, the influence of the constant fields E_0y and B_n becomes weak, and the final energy distribution does not depend on B_n. This means that the stochastic Fermi acceleration can be efficient even in the presence of a background magnetic field. Since the typical energies of protons are in good agreement with those observed for proton beams in the Earth's magnetotail, the joint effects of the random fields and the steady ones can explain particle acceleration processes in the distant and the near–Earth magnetotail regions.