SF2A 2004
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PARTICLE ACCELERATION IN A COMPLEX SOLAR ACTIVE REGION MODELLED BY A CELLULAR AUTOMATA MODEL

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1 Introduction

Cellular Automata (CA) models based on the concept of self organized criticality (SOC) can mimic the complex evolution of the magnetic energy released in a solar flare. Each burst of magnetic energy released is assumed to be the consequence of a magnetic reconnection process. We aim to calculate electron and ion energy distributions following the approach of Anastasiadis et al, 2004. We thus investigate the energy gain of these particles by direct electric fields in reconnecting current sheets (RCS) simulated in the CA model by the evolution rules of the magnetic field. However, the magnetic field configuration in the RCS implies different trajectories between different species of particles. The energy gained by electrons and ions thus depends on theirs acceleration lengths $\Delta l_{e,p,i}$ which are mainly determined by the magnitude of the longitudinal magnetic field.

2 Model and results

2.1 Acceleration model

In order to relate the electric field seen by the particles in each RCS to the magnetic energy $\sim B^2$ released by the CA model, we equate the Poynting flux into the sheet to the particle flux (see details given in Dauphin et al, 2004). The energy gain ϵ of a particle is given then by:

$$\epsilon_{e,p\ ,i} = \pm\alpha Ze\Delta l_{e,p\ ,i}\,\frac{B^2}{4\pi e(\Delta l_e n_e + \Delta l_p n_p)} \tag{2.1}$$

The sign plus or minus corresponds to the fact that the particle velocity and the electric field can be parallel or anti parallel. At each interaction α is a random

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number selected between 0 and 1. This number corresponds to the efficiency of the acceleration. We express the ratio of acceleration lengths for different particle by considering three different magnetic field configurations in the RCS: (1) a zero longitudinal magnetic field component (Speiser, 1965), (2) a large longitudinal magnetic field where electrons and ions are fully magnetized (see e.g. Litvinenko 1996), (3) an intermediate case in which electrons are fully magnetized and ions are partially magnetized.

2.2 Particle energy distributions

We calculate final energy distribution functions of particles after interactions with a given number N_{max} of RCS. Particles are injected in the acceleration volume with an initial Maxwellian distribution of temperature T. For each particle, we randomly selected N elements in the energy release time series given by the CA model. At each interaction the particle energy changes according to the expression 2.1. Figure 1 shows final energy distribution functions for electrons, protons

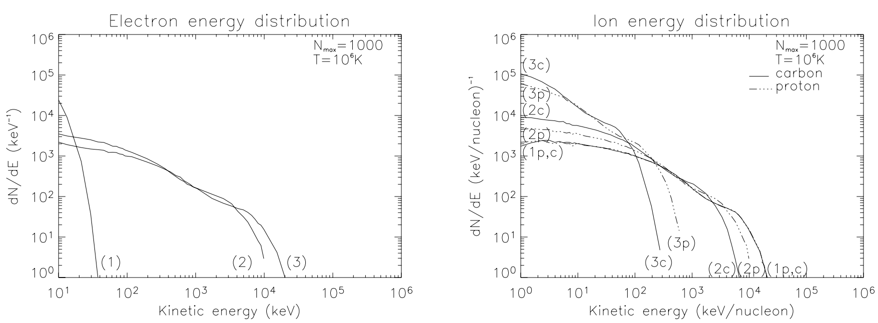

Fig. 1. Electron and ion energy distribution functions. The three different cases correspond to the different magnetic field configurations (see text for details).

and carbon ion assuming an ambient density of $10^{10}cm^{-3}$ and in the three cases presented in 2.1. As suggested by the work of Litvinenko, electrons are more efficiency accelerated in the presence of a large longitudinal magnetic field which fully magnetizes them. The maximum energy gained by each kind of ions depends on the assumption made on the magnetic field configuration in the RCS. While in case (1), the energy gain in each RCS is independent of Z/A, in case (2) it varies as Z/A and in case (3) as $(Z/A)^{3/2}$.

References

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