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Investigations of Particle Accelerations by Turbulent Magnetic Reconnection in Large-Scale CME/Flare Current Sheet: I. Protons and Electrons

Bojing Zhu[1,2,3], Yan Li[1,2], and Jun Lin[1,2,3]
[1]Chinese Academy of Sciences, Yunnan Observatories, CAS, Kunming, China (bjzhu@ynao.ac.cn)
[2]Center for Astronomical Mega-Science, Chinese Academy of Sciences, Beijing, 100012, China
[3]University of Chinese Academy of Sciences, Beijing, 100049, China

Turbulence, the self-generated turbulence by plasmas and magnetic field collective interaction, has been found to play an essential role in energizing charged particles in the large-scale reconnecting current sheet in the major solar eruption.

The typical large-scale CME/Flare events involve sudden bursts of particle acceleration from the sudden release of magnetic energy in a few minutes to a few tens of minutes. The X-rays emission and gamma rays burst produced by the combined result from the interactions of electrons, hydrogen, helium, and other heavier ions. Space and laboratory researchers are more inclined to believe that turbulence acceleration is belonged to shock acceleration. Solar and astrophysics researchers are more inclined to believe that turbulence acceleration is an independent acceleration mechanism that belongs to the flare acceleration. The evidence in both theories and observations from solar atmosphere activities shows that the acceleration is related to nonlinear resonant wave-particle interaction (e.g., Landau acceleration). So far, many-particle acceleration models consider turbulence acceleration as an effective way of generating energetic electrons, protons, and heavier ions. However, the detailed role of turbulence in this process remains unclear. More effort needs to invest in looking into particle accelerations by turbulence that occurs over a large range of the scale in space from the inertial scale of individual particles to the MHD scale.

In this work, applying the statistical treatment of plasma physics, combing with filter theory of turbulence, the actual ratio of the proton mass to the electron mass, and mass-to-charge ratios, we investigate the interaction of charged particles with the turbulent electric field and magnetic field in the large-scale CME/flare current sheet by applying the

We found the significant Langmuir turbulence acceleration (LTA) through the nonlinear resonant wave-particle interaction in the diffusion region via tracking the trajectories and analyzing the energy spectrum of energetic protons and electrons. The results show that protons and electrons could be efficiently accelerated simultaneously and that the way of LTA is similar to that of the shock acceleration}} but is much more efficient than the shock acceleration. This indicates that

large-scale reconnection is a good candidate for the mechanism for the efficient acceleration of protons and electrons in the major solar eruption.

The acceleration of heavy ion considered Helium (3He/4He) and other heavy elements in 3He-rich flares burst would explore in the follow-up work series.

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