PARTICLE ACCELERATION IN SOLAR FLARES AND TERRESTRIAL SUBSTORMS

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Submitted 30 March 2015

ABSTRACT

High-energy non-thermal particles are produced during explosive energy-release phenomena in space and solar environments. Previous studies have established that magnetic reconnection can convert magnetic energy to not only power flows and heating but also to produce non-thermal energetic particles. However, significant signatures of high-energy particles are often found far away from the reconnection region (e.g., at the footpoints of flaring loops and in the inner regions of the terrestrial magnetosphere). The reconnection scenarios in solar flares and terrestrial substorms are special in the sense that the particle and energy fluxes on one side go into an open region (interplanetary space), whereas on the other side they go into a region of closed field lines, connected to a solid body, providing an obstacle to the fluxes and constraints on the particle and entropy content of closed magnetic flux tubes. Here we combine observations, simulations and theories to systematically study particle acceleration of flares and substorms with particular emphasis on the energetics. Specifically, we will focus on the following key unanswered questions:

1. How energies are partitioned between thermal and non-thermal particles in the key regions of solar flares and the Earth's magnetosphere?
2. How energies are transported (in the forms of Poynting, enthalpy and bulk kinetic energy fluxes) to the obstructions (i.e., flaring loops and the chromosphere, the dipole magnetosphere and the ionosphere)?

We limit our studies to the obstructed side of magnetic reconnection because of the larger amount of available data sets suitable for studies of energy spectra (i.e., flaring loops rather than ejecta/CMEs in the case of flares; near-Earth rather than distant-tail in the case of substorms). On the other hand, we allow ourselves the use of the generalized Lorentzian (including the kappa distribution) in addition to the conventional models of Maxwellian and/or power-law. As for terrestrial substorms, the questions will be addressed using datasets obtained *in-situ* in various regions of the Earth's magnetosphere (e.g., reconnection region, flow-braking region, inner magnetosphere). For example, we have established datasets from Geotail, Cluster, THEMIS/ARTEMIS and Van Allen Probes. We also expect to have the new MMS and ERG data, which will enhance the coverage of the Earth's magnetosphere. As for solar flares, we will use the established imaging/spectroscopic data from solar observatories such as RHESSI, Hinode, SDO and IRIS. While *in-situ* measurement can provide detailed information such as pitch angle distributions and energy spectra over large energy ranges, remote-sensing measurements can better provide large-scale contexts (including global evolutions) of particle acceleration. Thus, we combine and compare results from both fields so that an idea in one field may lead to a development of new idea in the other field. The synergetic and interdisciplinary nature of the study should ultimately advance understanding of the universal physics of explosive energy-release phenomena. To this end, we have assembled a team of data analysts, experimentalists, theoreticians and plasma simulators from both solar and magnetospheric communities, with complementary expertise to tackle the proposed focused questions of particle acceleration. The findings from the proposed investigations will be applicable to explosive energy-release phenomena in general. The insights gained thus will be relevant for other settings where explosive energy-release takes place such as other planetary magnetospheres and astrophysical objects.

Research domains: Solar Physics, Magnetospheric Physics