

Cosmic Particle Acceleration during Magnetic Explosions

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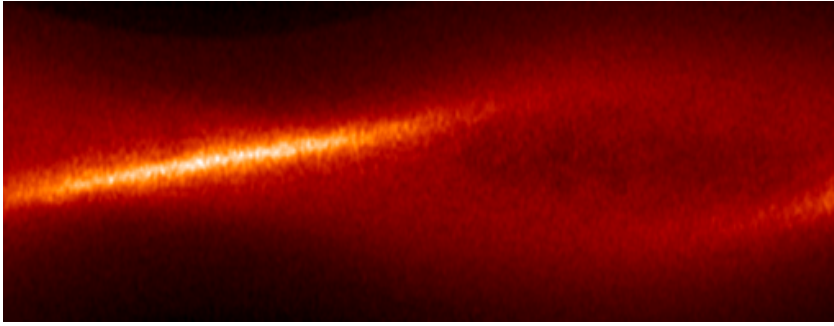
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For nearly four decades scientists have debated the mechanism governing the fast energy release seen in solar flares and magnetospheric storms as well as disruptions of laboratory fusion experiments. The thread connecting these diverse phenomena is magnetic reconnection, the primary mechanism by which magnetic energy is dissipated in the universe. Observations reveal that magnetic reconnection produces large numbers of very energetic electrons. A central issue in the discussion of the mechanism for electron heating and the release of magnetic energy has been the role of self-generated electric field fluctuations and their impact on the drag between electrons and ions, e.g. “anomalous resistivity”. Anomalous resistivity has been widely invoked as a catalyst for this “magnetic explosion” but its role has never been documented from observations or theory.

Computer simulations involving up to 500 million particles have now provided the first solid evidence that the generation of intense electric field fluctuations by reconnection can actually self-generate this enhanced resistivity. The electric fields take the form of “double layers”, localized regions where the electrons and ions of the plasma separate into regions of intense charge. These double layers are created by energetic streams of electrons generated during reconnection. As electrons pass through these localized layers they are scattered by the intense electric fields, producing the effective resistivity long expected.

Double layers have been widely observed by satellites in the auroral region of the ionosphere but up until now had not been definitively connected with magnetic reconnection. The strong electron scattering resulting from these localized fields becomes a candidate to explain the production of relativistic electrons observed in solar flares and other astrophysical systems.

Current



Electric Field

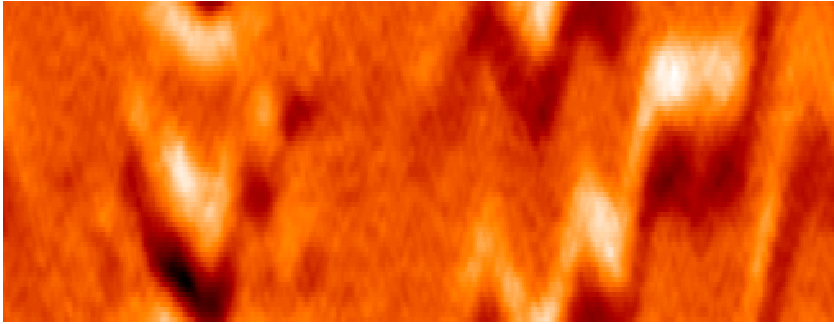


Figure 1: The top panel shows the strong electron flows (in the out-of-plane direction) generated during reconnection. The bottom panel shows the intense electric fields self-generated by the plasma in a plane perpendicular to that in the top figure and cutting through the region of strongest current. The adjacent regions of positive and negative polarity of the electric field are the signature of double layers.