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Dynamics of solar flares with microwave imaging spectroscopy[1]

GREGORY FLEISHMAN, New Jersey Institute of Technology

Release of magnetic energy due to reconnection is believed to drive such transient phenomena as solar flares, eruptions, and jets. This energy release should be associated with a decrease of the coronal magnetic field. Quantitative measurements of the evolving magnetic field strength in the corona are required to find out where exactly and with what rate this decrease takes place. The only available methodology capable of providing such measurements employs microwave imaging spectroscopy of gyrosynchrotron emission from nonthermal electrons accelerated in flares. Here, we report microwave observations of a solar flare, showing spatial and temporal changes in the coronal magnetic field at the cusp region; well below the nominal reconnection X point. The field decays at a rate of ˜5 Gauss per second for 2 minutes. This fast rate of decay implies a highly enhanced, turbulent magnetic diffusivity and sufficiently strong electric field to account for the particle acceleration that produces the microwave emission. Moreover, spatially resolved maps of the nonthermal and thermal electron densities derived from the same microwave spectroscopy data set allow us to detect the very acceleration site located within the cusp region. The nonthermal number density is extremely high, while the thermal one is undetectably low in this region indicative of a bulk acceleration process exactly where the magnetic field displays the fast decay. The decrease in stored magnetic energy is sufficient to power the solar flare, including the associated eruption, particle acceleration, and plasma heating. We discuss implications of these findings for understanding particle acceleration in solar flares and in a broader space plasma context.

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