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The Role of Magnetic Reconnection–associated Processes in Local Particle Acceleration in the Solar Wind

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Recent studies of unusual or atypical energetic particle flux events (AEPEs) observed at 1 au show that another mechanism, different from diffusive shock acceleration, can energize particles locally in the solar wind. The mechanism proposed by Zank et al. is based on the stochastic energization of charged particles in regions filled with numerous small-scale magnetic islands (SMIs) dynamically contracting or merging and experiencing multiple magnetic reconnection in the super-Alfvénic solar wind flow. A first- and second-order Fermi mechanism results from compression-induced changes in the shape of SMIs and their developing dynamics. Charged particles can also be accelerated by the formation of antireconnection electric fields. Observations show that both processes often coexist in the solar wind. The occurrence of SMIs depends on the presence of strong current sheets like the heliospheric current sheet (HCS), and related AEPEs are found to occur within magnetic cavities formed by stream–stream, stream–HCS, or HCS–shock interactions that are filled with SMIs. Previous case studies comparing observations with theoretical predictions were qualitative. Here we present quantitative theoretical predictions of AEPEs based on several events, including a detailed analysis of the corresponding observations. The study illustrates the necessity of accounting for local processes of particle acceleration in the solar wind.