Current sheets, magnetic islands and associated particle acceleration in the solar wind as observed by Ulysses near the ecliptic plane

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Recent studies of particle acceleration in the heliosphere have revealed a new mechanism that can locally energize particles up to several MeV/nuc. Stream-stream interactions as well as the heliospheric current sheet – stream interactions lead to formation of large magnetic cavities, bordered by strong current sheets (CSs), which in turn produce secondary CSs and dynamical small-scale magnetic islands (SMIs) of \textasciitilde 0.01 AU or less owing to magnetic reconnection. It has been shown that particle acceleration or re-acceleration occurs via stochastic magnetic reconnection in dynamical SMIs confined inside magnetic cavities observed at 1 AU. The study links the occurrence of CSs and SMIs with characteristics of intermittent turbulence and observations of energetic particles of keV-MeV/nuc energies at \textasciitilde 5.3 AU. We analyze selected samples of different plasmas observed by Ulysses during a widely discussed event, which was characterized by a series of high-speed streams of various origins that interacted beyond the Earth's orbit in January 2005. The interactions formed complex conglomerates of merged interplanetary coronal mass ejections, stream/corotating interaction regions and magnetic cavities. We study properties of turbulence and associated structures of various scales. We confirm the importance of intermittent turbulence and magnetic reconnection in modulating solar energetic particle flux and even local particle acceleration. Coherent structures, including CSs and SMIs, play a significant role in the development of secondary stochastic particle acceleration, which changes the observed energetic particle flux time-intensity profiles and increases the final energy level to which energetic particles can be accelerated in the solar wind.