Effects of local particle acceleration in the solar wind

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Recent observational and theoretical studies have shown that there is an unaccounted population of electrons and protons accelerated locally to suprathermal energies at reconnecting current sheets (RCSs) and 3-D dynamical plasmoids or 2-D magnetic islands (MIs) in the solar wind. The findings can be summarized as following: (i) RCSs are often subject to instabilities breaking those into 3D small-scale plasmoids/blobs or 2D magnetic islands (MIs) with multiple X- and O-nullpoints; (ii) RCSs and dynamical MIs can accelerate particles up to the MeV/nuc energies; (iii) accelerated particles may form clouds expanding far from a reconnecting region; and (iv) bi-directional(or counterstreaming) strahls observed in pitch-angle distributions (PADs) of suprathermal electrons may simply represent a signature of magnetic reconnection occurring at closed IMF structures (e.g., MIs), not necessarily connected to the Sun (Zharkova & Khabarova, 2012, 2015; Zank et al. 2014, 2015; Khabarova et al. 2015, 2016, 2017; 2018; le Roux 2016, 2017, 2018, 2019; Khabarova & Zank, 2017; Adhikari et al. 2019; Xia & Zharkova, 2018, 2020; Malandraki et al. 2019; Mingalev et al. 2019). We will briefly present an overview of the effects of local ion acceleration as observed at different heliocentric distances and focus on the impact of the locally-borne population of suprathermal electrons on typical patterns of PADs.

Suprathermal electrons with energies of ~70eV and above are observed at 1 AU as dispersionless halo and magnetic field-aligned beams of strahls. For a long time, it has been thought that both populations originate only from the solar corona. This view has consequently impacted interpretation of typical patterns of suprathermal electron PADs observed in the solar wind. We present multi-spacecraft observations of counterstreaming strahls and dropouts in PADs within a previously reported region filled with plasmoids and RCSs, comparing observed PAD features with those predicted by PIC simulations extended to heliospheric conditions. We show typical features of PADs determined by acceleration of the ambient thermal electrons up to suprathermal energies in single RCSs and dynamical plasmoids. Our study suggests that locally-accelerated suprathermal electrons co-exist with those of solar origin. Therefore, some heat flux dropout and bi-directional strahl events observed in the heliosphere can be explained by local dynamical processes involving magnetic reconnection. Possible implications of the results for the interpretation of the strahl/halo relative density change with heliocentric distance and puzzling features of suprathermal electrons observed at crossings of the heliospheric current sheet and cometary comas are also discussed.