Geophysical Research Abstracts
Vol. 21, EGU2019-18929, 2019
EGU General Assembly 2019

Latest Developments in Energetic Particle Acceleration by Contracting and Reconnecting Small-scale Flux-ropes in the Inner Heliosphere

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Recent observations near 1 AU suggest that dynamic small-scale magnetic flux-ropes (SMFRs) occur much more commonly than previously thought (Zheng et al. 2018), especially near reconnecting primary heliospheric current sheets (e.g., Khabarova et al. 2015, 2016). Furthermore, enhanced energetic particle fluxes are often observed to coincide with regions of active SMFRs, suggesting efficient energetic particle acceleration by these structures (e.g., Zank et al. 2015; Khabarova and Zank 2017). However, these are large-scale observations, while fully kinetic simulations are too limited currently in their spatial domain to model energetic particle acceleration by SMFRs on such scales, pointing to the need for the development of a kinetic transport theory. Considerable progress was made to interpret particle acceleration by SMFRs in kinetic particle simulations using guiding-center kinetic theory concepts (e.g., Drake et al. 2006, 2013) but, until recently, a guiding-center theory based large-scale kinetic transport theory that unify all the different SMFR acceleration mechanisms did not exist. In response, Zank et al. (2014) developed a kinetic focused transport equation based on simplified guiding center theory involving adiabatic invariants, focusing mainly on acceleration by the mean SMFR fields. This was followed by le Roux et al. (2015, 2018) that developed a non-linear kinetic focused transport equation based directly on guiding center kinetic theory which distinguishes between acceleration by the mean and by the variance in the SMFR fields. In this talk we plan to: (i) provide a brief overview of the different SMFR acceleration mechanisms unified in our kinetic focused transport theories, (ii) discuss examples of analytical solutions of our focused transport equations that show promise in reproducing large-scale observations of energetic ion flux enhancements and accelerated spectra near inner heliospheric primary current sheets and, (iii) discuss progress made in drawing conclusions which SMFR acceleration mechanisms are most likely to reproduce large-scale observations.