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Solar Energetic Particle transport along meandering interplanetary magnetic field lines

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Recent multi-spacecraft Solar Energetic Particle (SEP) observations have challenged the traditional view of SEP production and interplanetary transport. In several events, the SEP intensities rise fast even at 180 degree longitudinal distance from the flare location. For many events the anisotropy of the SEPs has been found to depend on the observer's longitude, being stronger at locations that are well magnetically connected to the assumed SEP source region, as compared to wider longitudinal reaches. This suggests that interplanetary transport is an important factor for the SEP cross-field extent. The traditional modelling approach, with diffusive cross-field propagation, however, requires diffusion across the mean magnetic field much faster than that supported by current theories. We study the temporal and spatial evolution of SEP intensities and anisotropy using a new SEP transport model, FP+FLRW, which incorporates field-line random walk (FLRW) into the Fokker-Planck (FP) transport modelling framework. The FP+FLRW model was introduced by Laitinen et al (2013), who found using full-orbit simulations that the cross-field propagation of particles early in an SEP event is not diffusive, but dominated by deterministic propagation along stochastically meandering turbulent field-lines. We have extended the FP+FLRW model to a Parker spiral geometry, and show that it is able to reproduce the observed fast access of SEPs to a wide range of longitudes. The observed Gaussian shaped distribution of peak intensities versus longitude, having a sigma=30-50 degrees, is reproduced already for a narrow source region, while using realistic interplanetary transport conditions. We compare the anisotropy evolution of an SEP event given by the FP+FLRW model to that given by the traditional FP approach, and discuss the implications of our findings for the SEP event origins, source width and the role of interplanetary turbulence in the interpretation of the SEP observations.