Fokker-Planck Modelling of Solar Wind Electron Velocity Distributions: Diffusive Transport vs. Ballistic Effects

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Résumé

In this work, we model electron transport in the interplanetary medium using the Focused Transport Equation (FTE), a gyrophase-averaged kinetic equation which takes the form of a Fokker-Planck equation. Our model accounts for magnetic focussing in a Parker-spiral magnetic field, the interplanetary ambipolar electric potential, and angular diffusion by Coulomb collisions and/or other turbulent mechanisms associated with magnetic field fluctuations. Motivated by measurements of non-thermal features by Parker Solar Probe and Solar Orbiter, such as the sunward electron deficit, we solve the FTE using the newly developed Solar Wind Electron Energisation and Transport (SWEET) code and reconstruct the radial evolution of the electron Velocity Distribution Functions (VDFs). We compare different transport regimes of solar wind electrons subject to a Parker-spiral magnetic field and an ambipolar electric potential. First, we study a collisionless regime and cross-check our simulation results with the Liouville analytical solutions typical of the exospheric approach. Second, we introduce pitch-angle diffusion driven by Coulomb collisions and show how they modify the VDFs, isotropising the thermal core and smoothing the sunward electron deficit with respect to the collisionless solution. Finally, we introduce turbulent scattering caused by magnetic field fluctuations and show how it is responsible for the appearance of an isotropic electron halo population at high energies.

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