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Methodology for calculation of radial diffusion coefficients for a relativistic electron population from hybrid-Vlasov simulation

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The relative importance of radial diffusion and local acceleration to the dynamics of outer radiation belt electron populations is an open question in radiation belt physics. A key component of this discussion is the calculation of the radial diffusion coefficients, which quantify the effect of radial diffusion on an electron population. However, there is currently a broad range of radial diffusion coefficient values in the literature, which presents difficulties when determining the dominant process governing radiation belt energisation. Here we develop a methodology for the calculation of radial diffusion coefficients using Vlasiator, a 5D hybrid-Vlasov simulation of near-Earth space, and calculate the radial diffusion coefficients for a 10 MeV electron population at multiple locations within the outer radiation belt.

Vlasiator currently models ions as velocity distribution functions and electrons as a magnetohydrodynamic fluid, so the drift motion of the electron population can not be directly studied. However, the ion dynamics accurately determine the magnetic field in the inner magnetosphere, and the spatial and temporal magnetic field variations can be used to calculate the radial diffusion coefficient of a population according to principles outlined in Lejosne et. al. 2020. Four magnetic field isocontours in the outer radiation belt are used to model the guiding centre drift contours of an electron population, and the corresponding Roederer L-star coordinates are calculated from the magnetic flux through each of these drift contours. The variation of the L-stars over time are calculated from population-specific variables and the Lagrangian magnetic field time derivative along the magnetic isocontours. The radial diffusion coefficients for the 10 MeV electron population are then calculated at each of these L-stars and compared to the literature. This methodology produces radial diffusion coefficients from Vlasiator that have the expected L-shell dependence and are consistent with the literature, including studies based on satellite measurements of radiation belt electrons. These results indicate that this is a valid methodology for the calculation of radial diffusion coefficients, and can therefore be extended to evaluate the radial diffusion coefficients in different solar wind conditions and at

more L-stars.