In 2020 May-June, six solar energetic ion events were observed by the Parker Solar Probe/ISoIS instrument suite at ~0.35 AU from the Sun. From standard velocity-dispersion analysis, the apparent ion path length is ~0.625 AU at the onset of each event. We develop a formalism for estimating the path length of random-walking magnetic field lines, to explain why the apparent ion path length at event onset greatly exceeds the radial distance from the Sun for these events. We developed analytical estimates of the average increase in path length of random-walking magnetic field lines, relative to the unperturbed mean field. Both a simple estimate and a rigorous theoretical formulation are obtained for field-lines’ path length increase as a function of path length along the large-scale field. Monte Carlo simulations of field line and particle trajectories in a model of solar wind turbulence are used to validate the formalism and study the path lengths of particle guiding-center and full-orbital trajectories. From these simulated trajectories, we find that particle guiding centers can have path lengths somewhat shorter than the average field line path length, while particle orbits can have substantially larger path lengths due to their gyromotion with a nonzero effective pitch angle. The formalism is also implemented in a global solar wind model, and results are compared with ion path lengths inferred from ISoIS observations. The long apparent pathlength during these solar energetic ion events can be explained by 1) a magnetic field line path length increase due to the field line random walk, and 2) particle transport about the guiding center with nonzero effective pitch angle due to pitch angle scattering. This research partially supported by the PSP /ISOIS project.
