Random Walk and Trapping of Interplanetary Magnetic Field Lines: 
Global Simulation, Magnetic Connectivity, and Implications for Solar 
Energetic Particles

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The random walk of magnetic field lines is an important ingredient in understanding how the 
connectivity of the magnetic field affects the spatial transport and diffusion of charged particles. 
As solar energetic particles (SEPs) propagate away from near-solar sources, they interact with the 
fluctuating magnetic field, which modifies their distributions. We develop a formalism in which the 
differential equation describing the field line random walk contains both effects due to localized 
magnetic displacements and a non-stochastic contribution from the large-scale expansion. We use 
this formalism together with a global magnetohydrodynamic simulation of the inner-heliospheric 
solar wind, which includes a turbulence transport model, to estimate the diffusive spreading of 
magnetic field lines that originate in different regions of the solar atmosphere. We first use this 
model to quantify field line spreading at 1 au, starting from a localized solar source region, and 
find rms angular spreads of about 20 – 60 degrees. In the second instance, we use the model to 
estimate the size of the source regions from which field lines observed at 1 au may have 
originated, thus quantifying the uncertainty in calculations of magnetic connectivity; the angular 
uncertainty is estimated to be about 20 degrees. Finally, we estimate the filamentation distance, 
i.e., the heliocentric distance up to which field lines originating in magnetic islands can remain 
strongly trapped in filamentary structures. We emphasize the key role of slab-like fluctuations in 
the transition from filamentary to more diffusive transport at greater heliocentric distances. This 
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