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Magnetic Field Line Random Walk in Isotropic Turbulence at Very High Kubo Number

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Most of the field line random walk (FLRW) theories proposed in the past were strongly influenced by studies of the limit of weak fluctuations. In this limit, the behavior of the FLRW can be characterized by the Kubo number $R = (b/B_0)(\ell_{\|}/\ell_{\perp})$, where b is the root mean squared fluctuation, $\ell_{\|}$ and $\ell_{\perp}$ are turbulence coherence scales parallel and perpendicular to the mean field B_0, respectively. In the case of $R \ll 1$, a quasi-1D limit, all theories and computer simulations agree that the FLRW is quasilinear. In the case of $R \gg 1$, a quasi-2D limit, there are strong trapping effects in which some field lines are trapped in topological structures. Then the Corrsin-based theory is less accurate. To study the FLRW at high R, while avoiding the topological effects in the quasi-2D limit at high R, we examine different versions of Corrsin-based theory in the limit $R \to \infty$ by taking $B0 \to 0$ for finite b instead of taking $\ell_{\|}/\ell_{\perp} \to \infty$. Naturally, with $B_0 = 0$, the FLRW is completely isotropic. We test the theory by performing computer simulations of the FLRW. All Corrsin-based theoretical results agree with simulation results for the FLRW at $B_0 = 0$ ($R = \infty$). We conclude that the applicability of Corrsin-based theories is limited not by high R, but by quasi-two-dimensionality.

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