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Stochastic Flux-Freezing and Fast Magnetic Reconnection GREGORY L. EYINK, The Johns Hopkins University — The convention that magnetic field-lines are "frozen-in" to an MHD plasma is based on the Alfven Theorem, which holds only for smooth, laminar solutions of ideal MHD. In the presence of resistivity, the motion of field-lines is instead naturally regarded as stochastic and can be represented by a path-integral formula. When the plasma is also turbulent and the velocity is "rough"—with a Kolmogorov-type energy spectrum—then the line-motion remains stochastic even for a tiny resistivity. This "spontaneous stochasticity" is due to the properties of turbulent 2-particle (Richardson) diffusion. Two plasma elements starting on the same magnetic field-line will lie on two distinct field lines, very far apart, a short time later. Charged particles spiral along magnetic field lines, but electric fields arise in the rest frame of the plasma to balance drag forces from collisions. These electric fields cause slight shifts in field-line attachments that are explosively amplified by turbulent 2-particle diffusion. Flux-freezing thus fails in the standard sense and only holds stochastically in a turbulent plasma at high magnetic and kinetic Reynolds numbers. As an application, we consider the problem of large-scale magnetic reconnection. Replacing resistive diffusion in the laminar Sweet-Parker solution by turbulent Richardson diffusion recovers the Lazarian-Vishniac theory of fast magnetic reconnection

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