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Indeterminism in Classical Dynamics of Particle Motion GREGORY EYINK, The Johns Hopkins University, ETHAN VISHNIAC, University of Saskatchewan, CRISTIAN LALESCU, The Johns Hopkins University, HUSSEIN ALUIE, Los Alamos National Laboratory, KALIN KANOV, RANDAL BURNS, CHARLES MENEVEAU, ALEX SZALAY, The Johns Hopkins University — We show that "God plays dice" not only in quantum mechanics but also in the classical dynamics of particles advected by turbulent fluids. With a fixed deterministic flow velocity and an exactly known initial position, the particle motion is nevertheless completely unpredictable! In analogy with spontaneous magnetization in ferromagnets which persists as external field is taken to zero, the particle trajectories in turbulent flow remain random as external noise vanishes. The necessary ingredient is a rough advecting field with a power-law energy spectrum extending to smaller scales as noise is taken to zero. The physical mechanism of "spontaneous stochasticity" is the explosive dispersion of particle pairs proposed by L. F. Richardson in 1926, so the phenomenon should be observable in laboratory and natural turbulent flows. We present here the first empirical corroboration of these effects in high Reynolds-number numerical simulations of hydrodynamic and magnetohydrodynamic fluid turbulence. Since power-law spectra are seen in many other systems in condensed matter, geophysics and astrophysics, the phenomenon should occur rather widely. Fast reconnection in solar flares and other astrophysical systems can be explained by spontaneous stochasticity of magnetic field-line motion

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