Abstract Submitted
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The Cascade of Circulations in Fluid Turbulence G. EYINK, H. ALUIE, Johns Hopkins Univ. — Kelvin's Theorem (1869) on conservation of circulations is an essential ingredient of G. I. Taylor's theory of turbulent energy dissipation by vortex-line stretching. We have proposed [1] a novel physical effect—a "cascade of circulations"—that leads to breakdown of circulation conservation in high Reynolds-number turbulence. Our theory is based upon an effective equation for large-scale "coarse-grained" velocity, which contains a turbulence-induced "vortex-force" that can violate Kelvin's Theorem. We show that singularities of sufficient strength, which exist in turbulent flow, can lead to non-vanishing dissipation of circulation for an arbitrarily small filtering length. This result is an analogue for circulation of Onsager's theorem on energy dissipation for singular Euler solutions. The physical mechanism of the breakdown of Kelvin's Theorem is diffusion of lines of large-scale vorticity out of the advected loop. This phenomenon is a classical analogue of Josephson-Anderson phase-slip in superfluids due to quantized vortex lines. We use locality of the circulation cascade to develop concrete expressions for the turbulent vortex-force by a multi-scale gradient-expansion. We point out a related cascade of magnetic-flux in magnetohydrodynamic (MHD) turbulence and its possible role for fast magnetic reconnection in astrophysics [2]. Supported by NSF grant # ASE-0428325 at Johns Hopkins University. [1] G. L. Eyink, Comptes Rendus Physique, 7: 449-455 (2006). physics/0605014; Phys. Rev. E, submitted (2006). physics/0606159 [2] G. L. Eyink & H. Aluie, Physica D, submitted (2006). physics/0607073

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