

Abstract Submitted
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Is the Kelvin Theorem Valid for High-Reynolds-Number Turbulence? M. WAN, Z. XIAO, S. CHEN, G. EYINK, Johns Hopkins Univ. — The Kelvin-Helmholtz theorem on conservation of circulations is supposed to hold for ideal inviscid fluids and is believed to play a crucial role in turbulent phenomena, such as production of dissipation by vortex line-stretching. However, this expectation does not take into account singularities in turbulent velocity fields at infinite Reynolds number. Recent theory [1,2] predicts a “cascade of circulations” due to the vortex-force induced by small-scale (subgrid) turbulence. We present evidence from a numerical simulation of the three-dimensional turbulent energy cascade [3] both for instantaneous violation of circulation conservation (non-zero time-derivative) and also for violation over finite intervals of time, by Lagrangian tracking of material loops. Although violated in individual realizations, we find that the circulations are still conserved in some average sense. For comparison, we show that Kelvin’s theorem holds for individual realizations in the two-dimensional enstrophy cascade, in agreement with theory. We also verify quantitative expressions for the turbulent vortex-force, predicted by a multi-scale gradient expansion [2]. Our results provide the first clear evidence for breakdown of Kelvin’s theorem (1869) in turbulent flow. Supported by NSF grant # ASE-0428325 at the Johns Hopkins University. [1] G. L. Eyink, *Comptes Rendus Physique*, 7: 449-455 (2006). physics/0605014 [2] G. L. Eyink, *Phys. Rev. E*, submitted (2006). physics/0606159 [3] S. Chen et al., *Phys. Rev. Lett.*, submitted (2006). physics/0605016

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