Universal constants and equations of turbulent motion

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(Submitted on 25 Jul 2011 (v1), last revised 28 Sep 2011 (this version, v2))

In the spirit of Prandtl's conjecture of 1926, for turbulence at high Reynolds number we present an analogy with the kinetic theory of gases, with dipoles made of quasi-rigid and 'dressed' vortex tubes as frictionless, incompressible but deformable quasi-particles. Their movements are governed by Helmholtz' elementary vortex rules applied locally. A contact interaction or 'collision' leads either to random scatter of a trajectory or to the formation of two likewise rotating, fundamentally unstable whirls forming a dissipative patch slowly rotating around its center of mass which is almost at rest. This approach predicts von Karman's constant as 1/sqrt(2 pi) = 0.399 and the spatio-temporal dynamics of energy-containing time and length scales controlling turbulent mixing [Baumert 2009]. A link to turbulence spectra was missing so far. In the present paper it is shown that the above image of random vortex-dipole movements is compatible with Kolmogorov's turbulence spectra if dissipative patches, beginning as two likewise rotating eddies, evolve locally into a space-filling bearing in the sense of Herrmann [1990], i.e. into an "Apollonian gear". Its parts and pieces are incompressible and flexibly deformable vortex tubes which are frictionless, excepting the dissipative scale of size zero. For steady and locally homogeneous conditions our approach predicts the dimensionless pre-factor in the 3D Eulerian wavenumber spectrum as [(4 pi)^2/3]/3 = 1.8, and in the Lagrangian frequency spectrum as 2. Our derivations rest on geometry, methods from many-particle physics, and on elementary conservation laws.

Comments:	18 pages, 8 figures, 63 references submitted to physics.fllu-dyn
Subjects:	**Fluid Dynamics (physics.flu-dyn)**; Mathematical Physics (math-ph); Chaotic Dynamics (nlin.CD); Atmospheric and Oceanic Physics (physics.ao-ph); Classical Physics (physics.class-ph)
Cite as:	**arXiv:1107.5305v2 [physics.flu-dyn]**

Submission history

From: Helmut Z. Baumert [view email]

[v1] Mon, 25 Jul 2011 23:02:59 GMT (1219kb,D)