12th International Couette-Taylor Workshop, September 6-8, 2001, Evanston, IL USA

THE LEGACY OF G. I. TAYLOR

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Abstract

G. I. Taylor's classic 1923 paper [1] was the first to directly compare a laboratory experiment to a specific prediction from the Navier-Stokes equation for instability in any fluid flow. Many eminent fluid dynamicists had attempted earlier without success to predict the point of instability for flows in various geometries, and some had come to doubt that a quantitative comparison of theory and experiment would ever be possible. After careful thought, Taylor chose the concentric cylinder geometry, and in a preliminary experiment he discovered that axisymmetric vortices form as the rotation rate of the inner cylinder was increased. He then conducted a linear stability analysis of the base (Couette) flow. To test the theoretical predictions, he designed a very clever experiment that took into account subtleties often overlooked by subsequent experimentalists. Taylor found remarkable agreement (within a few percent) between theory and experiment for a wide range of co-rotating and counter-rotating cylinder speeds, and for different radius ratios. This tour de force study provided a definitive demonstration of the validity of the Navier-Stokes equations and the no-slip boundary conditions. Some two thousand papers have subsequently been published on the Couette-Taylor problem, and the present conference testifies to the continuing legacy of G.I. Taylor's work. I have been conducting experiments of the Couette-Taylor system since 1975 [2], and I am still fascinated [3-6] by this very rich system. This talk will conclude by describing Taylor's research philosophy and by mentioning some of his other pioneering contributions, including Taylor columns in rapidly rotating fluids (Taylor-Proudman theorem); the Rayleigh-Taylor instability of an interface of a dense fluid above a less dense fluid; Saffman-Taylor fingering of an interface of a less viscous fluid invading a more viscous fluid; turbulence (Taylor microscale and Taylor's frozen turbulence hypothesis); and gas bubbles in a fluid with an electric field. (Supported by the Office of Naval Research)

References

[1] G. I. Taylor, “Stability of a viscous liquid contained between two rotating cylinders”,' Phil. Trans. Roy. Soc. London A 223, 289 (1923).
[2] J.P. Gollub and H.L. Swinney, “Onset of turbulence in a rotating fluid”, Phys. Rev. Lett. 35, 927 (1975).
[3] G. S. Lewis and H. L. Swinney, “Velocity structure functions, scaling, and transitions in high Reynolds number Couette-Taylor flow”, Phys. Rev. E 59, 5457 (1999).
[4] Z. She, K. Ren, G. S. Lewis, and H. L. Swinney, “Scalings and structures in turbulent Couette-Taylor flow”, submitted.
[5] C. Beck, G. S. Lewis, and H. L. Swinney, “Measuring non-extensitivity parameters in a turbulent Couette-Taylor flow”, Phys. Rev. E 63, 035303 (R), 1-4 (2001).
[6] K. Coughlin, F. Hamill, P. Marcus, and H. L. Swinney, “Turbulent bursts in Couette-Taylor flow”, submitted.