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Viscous vortex rings with axial symmetry

Abstract

A three-dimensional incompressible flow is called a vortex ring if the associated vorticity distribution is concentrated in a solid torus, so that the fluid particles spin around an imaginary line that forms a closed loop. Such flows are ubiquitous in nature, and appear to be very stable. For the Euler equations with axial symmetry, a large family of uniformly translating vortex rings can be constructed by variational techniques. In the viscous case, we show that the Navier–Stokes equations have a unique axisymmetric solution without swirl if the initial vorticity is a circular vortex filament with arbitrarily large Reynolds number. The solutions constructed in this way are archetypal examples of viscous vortex rings, and can be thought of as axisymmetric analogues of the self-similar Lamb–Oseen vortices in two-dimensional flows. This talk is based on a joint work with Vladimir Sverak (Minneapolis).