AME 530B: Incompressible Fluids: Vorticity Dynamics

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Class meetings: MW 11:00-12:20

The course will focus primarily on the vorticity formulation of the Euler equations for incompressible fluid dynamics. First we will introduce the concept of vorticity and describe the Hamiltonian structure of the inviscid Euler equations. The high Reynolds number limit of the Navier-Stokes equations and its relation to the Euler equations will be discussed. In two-dimensions, we will describe the point-vortex discretization of the Euler equations and the resulting nonlinear dynamical system governing their evolution. We will focus on the equations for vortex arrays, as exhibited most cleanly in superfluid helium where there is no viscosity. We will also describe 'desingularized' models, including vortex patches. In three-dimensions, we will describe the local induction approximation (LIA) of the Biot-Savart law, the Da Rios-Betchov system, the vortex ring equations, and interacting vortex filament models. If time permits, we will introduce the statistical formulation of the vorticity equations in two-dimensions, treating point-vortices as 'atomic' elements from which continuum theories based on averaging can be derived.

Grades will be based on class projects assigned to students near the beginning of the semester.

Books:

The N-Vortex Problem: Analytical Techniques, P.K. Newton, Springer-Verlag 2001
Vortex Dynamics, P.G. Saffman, Cambridge Press 1992