MAE Seminar

Potential Flows are Solutions of the Navier-Stokes Equations

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Abstract

They are needed to satisfy the boundary conditions like the no-slip condition on a rigid body. The role of the potential flows in Navier-Stokes theory can be formulated in terms of the Helmholtz decomposition. Boundary conditions cannot be satisfied by irrotational flows alone; both are required and they are tightly coupled. The boundary conditions in the exact theory are different than the no penetration condition for purely irrotational flows; Robin conditions in which a linear sum of Neumann and Dirichlet conditions should be considered. Purely irrotational theories of the flow of viscous fluids give excellent approximations to flows with small vorticity and large viscosity. The pressure is not continuous at a free surface as is assumed in hundreds of papers since Euler. The normal stress is continuous and it contains an irrotational viscous contribution. All the solutions of free surface problems for inviscid solutions can be improved by including the viscous term in the normal stress balance. Another irrotational approximation to the flow of a viscous fluid is based on the Dissipation method introduced by Stokes. In the case of capillary-gravity waves The assumption that the potential energy is one-half the kinetic energy, which is true for inviscid fluid, is flawed and greatly restricts the kind of results which have been obtained heretofore. Especially interesting results arise from the analysis of particle motions in potential flows of viscoelastic fluids. The peculiar facts about micro structural arrangements of particles, which are the opposite of the arrangements in Newtonian fluids, can be explained by change in the sign of the normal stress from compression to tension.

Biosketch

Daniel D. Joseph is a Regents Professor Emeritus and a Russell. J. Penrose Professor Emeritus at the University of Minnesota, as well as a Distinguished Adjunct Professor at the University of California, Irvine and Honorary Professor at Xi'an Jiaotong University. He is a member of the National Academy of Engineering, National Academy of Sciences, and the American Academy of Arts and Sciences; he is a Fellow of the American Physical Society and he is one of the Thompson Science Highly Cited Researchers. Dr. Joseph holds ten patents, has authored six books and has received numerous accolades including the Fluid Dynamics Prize of the APS, Timoshenko Medalist of the ASME, Bingham Medalist of the Society of Rheology, G.I. Taylor Medalist, Society of Engineering Science, Thomas Baron Fluid-particle Systems Award of the AIChE and Shell. His current research interests include exceptional properties of semi-diluted solutions of nanoparticle laden polymers in water, irrotational motion of viscous and viscoelastic fluids and particle motions in fluid surfaces.

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Refreshments will be provided

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