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The Hamiltonian description of incompressible fluid ellipsoids
P.J. MORRISON, University of Texas at Austin, N.R. LEBOVITZ, University of Chicago, J.A. BIELLO, University of California at Davis — We construct the noncanonical Poisson bracket associated with the phase space of first order moments of the velocity field and quadratic moments of the density of a fluid with a free-boundary, constrained by the condition of incompressibility. Two methods are used to obtain the bracket, both based on Dirac's procedure for incorporating constraints. First, the Poisson bracket of moments of the unconstrained Euler equations is used to construct a Dirac bracket, with Casimir invariants corresponding to volume preservation and incompressibility. Second, the Dirac procedure is applied directly to the continuum, noncanonical Poisson bracket that describes the compressible Euler equations, and the moment reduction is applied to this bracket. When the Hamiltonian can be expressed exactly in terms of these moments, a closure is achieved and the resulting finite-dimensional Hamiltonian system provides exact solutions of Euler's equations. This is shown to be the case for the classical, incompressible Riemann ellipsoids, which have velocities that vary linearly with position and have constant density within an ellipsoidal boundary. The incompressible, noncanonical Poisson bracket differs from its counterpart for the compressible case in that it is not of Lie-Poisson form.

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