The dynamics of elliptically shaped regions of uniform vorticity in time-periodic, linear external velocity fields

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Received 09-APR-93
in revised form 25-JUL-94

In this paper we extend results of Kida (J. Phys. Soc. Japan 50 (1981) 3517) and Neu (Phys. Fluids 27 (1984) 2397) on the dynamics of elliptically shaped regions of uniform vorticity in external linear velocity fields. The work of Kida and Neu was concerned with time-independent external linear velocity fields and we consider the case in which the linear external linear velocity fields may be time-periodic. We derive a Hamiltonian formulation for such problems in such a way that a study of the problem can be reduced to the study of a two-dimensional, area preserving Poincare map. In this way techniques from dynamical systems theory such as KAM theory and the subharmonic and homoclinic Melnikov methods can be used. With these techniques we show the existence of a variety of new solutions to the two-dimensional Euler equations on an unbounded domain; these include vortex motions that are temporally quasiperiodic, in subharmonic resonance with the linear external velocity field, and chaotic in the sense of Smale horseshoes. We give physical interpretations of these motions in terms of exchanges of energy between different components of the total excess kinetic energy of the flow field.

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