FM23L_11660

XXI International Congress of Theoretical and Applied Mechanics
Warsaw, Poland, August 15–21, 2004

Particle Transport by a Vortex Soliton

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Motions of fluid particles advected by a vortex soliton are studied. In the moving frame which makes the vortex soliton steady in space, particle motions are confined in a torus near the loop for a wide range of three parameters that characterize the shape and strength of the vortex soliton. The transported volume is obtained numerically as a function of these parameters. The product of the volume and the translational velocity of the soliton provides the rate of transport. By calculating this quantity, the optimized shape of the soliton for the maximum rate of transport is considered. The torus is composed of groups of invariant surfaces around periodic trajectories. Similar phenomena are observed with the KAM tori for non-integrable Hamiltonian systems. To extract the essential mechanism of the transport properties, an ODE model is proposed, which is named the chopsticks model. This model explains the qualitative features of the transport.

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