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Nonlinear Schrödinger equation for low-vorticity waves in deep water

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The nonlinear Schrödinger (NLS) equation describing the propagation of weakly rotational wave packets in an infinitely deep fluid in Lagrangian coordinates has been derived. The vorticity is assumed to be an arbitrary function of the Lagrangian coordinates and quadratic in the small parameter proportional to the wave steepness. The vorticity effects manifest themselves in a shift of the wave number in the carrier wave and in variation in the coefficient multiplying the nonlinear term. In the case of vorticity dependence on the vertical Lagrangian coordinate only (the Gouyon waves), the shift of the wave number and the respective coefficient are constant. When the vorticity is dependent on both Lagrangian coordinates, the shift of the wave number is horizontally inhomogeneous. There are special cases (e.g., Gerstner waves or subclass of Guyon waves) in which the vorticity is proportional to the squared wave amplitude and nonlinearity disappears, thus making the equations for wave packet dynamics linear. It is shown that the NLS solution for weakly rotational waves in the Eulerian variables may be obtained from the Lagrangian solution by the simply changing the horizontal coordinates.

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