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Stability and horizontal mixing in shear shallow flows

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In the natural environment most large-scale flows in rivers and coastal areas can be considered as shallow, i.e. the horizontal length scales of the flow domain are much larger than the depth. In shallow waters the flows are considered as two-dimensional, they are highly affected by bottom friction and are subjected to lateral shear like in mixing layers, wakes and jets. Shallow free shear flows are a combination of a plane shear flow and open channel flow, which makes them interesting from the theoretical point of view and complicated when it comes to mathematical modeling.
Open channel flows of ideal incompressible fluid with velocity shear in the long wave approximation are considered. Nonlinear integrodifferential models of shallow flow with continuous velocity distribution are derived. A distinctive feature of integrodifferential models is the presence of both discrete and continuous spectrum of characteristic velocities. This is due to the fact that disturbances in flows are transmitted through the surface waves and lateral shear. Necessary and sufficient conditions of generalized hyperbolicity for the equations of motion are formulated. Stability of shear flows in terms of hyperbolicity of the governing equations is studied.
The concepts of sub- and supercritical flows are introduced for the model describing the steady-state horizontal-shear shallow flows of an ideal incompressible fluid with a free boundary in a channel of variable cross-section. Internal structure of flow developed in a local channel contraction or expansion is analyzed. Continuous and discontinuous exact solutions describing different flow regimes are constructed and their properties are studied. Analytical solutions for flows with the formation of recirculation zones are obtained.
A mathematical model describing the nonlinear stage of the Kelvin–Helmholtz instability of shallow shear flows is derived. The interaction of two streams of different velocities and the subsequent development of the horizontal mixing layer is considered.
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