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Vortical coastal currents

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There are many flows in nature in which anomalous fluid enters a larger body of fluid from a confined source region located on the boundary. Examples include river outflows discharging into the coastal ocean and flows through narrow straits into larger oceans. Often the source fluid has anomalous vorticity which causes the source fluid to propagate along the boundary away from the source region driven by its image in the boundary. When the vorticity of the current is constant and the receiving fluid is quiescent, contour dynamics has been used to study the evolution of such vorticity driven currents, and with applications to coastal currents in mind, their interaction with topography in the form of escarpments, seamounts and canyons has been studied.

In this talk two exact solutions are derived for fully nonlinear uniform vortex layers adjacent to solid boundaries. The first solution describes the steady flow of fluid with uniform vorticity from a point source (or sink) against an infinitely long wall. Contour dynamics is used to demonstrate that the steady solution represents the large-time limit of an unsteady problem in which fluid of uniform vorticity is expelled from a line source against a wall. The second geometry is that of a vortex source-sink pair against a wall. The exact nonlinear solution is derived using similar methods to the first problem. Contour dynamics establishes the stability of the solution. If the bubble of fluid has greater area than that of the equilibrium shape, contour dynamics shows that excess fluid is shed and the shape approaches that of equilibrium.

The linear stability of these fully nonlinear vortex flows is also described analytically.