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Stability and evolution of uniform-vorticity dipoles

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Using an iterative algorithm, a family of stationary two-dimensional vortical dipoles is constructed, including translational (symmetric and asymmetric about the translation axis) and orbital (i.e. moving in circles) dipoles. The patches of uniform vorticity comprising a dipole possess symmetry about the axis passing through their centroids and are, generally, unequal in area and absolute value of vorticity. The solutions are discriminated by three parameters, the ratio of the areas of individual vortices, the ratio of their vorticities, and the separation between the centroids of the patches. The dipole stability and evolution of unstable states are studied numerically with a contour dynamics method, where the perturbations allowed are, generally, asymmetric. The diagrams of convergence of the iterative algorithm (without any symmetry constrains) are built in three cross sections of the parameter space: at opposite vorticity of the individual vortices, at equal areas of the vortices, and at zero net circulation of the vortex pairs (when inequality of areas of the individual vortices is offset by inequality of the absolute values of vorticity). The convergence bound is shown to be close to the stability bound in the parameter space, and the larger is the separation, the stronger are the perturbations needed to move the dipole out of equilibrium. Typical scenarios of the evolution of unstable symmetric translational dipoles and weakly stable dipoles of other kinds are described, including the transition of a dipole into an oscillating tripole – the scenario that has not been discussed so far.

Palabras clave: contour dynamics, vortex breakdown, vortex instability