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Stability of Relative Equilibria in the N-Vortex Problem

In the weather research and forecasting models of certain hurricanes, "vortex crystals" are found within a polygonal-shaped eyewall. These special configurations can be interpreted as relative equilibria (rigidly rotating solutions) of the point vortex problem introduced by Helmholtz. Their stability is thus of considerable importance. Adapting an approach of Moeckel's for the companion problem in celestial mechanics, we present some useful theory for studying the linear stability of relative equilibria in the N-vortex problem. The analysis is developed in a rotating coordinate frame and special properties of the Hamiltonian play a key role. For example, we show that in the case of equal strength vortices, a relative equilibrium is linearly stable if and only if it is a minimum of the Hamiltonian restricted to a level surface of the moment of inertia. Some symmetric examples will be presented, including a linearly stable family of rhombii in the four-vortex problem.