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Vortex swarms

We investigate the dynamics of N point vortices in the plane, in the limit of large N. We consider *relative equilibria*, which are rigidly rotating lattice-like configurations of vortices. These configurations were observed in several recent experiments [Durkin and Fajans, Phys. Fluids (2000) 12, 289–293; Grzybowski *et.al* PRE (2001)64, 011603]. We show that these solutions and their stability are fully characterized via a related *aggregation model* which was recently investigated in the context of biological swarms [Fetecau *et.al.*, Nonlinearity (2011) 2681; Bertozzi *et.al.*, M3AS (2011)]. By utilizing this connection, we give explicit analytic formulae for many of the configurations that have been observed experimentally. These include configurations of vortices of equal strength; the $N+1$ configurations of N vortices of equal strength and one vortex of much higher strength; and more generally, $N+K$ configurations. We also give examples of configurations that have not been studied experimentally, including $N+2$ configurations where N vortices aggregate inside an ellipse.