Gradient Catastrophe and Flutter in Vortex Filament Dynamics

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Flutter type instability in the motion of a thin vortex filament in an unbounded inviscid incompressible fluid is discussed. Within the localized induction approximation the origin of this phenomenon is in the gradient catastrophe for the dispersionless Da Rios system. This system describes the motion of a filament with slow varying curvature and torsion. Geometrically, the gradient catastrophe manifests as a rapid oscillation of a filament curve in a point that resembles the flutter of airfoils. At the point of catastrophe the curvature radius remains finite while the radius of osculating sphere blows up to infinity. Analytically, the catastrophe is the elliptic umbilic singularity in the terminology of the catastrophe theory. Its double scaling regularization is governed by the Painlevé-I equation. Deeper singularities, in particular the unimodular parabolic singularity X_9, are also studied.

Gradient catastrophe and flutter type instability for the integrable extensions of the dispersionless Da Rios system arising in more general models of self-induced motion of filament which include axial velocity and other effects are considered too.

References

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