Absolute/convective instabilities in the Batchelor vortex: a numerical study of the linear impulse response

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Abstract:

The absolute/convective instability properties of the Batchelor vortex are determined by direct numerical simulation of the linear impulse response. A novel decomposition procedure is applied to the computed wavepacket in order to retrieve the complex wavenumber and frequency prevailing along each spatio-temporal ray. In particular, the absolute wavenumber and frequency observed in the laboratory frame are determined as a function of swirl parameter and external flow. The introduction of a moderate amount of swirl is found to strongly promote absolute instability. In the case of wakes, the transitional helical mode that first undergoes a switch-over to absolute instability is found to be m=-1 without requiring any external counterflow. In the case of jets, the transitional helical mode is very sensitive to swirl and varies in the range m=-1, -2, ..., -5. Only a slight amount of external counterflow (1.5% of centerline velocity) is then necessary to trigger absolute instability. The results of this numerical procedure are in good qualitative and quantitative agreement with those obtained by direct application of the Briggs-Bers criterion to the inviscid dispersion relation (Olendraru *et al.*, 1996). Implications for the dynamics of swirling jets and wakes are discussed.
