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The influence of pressure gradients on the development of spiral-type breakdown of a Batchelor vortex SPENCER SHERWIN, MICHAEL BROADHURST, Imperial College London — Starting from a BiGlobal linear stability analysis, the development of helical instabilities on a jet-like Batchelor vortex are analysed using Direct Numerical Simulation (DNS). Initially, an axial periodicity is assumed in the streamwise flow direction, and the vortex is perturbed by the most unstable eigenmode. As this mode develops, there is a lateral expansion of the vortex into a helical structure, accompanied by a drop in axial velocity on the vortex core. The imposed axial periodicity limits the extent of this axial deceleration, and prevents a stagnation point – indicative of vortex breakdown – from developing. If the assumption of periodicity is relaxed, however, an abrupt and rapid deceleration of the vortex core is identified. The extent of this deceleration, and the time in which it develops, is very sensitive to external pressure gradients. For example, DNS indicates that breakdown develops more rapidly in an adverse pressure gradient. This cannot be analysed with a BiGlobal stability analysis, as there is an underlying assumption of axial homogeneity. Consequently, the Parabolised Stability Equations (PSE) for three-dimensional flows have been developed: The results of a PSE analysis agree with the DNS, confirming that an adverse pressure gradient is destabilising.

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