Effect of stretching on vortices with axial flow

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Abstract It is shown that a weak time-dependent stretching might rapidly destabilise a vortex, thus providing a mechanism for vortex bursts observed in turbulent flows. This study addresses the three-dimensional stability of a stretched viscous Batchelor vortex. In a fashion quite similar to Lundgren's transformation, the strain field is almost eliminated from the linear equations that govern three-dimensional perturbations. Such transformed equations, which are reminiscent of those for the swirling jet instability, are then numerically solved in the simple case of a compression phase followed by a stretching phase. Simulations qualitatively demonstrate how strain and azimuthal vorticity cooperate to destabilise the vortex.

When the strain on a tube is unsteady,
For excitable modes please be ready!
By scaling we claim:
In a suitable frame,
A vortex bursts into an eddy.

1. Introduction

In turbulent flows, vorticity filaments have been individuated in real experiments (Cadot, Douady & Couder 1995) or numerical simulations (Vincent & Meneguzzi 1991). Their evolution clearly depends on the varying background stretching field generated by surrounding vortices. In this context, numerical studies have been performed where the stretching field acting on a straight vortex is non-uniform, time-periodic or generated by an array of vortex rings (see for instance Verzicco, Jiménez &