Merging of non-symmetric Burgers vortices

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Abstract The merging of two Burgers vortices in an irrotational background straining flow at high Reynolds number is studied. Both axisymmetric and biaxial strain fields are considered. The merging events produce fine scale spiral vortex structures. For biaxial strain, a *cat's-eye* streamline pattern emerges and vorticity is transported away by the background strain. For intermediate strain ratios, the onset of vortex merging is delayed and the resulting vorticity contours are distorted compared to the axisymmetric case. The merging is suppressed for sufficiently large strain ratios.

With a strain that's non-axisymmetric,
The dance of two whorls is quite hectic;
They pulse and converge
And eventually merge;
The whole process is quite apoplectic!

1. Introduction

The discovery of coherent vortical structures in numerical simulations of turbulence has renewed interest in the properties of the Burgers vortex, a well-known equilibrium solution of the Navier-Stokes equations. The Burgers vortex has been used in the development of many theories of turbulent fine scales, where these are modelled using spatial ensembles of stretched vortices (Pullin & Saffman 1998 and references therein).

The Burgers vortex results when a unidirectional vorticity field $\boldsymbol{\omega} = \omega(r,\theta)\hat{\boldsymbol{k}}$ is embedded in an axisymmetric irrotational background straining flow,

$$\boldsymbol{u}_s = \alpha x\hat{\boldsymbol{i}} + \beta y\hat{\boldsymbol{j}} + \gamma z\hat{\boldsymbol{k}}, \tag{1}$$

where α, β and γ are the strain rates and $\alpha + \beta + \gamma = 0$. This strain field can be characterised by a strain ratio,