Low-pressure vortex analysis in turbulence: life, structure, and dynamical role of vortices

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Abstract The low-pressure vortex analysis is performed for the study of dynamical properties of tubular vortices in turbulence. An automatic tracking scheme of arbitrarily chosen vortices is developed which makes it easier to examine the history of individual vortices. The low-pressure vortices have typically two distinct regions of high vorticity, that is, the tubular central core and surrounding spiral arms. The vorticity in these two regions is perpendicular to each other. It is observed that both the length of fluid lines and the area of fluid surfaces increase, in average, exponentially in time with growth rates of 0.17 and 0.30 (Kolmogorov time)$^{-1}$, respectively. The main contribution to these stretching comes from the velocity induced by vortices.

Vortex core pressure is low,
And it's usually curved like a bow;
Computational sketching
Shows non-uniform stretching
And spirals wrapped up by the flow.

1. Introduction

Turbulence is full of vortical motions of various types. Among others, the tubular swirling vortices are commonly observed in many kinds of turbulent flows. They play central roles in turbulence dynamics, such as the enhancement of mixing, diffusion, resistance, etc. The dynamical properties of vortical motions in isotropic turbulence is the main theme of the present paper. Stationary isotropic turbulence is investigated by the low-pressure vortex analysis which we have recently introduced (Miura & Kida 1997).

The fluctuations of physical quantities are statistically invariant in stationary turbulence, but individual vortices, if identified, have their own lives of finite time. It is anticipated that they are born through a