§47. Orthonormal Divergence-free Wavelet Analysis of Nonlinear Transfer Process in Rolling-up Vortex Sheets

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Orthonormal divergence-free wavelet analysis of nonlinear transfer in some isolated vortices, which evolve from the instability of a thin shear layer, reveals that the rolling-up vortices are relevant to the energy cascade to smaller scales. A graphical representation method for the "location-to-location" wavelet nonlinear interactions, each of which is given by

$$\langle j, \vec{l} | \boldsymbol{u} | k, \vec{l'} \rangle = \int \boldsymbol{u}_{j,\vec{l}} \cdot (\boldsymbol{u} \cdot \nabla) \boldsymbol{u}_{k,\vec{l'}} d^3\vec{x} \qquad (1)$$

is developed which depicts the information on spatial scale(j) and location($\vec{l}$) of the wavelets. It is found that the active nonlinear interactions are very closely distributed around the coherent structures irrespective of the forward or backward transfers and that the dominant nonlinear interactions are "local" in the sense of distance.[1)]

In Fig.1 it is shown that time development of turbulent nonlinear interactions between the wavelet modes with different spatial scales during the rolling-up process. The "needles" around the enstrophy isosurfaces in these figures are strong "location-to-location" nonlinear interactions between the wavelet modes of $k = 4$ and $j = 5$ wavelet resolution classes. Our new representation method of nonlinear interactions clearly illustrates that the active nonlinear interactions become more and more localized in space as the time goes. This implies that the principal nonlinear energy transfer tends to concentrate in some narrow regions around the vortical structures spontaneously. This may suggest that the intermittency of turbulent velocity field is generated by the winding-up process of each vortical structures.

1). K. Araki, H. Miura, "Orthonormal Divergence-free Wavelet Analysis of Nonlinear Energy Transfer in Rolling-Up Vortices", at IUTAM Symposium 2006 NAGOYA "Computational Physics and New Perspectives in Turbulence" September 11-14. 2006, Nagoya University, Nagoya, Japan.

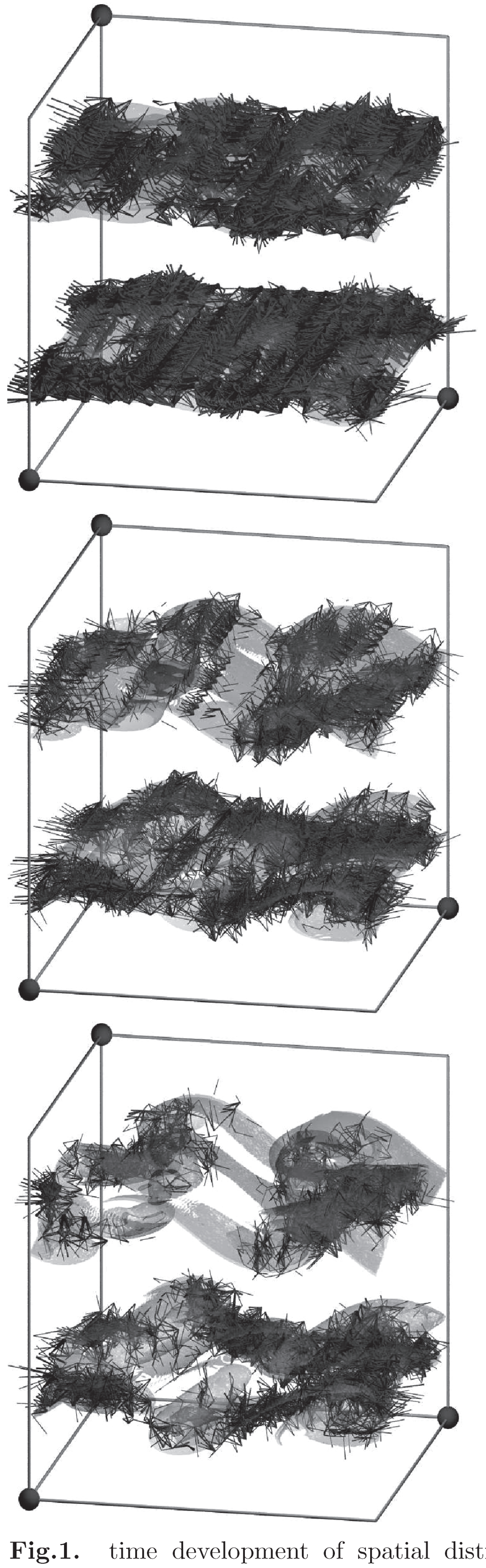

Fig.1. time development of spatial distribution of strong nonlinear transfers. Top: t=15.0, middle: t=17.5, bottom: t=20.0 in dimensionless time.