Sharp vorticity gradients in two-dimensional turbulence and the energy spectrum

Formation of sharp vorticity gradients in two-dimensional (2D) hydrodynamic turbulence and their influence on the turbulent spectra are considered. The analog of the vortex line representation as a transformation to the curvilinear system of coordinates moving together with the di-vorticity lines is developed and compressibility of this mapping appears as the main reason for the formation of the sharp vorticity gradients at high Reynolds numbers. In the case of strong anisotropy the sharp vorticity gradients can generate spectra which fall off as $k^{-3}$ at large $k$, which appear to take the same form as the Kraichnan spectrum for the enstrophy cascade. For turbulence with weak anisotropy the $k$ dependence of the spectrum due to the sharp gradients coincides with the Saffman spectrum: $E(k) \sim k^{-4}$. Numerical investigations of decaying turbulence reveal exponential growth of di-vorticity with a spatial distributed along straight lines. Thus, indicating strong anisotropy and accordingly the spectrum is close to the $k^{-3}$-spectrum.