The Solitonic Hydrodynamical Turbulence

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A.S. Monin and A.M. Yaglom [1] define coherent structure as nonrandom nonlinear steady superposition of large-scale turbulence components. However, as it is established in [2–4], the process of the disintegration of a hydrodynamic cell proceeds to the smallest vortexes, which else can exist in air. Therefore in [2–4] the concept «coherent structure» is expanded. The hydrodynamic coherent structure is called the compact formation containing into itself the long-living spatial vortical structure (appearing as a result of the long action of thermodynamic gradients) and products of its discrete coherent cascade disintegration. In the expanded understanding, the coherent structure is the solitonic solution of the hydrodynamic equations (solitary wave), and contains both large-scale, and small-scale turbulence.

Frequency of the coherently disintegrating main power-carrying vortex is the basic feature of the coherent structure. The size of coherent structure is indistinct. The currents, external in relation to the main vortex, can transfer products of its disintegration on considerable distances, forming a long turbulent wake. As shown in [2–4], the known processes of transition of laminar currents to turbulent currents (disintegration of a Benard cell, a fluid flows around obstacles (fig. 1 [5] see), etc.) are possible to consider as coherent structures. The spectrum of a passive impurity (temperature) in a cell is fractal; a cell disintegrates under the Feigenbaum scenario (the period doubling).

Experimental data [2–6] of our multiyear turbulence measurements (by ultrasonic digital sensors) in the various areas and meteosituations show that large areas are often observed in open atmosphere, in which one large coherent structure has the main influence. Turbulence in such areas is called as coherent (curves 1, 2 on fig.2). Incoherent Kolmogorov turbulence (curves 3-5 on fig. 2) is detecting, as a rule, on sites with a flat surface. Coherent turbulence differs from Kolmogorov turbulence by the faster decrease of a time spectrum in an inertial interval ($\sim f^{-8/3}$ instead of $\sim f^{-5/3}$) and the smaller contribution of the high-frequency components (fig.1–2).

It is shown by us in [2–4] the Kolmogorov turbulence is possible to consider as a mix of the various coherent structures with incommensurable frequencies of the main vortexes. Therefore the coherent structure can be considered as a structural element (an elementary particle) of which the turbulence consists. In the viscous mediums the coherent structures do not disintegrate, and therefore they (as well as the not-solitonic usual waves) represent kinds of laminar currents.

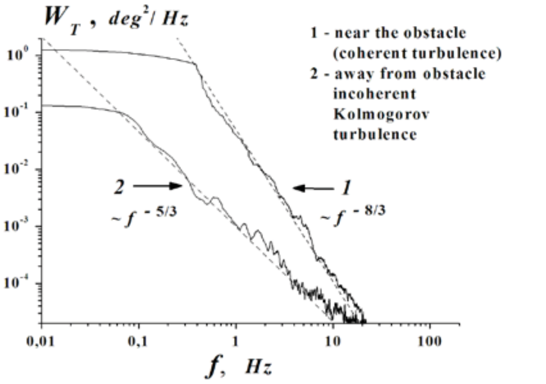

Fig. 1. Typical spectra of the temperature fluctuations W_T, registered in the flow behind of the large-scale obstacles (near the axis of the turbulent wake) 1 - coherent turbulence near the obstacle, 2 - incoherent Kolmogorov turbulence away from obstacle

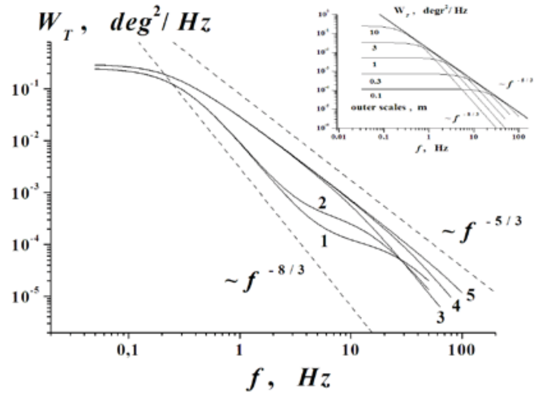

Fig. 2. The theory coincides with the experimental data(each of these spectra is the sum of the spectra of *N*-various coherent structures). 1, 2 – large and small structures (N = 2); 3, 4, 5 – N structures with the sizes successively decreasing in 3 times (N=4, 5, 6). On the right above - spectra of the isolated structures (N=1) with the different sizes

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