# Energy spectrum in shear flows. A general pre-unstable large set of multiple transient three dimensional waves and the turbulent state.

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In order to understand whether, and to what extent, spectral representation can effectively highlight the nonlinear interaction among different scales, it is necessary to consider the state that precedes the onset of instabilities and turbulence in flows. In this condition, a system is still stable, but is however subject to a swarming of arbitrary three-dimensional small perturbations. These can arrive any instant, and then undergo a transient evolution which is ruled out by the initial value problem associated to the Navier-Stokes linearized formulation. The set of all possible 3D small perturbations constitutes a system of multiple spatial and temporal scales which are subject to all the processes included in the perturbative Navier-Stokes equations: linearized convective transport, linearized vortical stretching and tilting, and the molecular diffusion. Leaving aside nonlinear interaction among the different scales, these features are tantamount to the features of the turbulent state.

If it were possible to observe such a system in a temporal window and obtain the instantaneous 2D wave number spectra, it would be possible, among others, to determine the exponent of the inertial range of the arbitrary perturbation evolution, and to compare it with the exponent of the corresponding developed turbulent state (notoriously equal to $-5/3$). Two possible situations can therefore appear. (i) The exponent difference is large, and as such, is a quantitative measure of the nonlinear interaction in spectral terms. (ii) The difference is small. This would be even more interesting, because it would indicate a higher level of universality on the value of the exponent of the inertial range, not necessarily associated to the nonlinear interaction.

We propose building temporal observation window for the transient evolution of a large number (order of $10^3$) of arbitrary small 3D perturbations acting on a typical shear flow. In particular we can take advantage of a recently - numerically obtained - set of solutions yielded by the initial value problem applied to 3D perturbations of a plane bluff-body wake[1,2]. These solutions have revealed the existence of many different kinds of transient behaviour, not all of which is trivial[3,4,5]. If these transients, obtained in association with arbitrary, statistically selected, initial conditions, are injected in a statistical way into the temporal observation window, we can obtain a close representation of the perturbation state that precedes the onset of instability-turbulence.

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