Experimental study of the collapse of the statistical equilibrium of large scales hydroelastic wave turbulence

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Résumé

At scales larger than the forcing scale, several out-of-equilibrium turbulent systems-such as hydrodynamic turbulence, wave turbulence, and nonlinear optics-can reach a state of statistical equilibrium characterized by energy equipartition among large-scale modes, consistent with a Rayleigh–Jeans spectrum. This is interesting in itself because it allows statistical mechanics tools to be used on systems that are, in principle, out of equilibrium. While this statistical equilibrium is now well established for various systems, its subsequent non-stationary evolution remains largely unexplored.

While the statistical equilibrium has been demonstrated experimentally for the large-scale hydroelastic turbulent waves, this work focuses on the experimental study of its free decay. The large-scale hydroelastic turbulent waves prepared in an initial state of statistical equilibrium thus collapse once the external forcing is turned off. Using space- and time-resolved measurements, we observe that the total energy of the large-scale tensional waves decays as a power law in time. We found a decay law based on the initial equilibrium spectrum and linear viscous damping, under the assumption that no net energy flux is present. The predicted decay is found to be in excellent agreement with experimental measurements over nearly two decades in time and for a wide range of initial effective temperatures. We also identify the dominant dissipation mechanism and validate it experimentally. These results provide a simple and predictive framework for the decay of turbulent systems whose large scales are initially in statistical equilibrium, and may be extended to other forms of decaying turbulence. This work has been published in JFM.

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