Fluids and Space Engineering Seminar

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The structure of entropy production in the turbulence cascade

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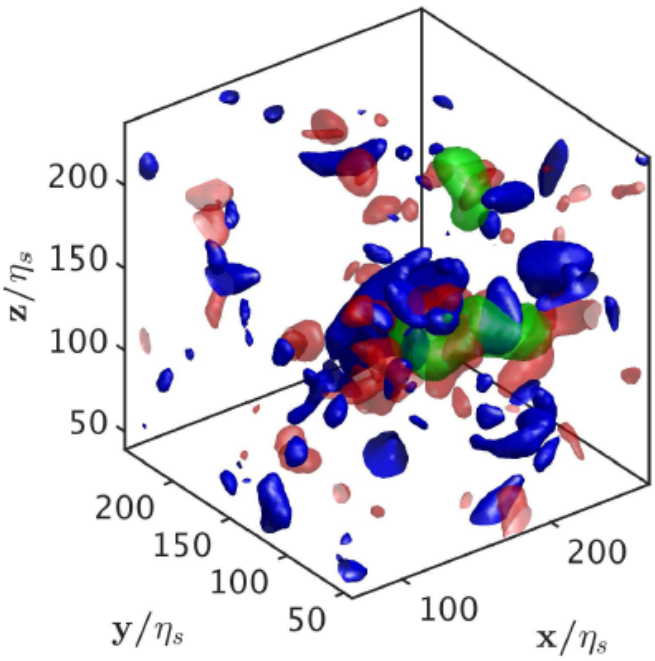

Isosurfaces of intense vorticity regions (blue), intense rate-of-strain tensor (red) and intense local entropy production in the inertial scales of reversible homogeneous isotropic turbulence.

This work analyses the turbulent energy cascade under the theory of dynamical systems and relates inter-scale energy fluxes to chaotic phase space mixing and information entropy production. A reversible homogeneous turbulent system demonstrates the existence of inverse cascade regimes where energy is on average transferred towards the large scales. These unlike inverse regimes expose the entropic nature of the energy cascade. The direct cascade is not directly enforced by the dynamics but simply more probable. This reversible turbulent system is used to study microscopical reversibility, the origin of statistical irreversibility and entropy production in the turbulence cascade. The inverse and direct cascades are compared through the dynamics of the velocity gradient tensor, revealing the causes for the prevalence of direct energy transfer and a strong relation between entropy production, energy transfer and the dynamics the rate-of-strain tensor. It is found that the inverse cascade requires the organization of a large number of non-locally coupled degrees of freedom, whereas the direct cascade appears as the consequence of local interactions. In order to further identify potential entropy production mechanisms a space-local definition of entropy production is constructed based on the statistics of the highest Lyapunov exponent and its associated Lyapunov vector. The field of local entropy production is highly intermittent and localized in regions of the turbulent flow characterized by an intense magnitude of the rate-of-strain tensor.