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On the kinematic viscosity, scaling laws and spectral shapes in Rayleigh-Taylor mixing plasma experiments

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Far from equilibrium dynamics are omnipresent in plasma processes in nature and technology. Examples include plasma instabilities in the inertial confinement fusion, thermonuclear flashes in supernovae, and efficiency of plasma thrusters. This work explores the physics of matter at the extremes by analyzing experimental data of fluctuations spectra in Rayleigh-Taylor mixing in high energy density plasmas by using a rigorous statistical method. [1,2,3,4]

We consider the experimental data on Rayleigh-Taylor mixing in high energy density plasmas. [1,2,3,4]

We analyze the fluctuations spectra of the x-ray imagery intensity versus spatial frequencies. Rigorous statistical method is employed to find parameters of the data model, including their mean values, statistical errors, goodness-of-fit and statistics of residuals. We examine the effect of the range of spatial frequencies and select the interval with tolerable statistical attributes and large span of scales. [1,2,3]

We find that the fluctuations spectra are accurately described by compound functions capturing, through a product of a power-law and an exponential, both self-similar and scale-dependent spectral parts. The self-similar dynamics have steep spectra, strong correlations and weak fluctuations. The attributes of the scale-dependent dynamics directly determine the value of the kinematic viscosity. Our data analysis finds the characteristics of Rayleigh-Taylor mixing and the physics of the matter in high energy density plasmas. Our results explain the experimental observations and elucidate their consistency with group theory and other experiments. [1,2,3]

We report the first data based value of the kinematic viscosity in high energy density plasmas. [1,2,3]

References

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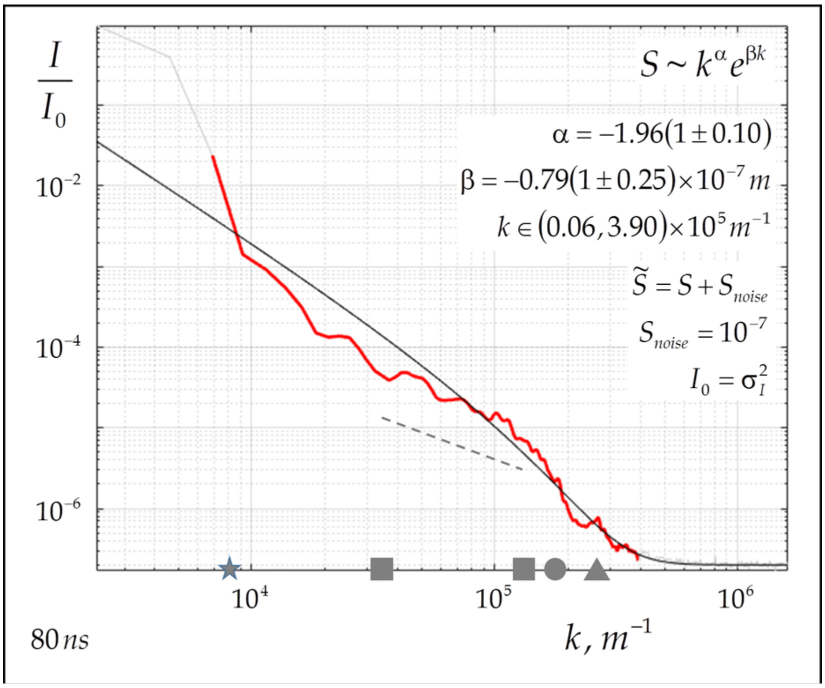

Figure 1. Modeling data of the fluctuations spectra by the method [1-3] in the experiments [4] by the compound function in the late time Rayleigh-Taylor mixing. The image represents in grey the spectral shape (solid curve) and the available data, and marks in red the data from the (best fit) interval in which the spectral shape parameters are identified. The spectral shape evolves into a constant to the right of the colored part for high spatial frequencies, which are influenced by the experimental noise. The grey dashing line marks the canonical turbulence fiducial in the interval with the endpoints marked by the grey squares. The grey circle (triangle) denotes the ‘knee’ (‘bump’) from the visual data fit in the work [4].