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Non Local Fluctuations in the Oscillation Systems

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Any oscillating system is characterized by two main parameters: the proper frequency and the quality factor (Q factor). The latter is inversely proportional to the width of the spectral line of the parameter fluctuations. The higher Q factor, the more sensitive the system is. In thermodynamic equilibrium, fluctuations are determined by the system temperature and the dissipation [1]. In the general case parameters of the systems can be change in both time and space. Inhomogeneities in space and time of these quantities will certainly also contribute to the fluctuations. The fluctuation-dissipation relation has been generalized to the non-equilibrium systems with slowly varying parameters [2]. The important conclusion of this analysis is to reveal that the spectral function of the fluctuations is determined not only by dissipation but also by the derivatives of the dispersion. The non-Joule dispersion contribution is characterized by a new non-local effect originating from an additional phase shift between the force and the response of the system. That phase shift results from the parametric control to the system.
In the context of plasma physics, using the Langevin approach and the time-space multiscale technique, it has been shown that the amplitude and the width of the spectral lines of the electrostatic field fluctuations and the electron form factor are determined not only by the imaginary (dissipative) part of the dielectric susceptibility but also by the derivatives of its real (dispersive) part [3]. As a result of the inhomogeneity, these properties become asymmetric with respect to the inversion of the sign of the frequency. In the kinetic regime, the form factor is more sensitive to space gradients than the spectral function of the electrostatic field fluctuations. This asymmetry of lines can be used as a diagnostic tool to measure local gradients in the plasma. These results are applicable to other oscillation systems and are important for the understanding of various behaviors observed in different field of physics.

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