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Dielectric response and collective modes of strongly coupled plasmas

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The properties of strongly coupled plasmas are largely determined by their Coulomb interactions, which give rise to liquid-like structure and dynamics. Examples include dusty plasmas, ultra-cold neutral plasmas, and warm dense matter. This talk will focus on how simulations and theory can contribute to an improved understanding of their dielectric response and collective excitations. Molecular dynamics simulations are a valuable tool to compute the dynamics of classical plasmas. It is shown how they provide access to the local-field correction (LFC) of the one-component plasma (OCP) [1], the key ingredient to include correlations in the dielectric response function. The frequency dependence of the LFC is explored in detail, and its relation to the transport properties of the OCP is investigated using a hydrodynamic model. With effective quantum potentials, the simulations can be extended to dense hydrogen plasmas, allowing one to compute their equation of state and ionic collective modes. In particular, in the long wavelength limit, preliminary results indicate the formation of an ion-acoustic mode[2]. Complementing the simulations, the quasi-localized charge approximation (QLCA) [3] has been a highly successful theory to decipher the mode structure in classical strongly coupled plasmas. With the goal of extending its applicability to more complex systems, it will be discussed how quantum effects can be incorporated [4] and how the QLCA relates to the instantaneous normal modes of liquids [5]. The former is achieved by considering the BBGKY hierarchy in the Wigner representation while the latter is demonstrated explicitly for a Yukawa plasma. The results could be valuable for future studies of strongly correlated classical and quantum systems.

References

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