Critical Point in Complex Plasmas

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In simple liquids the existence of two distinct fluid phases, gas-liquid transition and critical point requires the presence of an attractive well in the pair interaction potential [1]. In dense dust clouds, the complex plasma system can be considered as a one-component gas of "dressed" dust particles with the background plasma medium providing screening, charging and dissipation. The plasma fluxes maintaining the grain equilibrium charge become collective and result in the existence of an attractive well in the effective dust-dust interaction potential [2], in a wide range of parameters that are accessible to experiments [3].

This form of the potential can be used to solve the Ornstein-Zernicke equation in the mean spherical approximation for dust particles [4]. This approach provides the analytical expressions for (i) the direct correlation function of the dust particles $C(r)$, (ii) the structure factor $S(k)$, (iii) the excess energy in terms of free parameters.

At first, a long range attraction in the pair potential of interaction produces a minor pre-peak in the structure factor at long wavelengths, appearing before the main peak due to the nearest neighbors [5]. Strong resolution in such wavelength regions will experimentally verify collective attraction and can indirectly be used for the determination of the ion distribution in the vicinity of the grain. Moreover, the equation of state can be found from the long wavelength limit of the structure factor $S(0)$, allowing to find the critical region and the coexistence of the two fluid phases by plotting the isotherms and also the critical temperature and density by the inflection point of the curves [6].

References