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Critical point of fine particle plasmas and experiments on ISS

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Fine particle plasmas are mixtures of macroscopic fine particles and plasmas. One of the most important merits of fine particle plasma experiments is the possibility to trace the orbits of fine particles. The observation of collective phenomena on the kinetic level is expected to be of great help in our understanding of them.
When fine particles are of micron size, they have huge amount of negative charges and the system of fine particles becomes strongly coupled. It has been pointed out that, in such a strongly coupled fine particle plasmas, we have critical points and critical phenomena can be observed. In order to make observations, however, we have to have three-dimensional isotropic systems which are difficult to realize in experiments on earth due to large gravity on fine particles. The microgravity environment is a solution to this difficulty and experimental attempts have been made in the fine particle plasma experiments performed on ISS by Germany (MPE) and Russia (JIHT, RAS)[1].
In general, Coulombic and Coulomb-like one component systems (one-component plasmas) have an isothermal compressibility which increases with the coupling. With further increase of the coupling, the compressibility diverges. Simply minded, this is a thermodynamic instability and we do not have a homogeneous system beyond that point: we have a phase separation which is generally accompanied by the critical point. In the case of one-component systems, however, there exists another component (the background charge) which guarantees the overall charge neutrality and the contribution of the latter component to the compressibility is not included in the compressibility of one-component systems by definition. Therefore the divergence of isothermal compressibility of one-component plasmas is not directly related to thermodynamic instability of the total system. In fact, the contribution of the charge-neutralizing component is usually large compared with that of one-component system and the divergence of the isothermal compressibility of one-component plasmas has long been regarded as an artifact of the model: For example, degenerate electrons with larger positive pressure and almost incompressible form the background for ion one-component systems.
In fine particle plasmas, fine particles can become of extreme strong coupling due to large negative charges on them and the background charge is the classical plasma. Though the temperature and density of background components are higher than fine particles, there exist a possibility to observe the critical phenomena in fine particle plasmas[2]. The critical parameters, experimental conditions and phenomena near the critical points have been shown[2]. Within the structure and limited size and density of fine particles in experimental apparatus on ISS, we may observe some phenomena indicating the approach to critical point such as enhanced density fluctuations.
In this presentation, theoretical background and experimental status will be introduced.

[1] For example, H. M. Thomas et al., New J. Phys. 10, 033036(2008).
[2] For example, H. Totsuji, Phys. of Plasmas, 15, 072111(2008).

Keywords: fine particle plasma, strongly coupled plasma, critical phenomena, experiments on ISS