From novel diagnostics towards new insight into dusty plasmas

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Since 30 years dusty plasma is a very active research field. A dusty plasma consists of regular plasma, i.e. electrons, ions and neutrals, as well as solid particles which are embedded in the plasma environment. As floating objects they typically charge up negatively and attain quite high charges in the order of several thousand elementary charges for a particle with a diameter of a few micrometer. Thus, the mutual electrostatic interaction of the particles is despite of the screening strong and dominates in may cases the particle dynamics. Such systems are called strongly coupled systems and are found in many places as liquids or solids are in a strongly coupled state [1].

One of the driving motors for dusty plasma research has always been the excellent possibility to study the kinetics of individual particles even in extended systems experimentally. Having such unique access to a strongly coupled system allowed to explore many collective phenomena ranging from waves and instabilities via phase transitions to basic thermodynamics.

In recent years the research focus shifted more and more from qualitative to quantitative studies. The basic difficulty related with this is that it requires a precise measurement of a number quantities. The most prominent one is the particle charge. Although it seems trivial to measure this at first glance it is not. The charging of dust grains is still an open issue if a precise absolute value is needed. This talk will introduce to novel diagnostic techniques and show by means of examples how they help to solve the charging problem, give access to an improved understanding of dusty plasma and open new research directions.

The talk will have three part. The first part will focus on a method to determine the particle size with high accuracy during plasma operation [2,3]. This in-situ diagnostic which is based on a Mie-scattering approach has two basic advantages: a) it yields absolute values of size and refractive index and b) it has good temporal resolution. While the size is an important input parameter for the charge, the temporal evolution of size and refractive index allows us to have a closer look at the interaction of plasma and particle surface.

The second part will introduce two methods to measure the particle charge in extended systems. These methods both rely on the dynamics of the system. While one method uses a measurement of the thermal motion of the particles to calculate the dispersion relation and finally to determine charge and screening length [4,5], the second method makes use of an alternative temperature definition to finally deduce the charge[6,7]. Both methods are non invasive as they rely on the pure thermal motion of the particles and require no external manipulation. Furthermore, both methods are also applicable if the dusty plasma system is a binary mixture [8,9], i.e. consists of two particles species which differ in size and thus in charge.

The final part of the talk will have a closer look at these binary systems. If such a binary system is externally driven, it becomes possible to get access to a quantity that is usually not measureable. It is demonstrated that dusty plasmas allow to measure entropy based on the very fundamental definition of Boltzmann and Gibbs[10].

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