Configurational temperature: Temperature and charge measurements in dusty plasmas

M. Himpel\textsuperscript{1}, A. Melzer\textsuperscript{1}

\textsuperscript{1} Institute of Physics, University Greifswald, Germany

When microparticles are injected in a plasma, they usually attain a highly negative charge. The complex interactions of this macroscopic plasma species give rise to many interesting phenomena. To describe such dusty plasmas, the temperature associated to the motion of the particles is a fundamental parameter. Often, this kinetic temperature is defined and measured by using the equipartition theorem as

$$\left\langle \frac{1}{N} \sum_{i=1}^{N} \frac{p_i^2}{m_i} \right\rangle = D k_B T_{\text{kin}},$$

with $p$ being the $D$-dimensional momentum of the $i$-th (out of $N$) particle. Unfortunately, the measurement of proper velocity distributions based on Eq. (1) is difficult\cite{1}. Based on an approach from the fluid community\cite{2}, we discuss the concept of a configurational temperature for dusty plasmas. There, the temperature is expressed in terms of the net forces $\mathbf{F}$ acting on the particles as

$$k_B T_{\text{conf}} = - \frac{\left\langle \sum_{i=1}^{N} \mathbf{F}_i^2 \right\rangle}{\left\langle \sum_{i=1}^{N} \nabla_i \cdot \mathbf{F}_i \right\rangle}.$$  

The advantage of this approach is, that the forces in Eq. (2) generally only depend on the particle positions rather than on velocities. Hence, this approach allows to measure the temperature from static images of the dust system.

In this presentation, we will demonstrate how to apply the configurational temperature approach to simulated and measured data. Furthermore, we will determine the particle charge and/or the screening length of the particle interaction potential from comparisons of the kinetic and configurational temperature (see also \cite{3}).

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References