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Direct measurements of ion dynamics in a dusty plasma

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Ion flows play a critical role in initiating many dusty plasma phenomena. However, the experimental measurement of ion behavior was of extreme challenge due to the parameter regime and hardware requirements. The major efforts for understanding ion behavior were limited to theoretical calculations and simulations. This talk will share the first direct measurements of the ion flow and ion temperature which lead to the calculation of the ion drag force and ion streaming instability in a dusty plasma environment. We used laser induced fluorescence (LIF), a highly sensitive and non-perturbative diagnostic to measure the ion velocity distribution function (IVDF). A de-convolution technique was used to extract the proper IVDF from the measured spectra while accounting for various line broadening mechanisms. Measurements were taken in the plane of the dust cloud and perpendicular to the electrode surface. We observed that the ion flow is much faster than the thermal speed and slightly above the ion sound speed while the ion temperature is slightly above room temperature for all rf power and operating pressures studied. Further, we calculated the (transverse) ion drag force for the first time which was significantly higher than the vertical ion drag force based on models and simulations. This new result suggests that dusty plasma phenomena such as waves, crystal formation, and instabilities will be strongly affected by ion properties which have not been properly understood so far. These groundbreaking measurements open the door for detailed studies of dusty plasma phenomena that are dictated by the ions.