Particle Pairing In Complex Plasmas

Vladimir Nosenko[1], Alexei Ivlev[2], Roman Kompaneets[2], and Gregor Morfill[2]
[1]*Deutsches Zentrum für Luft- und Raumfahrt, Forschungsgruppe Komplexe Plasmen, D-82234 Weßling, Germany*
[2]*Max-Planck-Institut für extraterrestrische Physik, D-85748 Garching, Germany*

Pairing of particles is a ubiquitous phenomenon in complex plasmas. The latter are suspensions of charged micron-size solid particles in a plasma, often in the (pre)sheath area above the lower electrode in a gas discharge [1]. Particle pairing was observed in various settings from isolated pairs and larger strings to pairs in 2D crystals and particle bilayers. An important role in the formation of particle pairs belongs to the plasma wakes that appear behind charged particles in the flow of ions. Fundamental questions are what determines the spatial extent of pairs and their stability. These questions recently received attention, but to the best of our knowledge no systematic study was done.

In this work, we systematically study the dependence of particle pair size on experimental parameters. We used an experimental setup based on a modified Gaseous Electronics Conference (GEC) radio-frequency (rf) reference cell [2]. Plasma was sustained by a capacitively coupled rf discharge in argon at the pressure of 2 Pa. Melamine-formaldehyde (MF) microspheres with a diameter of 9.19±0.09 μm were suspended in the (pre)sheath area above the lower rf electrode. The particle suspension was imaged from the top and side with two video cameras.

A specially designed "pair state" of complex plasma was prepared where particles formed multiple pairs that were vertically oriented, had a well-defined size, and levitated at the same height but were weakly coupled with each other and did not form any regular structure. As the discharge voltage was decreased, the pairs shifted downward and extended vertically. The vertical size of pairs was measured as a function of experimental parameters. We offer an interpretation of our observations based on a recent theory [3] that takes plasma non-uniformity into account.

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