Spectrum of energy states of dust Coulomb clusters

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Coulomb cluster is a phenomenon in classical physics which is under substantial amount of attention. These clusters are characterized by the strong electrostatic interaction of highly charged particle trapped within an external confining potential. Examples of such systems include ion traps and quantum dots. Investigation in this area had been further encouraged in the past few decades with the discovery of complex (dusty) plasmas and the increase in the computer simulation of complex plasma experiments. In discharge complex plasma system, micron-sized dust particles which are highly negatively charged ($\sim 10^4$e) repel each other under strong coulomb forces to arrange themselves into well ordered structures. Such structures with limited number of particles are referred as Coulomb clusters in dusty plasma.

In this study, dynamic coulomb cluster systems are simulated on a computer for various particle numbers. The system is modelled using electrostatic confinement from a potential well, classical coulomb repulsion, friction force and a stochastic force. Classical force equations are used to simulate the behaviour of highly charged dust particles in such a field. Our model allowed us to predict the structural configuration of the dust cluster under particular experimental conditions and the results are symmetrical clusters with concentric shells with multiple stable (metastable) states (referred to as packing sequences). It was shown that configuration of Coulomb clusters depends on friction force (pressure). A simple explanation based on limited-time metastable states approach was proposed.

Spectrum of energy states of dust Coulomb clusters corresponding to various packing sequences had been obtained. The broadening of the spectrum due to inter-shell rotation was discovered. Indisputably, the inter-shell rotation will lead to a change in the energy spectrum of Coulomb cluster. However, the obtained results suggest that there is an additional aspect to the intershell interaction. The only way to minimize energy for a given configuration without compromising the inter-shell rotation is to distort the stable shells. Although in such case, the particles are able to compensate for any additional Coulomb energy (owing to the inter-shell rotation) by further reducing their radial distance as much as possible. The overall effect is a change in the outer-shell from circular to elliptical.