Structural phase transitions in cylindrically confined electronic clusters

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The space-dimensional transformations of an electronic structure in mesoscopic cluster systems are investigated in a classical approach. The model of a cluster with a confinement of the electrostatic nature is used. The model confining potential is assumed to originate from the uniform cylindrical charged distribution (positive background) on a finite length scale and can be found by solving the Poisson Eq. Provided the Coulomb interactions between electrons the cluster model becomes a purely electrostatic system. These systems are characterized by the parameters of background and the values of ionic power. In practice, such kind of systems can be fabricated in dielectric or semiconductor devices.

Numerical calculation of equilibrium electron distributions in neutral clusters results in four types of the space-dimensional structure. There exist quite perfect 1D-grid structures in extended clusters [1]. Lowering of a cluster length leads sequentially to $2D_x$-structures ordered in one of longitudinal planes including a cluster x-axis, then to variety of 3D-structures, and at last to $2D_{yz}$-structures in a transverse yz-plane of oblate clusters. All of the space-dimensional structures are performed on the phase diagram. The changes of space-dimensionality in the cases $1D\leftrightarrow 2D_x$ and $3D\leftrightarrow 2D_{yz}$ can be interpreted as the structural phase transitions of the 2-d order. They reflect abrupt changes (freezing or unfreezing) of the values of space parameters (coordinates) responsible for the space-dimensional transformations of a whole structure whereas the dimensional transformation $2D_x\leftrightarrow 3D$ is accompanied by continuous changes of the space parameters. The results obtained are compared with those for extended 2D-systems of charged particles [2].

1. S.Ya. Goroshchenko, 2-d Intern. Conf. "Physical and Chemical Principles of Formation and Modification of Nanostructures", October 2008, Kharkiv, Ukraine; Proceedings, v.2, p.476.
2. G. Piacente, I.V. Schweigert, J.J. Betouras, and F.M. Peeters, Phys. Rev. B **69**, 045324 (2004).