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Confinement and Structural Changes in Vertically Aligned Dust Structures

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In physics, confinement is known to influence collective system behavior. Examples include coulomb crystal variants such as those formed from ions or dust particles (classical), electrons in quantum dots (quantum) and the structural changes observed in vertically aligned dust particle systems formed within a glass box placed on the lower electrode of a Gaseous Electronics Conference (GEC) rf reference cell. Recent experimental studies have expanded the above to include the biological domain by showing that the stability and dynamics of proteins confined through encapsulation and enzyme molecules placed in inorganic cavities such as those found in biosensors are also directly influenced by their confinement. In this paper, the self-assembly and subsequent collective behavior of structures formed from n, charged dust particles interacting with one another and located within a glass box placed on the lower, powered electrode of a GEC rf reference cell is discussed. Self-organized formation of vertically aligned one-dimensional chains, two-dimensional zigzag structures, and three-dimensional helical structures of triangular, quadrangular, pentagonal, hexagonal, and heptagonal symmetries are shown to occur. System evolution is shown to progress from one-dimensional chain structures, through a zigzag transition to a two-dimensional, spindle like structures, and then to various three-dimensional, helical structures exhibiting various symmetries. Stable configurations are shown to be strongly dependent upon system confinement. The critical conditions for structural transitions as well as the basic symmetry exhibited by the one-, two-, and three-dimensional structures that subsequently develop will be shown to be in good agreement with molecular dynamics simulations.