Clusters and Nanoparticles: the Essentials

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Between physics and chemistry, between the atom and the solid state, "clusters" are nanoparticles containing a few to several hundred atoms. Bridging the gap between molecular and condensed mater science is the major issue of cluster science. What is it that makes clusters so different from the bulk solid? Properties of the finely divided matter change drastically when the energy level spacing become larger than typical excitation energies such as k_BT, μ_BB,... In simple systems such as alkali metal clusters the energy level spacing is roughly given by E_F/N where N is the number of atoms. In this size range, adding or removing a single atom to the cluster may change significantly its properties.

In this lecture series, we will see that marked deviations from the solid state the so-called "size effects" manifest themselves in most properties of clusters (in some cases magic numbers appear). As a result, usual experimental and theoretical approaches are not appropriate anymore because of symmetry braking, discreteness of energy levels and still large number of atoms compared to simple molecules. We explore to which extent various properties of clusters can influence fundamental processes in magnetism, optics, catalysis and superconductivity. Particular focus is placed on cutting-edge research which explores the interaction of clusters with electromagnetic fields, in new experiments. Emphasis will be put on the intrinsic properties of clusters as they can be studied in molecular beams, in the absence of any interaction with a substrate.

Among all the motivations to study clusters, scientific curiosity certainly comes first but the next important motivation is driven by applications of nanoparticles in various fields of science and technology such as data storage, electronic devices, solar energy, catalysis, … It is expected that the interdisciplinary approaches of clusters and nanoparticles stimulate the emergence of new research topics, enabling innovative applications in nanoscience and inspiring the next generation of functional materials.

Main topics:

- Energy level statistics, Kubo's model
- Quantum size effect
- Thermodynamic properties
- Free or supported?
- Cluster beams: a jump in knowledge
- Geometric & electronic structure, magic numbers
- Electron dynamics and optical properties
- Magnetic properties, superconductivity
- What about the Stern-Gerlach experiment?
- Chemisorption and catalysts

Time: 24, 29 Mai and 5, 12, 19, 26 June and 3 July 2018 from 16:00 to 18:00
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