Physics and Mathematics of Big and Giant Atoms

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We will discuss here the specific features of multi-electron atoms and Giant atoms that are constructed by an ordinary atom stuffed inside of a shell that consist of a big number od carbon atoms, so-called endohedrals. The nontrivial physics of these objects is determined by multi-electron or collective effects. To treat them we to determine at first clearly what can be attributed to the single-electron picture. We describe it in the frame of Hartree-Fock (HF) approximation.

We will discuss the mathematical peculiarities of HF equations and their solutions, namely non-uniqueness, specifics of asymptotic behaviour, gauge non-invariance etc. These peculiarities affect processes with participation of ordinary and Giant atoms. As a tool to study collective effect we will use the the perturbation theory and one of its infinite summations - the so-called random phase approximation with exchange (RPAE). An important feature of perturbation theory expansions is the presence of logarithmic terms along with the power ones.

We will give examples that illustrate strong collective effects in different processes such as photoionization, electron scattering and vacancy decay of big and, particularly, Giant atoms.

The combination of Coulomb long-range interparticle interaction and exchange leads to specific singularities in the analytic behavior of the scattering electron-atom amplitude that acquire higher order poles and complex cuts. Coulomb forces modify qualitatively the near threshold behavior of ionization cross-section.

Strong field and short duration laser pulses acting upon big and Giant atoms introduce new physics and require new mathematical tools for their description.