Many-body calculations on vertical quantum dots

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During the last decade a new field on the border between condensed matter physics and atomic physics has emerged. It all started with the fabrication of so called vertical quantum dots, also called artificial atoms. Modern semi-conductor techniques allowed for the fabrication of adjustable quantum confinements containing only a few and controllable number of electrons. The experimental techniques are so refined that one can start with zero electrons in the dot and then inject one electron at a time. This procedure has shown many similarities between quantum dots and atoms, for example the existence of shell structure. The tuneability of their properties through external electric or magnetic fields makes quantum dots a promising candidate for quantum computers and nano–electronics. A few good experimental studies have worked as catalysts for a vast number of theoretical studies on the subject. Most of the theoretical studies have worked within the framework of Density Functional Theory (DFT) but also a number of Hartree–Fock (HF) and Configuration Interaction (CI) studies have been performed. The DFT–studies have been very successful, however they are limited in that one has to guess the density functional. The CI studies are limited by the long computation times and therefore the largest number of electrons in a full CI study yet is six. Therefore we believe that the existence of an ab initio calculation on quantum dots is very important and this has led us into believing that Many Body Perturbation Theory (MBPT) could be the best way. We have performed second order perturbation theory calculations on so called vertical 2D circular quantum dots. We have compared these results to our own HF–calculations and thereby proved the importance of correlation effects in 2D vertical quantum dots. We have also compared our calculations with others experimental results, DFT–calculations and CI–calculations and we know believe that MBPT of higher order is very promising since ab initio correlation calculations up to the experimental limit (about 20 electrons) seems important and feasible through this method.