Electron localization in semiconductor nanostructures: from quantum to classical correlations

A. Puente, M. Pons

Universitat de les Illes Balears, Departament de Física, E-07122 Palma de Mallorca, Spain
toni.puente@uib.es

Abstract

The properties of electronic ground state wave functions in semiconductor nanostructures under the influence of a magnetic field, has been the subject of many theoretical efforts in the last decades. Many finite system studies have been carried out [1] providing also useful insight into the behavior of the 2d electron gas at different filling factors, and in particular in the fractional quantum Hall regime. Several theoretical descriptions have been proposed, differing mainly in the way correlations are included and how symmetries are dealt with in the wave functions. Starting from the seminal paper by Laughlin [2], these include composite-fermion methods [3], pinned Hartree-Fock Wigner crystals [4] or the quantal theory of roto-vibrational electron molecules [5] for finite systems. In this work we analyze the infinite magnetic field limit as a source of electron localization by using simple pinned Wigner crystal wave functions. Supported by exact solutions for N=2 and N=3 [6] electrons at very high magnetic fields, we explicitly show that the interplay of confinement and electronic interaction, essential to describe fractional filling factor states, can be dealt with in a perturbative way for any number of electrons. The role of different shape isomers and their effect on quantum dot addition energies at high magnetic fields will be discussed.

References

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