Quantality and correlation measures in many-body systems

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The "quantality" parameter $\Lambda = h^2/(Ma^2V_0)$, introduced by de Boer and others in studies of gas solids [1], measures, in a loose sense, the strength of a two-body (or more complicated many-body force), V_0, expressed in units of the quantal kinetic energy associated with a localization of a constituent particle of mass M within the distance a corresponding to the radius of the force at maximum attraction. For small Λ the quantal effect is small and the ground state of the many body system will be, as in classical mechanics, a configuration in which each particle finds a static optimal position with respect to its nearest neighbors. If Λ is big enough the ground state may be a quantum liquid in which the individual particles are delocalized and the low-energy excitations (quasi-particles) have infinite mean free path. A parameter related to Λ was first used by de Boer in the analysis of quantal constants of the noble gas solids.

The aim of this work is to study in more detail the above quantality parameter by using the expectation values of the kinetic and potential energies obtained from *ab initio* calculations of various quantum mechanical systems. In particular we focus on quantum dots and nuclei. The aim is extract information about correlations in complicated many-particle systems. Quantum dots have been chosen as one of the systems due to the possibility to tune the frequency of the trapping potential. With a small frequency we enter a region where correlations induced in the potential energy become more important with respect to the kinetic energy, leading thus to a decrease in Λ. Similarly, for nuclei, we investigate the role of two-body and three-force in chains of isotopes like the oxygen, calcium and nickel isotopes. The latter gives us the possibility to study the evolution of Λ as a function of an increasing number of neutrons. As the system becomes more and more neutron reach, one reaches the so-called neutron drip line, where adding one additional neutron renders the nucleus unstable with respect to one-neutron decays. Towards the drip line, nuclei become weakly bound, reflected in a diminishing separation energy (give definition). This is reflected in a dimishing value of the kinetic and potential energies.

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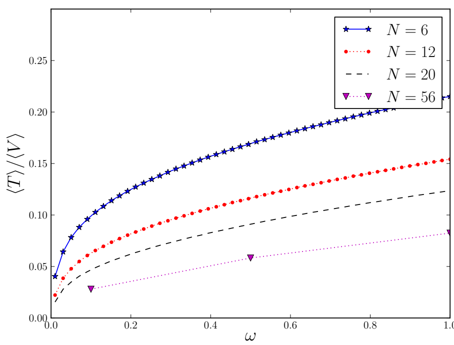

FIG. 1: Diffusion Monte Carlo results for the ratio $\langle T\rangle/\langle V\rangle$ as function of the oscillator frequency ω.

[1] B. R. Mottelson, Nucl. Phys. A **649**, 45 (1999).