13.5 Quantum Fluids, Solids and Droplets: Some Recent Results

Many new calculations have been done on quantum fluids, solids and droplets. We will mention a few of the new applications and techniques. Improvements and enhancements to the variational wave functions have been made. Among these are better optimized wave functions and the application of the Shadow wave function to a wide variety of problems.

Optimized two-body correlations have been calculated using a basis set expansion by Vitiello and Schmidt [13.115]. Shadow wave functions have been applied to a variety of problems. In ^{4}He these include the density matrix of ^{4}He [13.116], the vortex line [13.117] and excitations [13.118-120]. The basis set expansion above has been included in the shadow wave function for the ground state [13.121,2]. The shadow wave function seems to give a better variational description of ^{4}He properties. The shadow results have also been extended to finite temperatures [13.119].

Helium in two-dimensions has been studied variationally by Belic et al. [13.123].

Droplets of helium atoms with impurities have been studied both variationally and with diffusion and Green's function Monte Carlo by several groups. Barnett and Whaley [13.124] have studied the effect of H_2, D_2, Cl_2 and SF_6 on He droplets. SF_6 also has been studied by Krotscheck and Chin [13.125] and Cl_2 impurities have been studied by Bacic et al. [13.126]. ^{3}He impurities in ^{4}He droplets have been studied by Belic et al. [13.127].

A diffusion Monte Carlo calculation of liquid ^{4}He at negative pressures near the spinodal density have been made by Boronat et al. [13.128].

A number of new path integral Monte Carlo results and methods have been obtained. Pollock and Runge have analyzed the superfluid transition of ^{4}He using finite size scaling [13.129]. Sindzingre et al. [13.130] have studied clusters of parahydrogen and find that small clusters can undergo a superfluid transition. Hydrogen surfaces have been simulated using path integral Monte Carlo by Wagner et al. [13.131,2].

D.M. Ceperley had developed the analog of the fixed-node approximation for the path integral Monte Carlo method and applied it to solving the finite temperature fermion problem. A trial density matrix is used to restrict the paths so that the sign problem does not arise. The simplest example for a trial density matrix is the free fermion density matrix. Only Monte Carlo paths, where the path evaluated from the trial density matrix gives a positive contribution, are used. The method becomes exact if the trial density matrix is the correct density matrix. Liquid ^{3}He at finite temperature has been successfully simulated [13.133].

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