Quantum Monte Carlo study of the two-dimensional electron gas in presence of Rashba interaction

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The Rashba interaction, an electric field induced spin-orbit coupling, has been observed in semiconductor hetero-structures, and has been proved to be tunable in strength through a gate voltage. Electrons are confined inside of a narrow quantum well, subject to an effective magnetic field coupling to their spin. Such coupling gives rise to the well known Rashba potential:

$$V_{Rashba} = \lambda \sum_i^N [\, p_i^y \sigma_i^x - p_i^x \sigma_i^y]$$

The external voltage can then be used to control the spin state of the system. This property becomes extremely interesting in view of spintronics applications.
Though the problem for uncharged electrons would be analytically solvable, once the Coulomb interaction is included in the Hamiltonian, together with the kinetic energy and the Rashba interaction, no analytic solution is available.
We introduce a variant to the Diffusion Monte Carlo algorithm which can be employed in order to obtain very accurate results for the ground state of the interacting electron gas. Because of its spin-orbit nature, the Rashba interaction depends on momenta and spins of the electrons and therefore cannot be treated within the frame of a standard algorithm. A specific imaginary time spin dependent propagator has been developed and implemented, containing besides a diffusion and weighting factor, also a spin rotation.
With the use of our extended Diffusion Monte Carlo we calculated an equation of state for the system, giving the ground state energy as a function of density, Rashba interaction strenght and Rashba spin states polarization[1]. What we found is a non zero Rashba spin states polarization, whose intensity depends on the Rashba potential strength and becomes more pronounced at lower densities.

[1] A.Ambrosetti, F.Pederiva, E.Lipparini and S.Gandolfi, Phys. Rev. B 80, 125306 (2009)