PERSISTENT CURRENT OF FEW INTERACTING ELECTRONS

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Up to three interacting electrons confined in a quasi-one dimensional ring are investigated by numerical diagonalization. The limit of strong repulsion is identified with a rigid rotator. For spinless electrons the persistent current in a clean ring is independent of the interaction. With spin the periodicity of the current of N electrons changes to $h/(eN)$ in the rigid rotator limit. Introducing a delta-barrier in this *continuous* model destroys the translation invariance. First results indicate that the persistent current of spinless electrons increases with increasing interaction.

The persistent current caused by a flux ϕ penetrating the ring at zero temperature is proportional to the slope of the ground state energy with respect to ϕ. We have obtained exact many-body eigenstates of N interacting electrons in a quasi-one dimensional ring by numerical diagonalization for given values of ϕ and L. The circumference L parametrizes the strength of the interaction [1]. The levels can be classified according to the total spin S and their sequence depends on ϕ and on L. Maximum spin $S = N/2$ corresponds to spinless electrons.

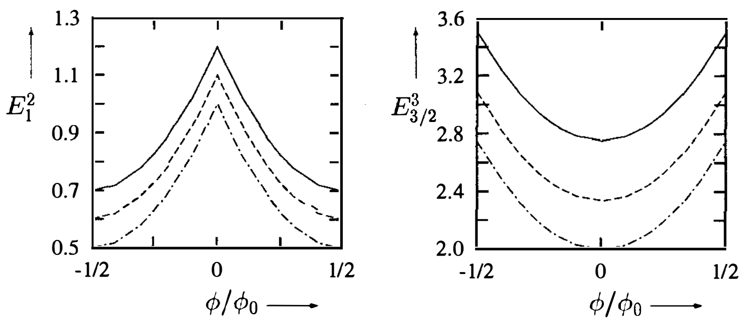

FIG. 1. Energy of the lowest state with maximum spin ($S = N/2$) versus ϕ, left for $N = 2$ ($E_{S=1}^{N=2}$) and right for $N = 3$ ($E_{S=3/2}^{N=3}$), in units of hB_N ($B_N = \pi\hbar/(Nm_e^* L^2)$: rotational constant). Dashed-dotted $L = 0.001 a_B$, dotted $L = 1 a_B$, solid $L = 1000 a_B$ or $L = 100 a_B$ for $N = 2$ or $N = 3$, respectively.

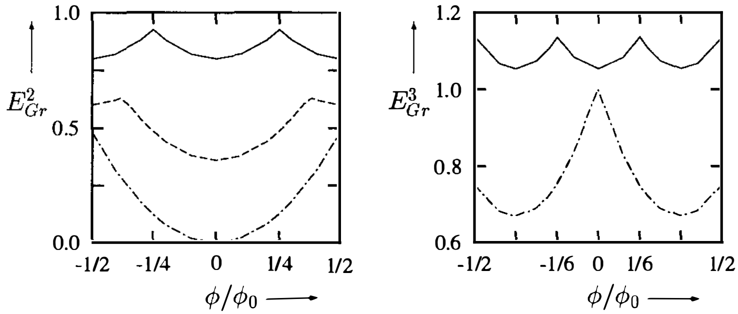

FIG. 2. Same as Fig. 1 but now for the ground state energy versus ϕ.

Figure 1 shows the energy of the lowest state with maximum spin and Figure 2 the true ground state energy versus ϕ. For $L = 0.001 a_B$ the electrons are effectively non-interacting. On the other hand the strong interacting limit is reached for $L \gtrsim 100 a_B$. In this case the spectrum corresponds to the one of a rigid rotator.

The slopes seen in figure 1 are exactly equal despite the Coulomb interaction increases by a factor of 10^3 from curve to curve. For spinless electrons in the translationally invariant case the wavefunctions can be separated into a center of mass and a relative part. The persistent current depends only on the former while the interaction affects only the latter. This separation does no longer occur for electrons carrying spin. Strong interaction makes the persistent current $h/(eN)$-periodic as can be seen in figure 2. This result has also been found for the lattice model of a Hubbard ring in the large U limit [2].

Our main motivation for this work is to analyze the persistent current when the translational invariance is destroyed. We choose to introduce a delta-barrier in the ring. The first results indicate that the Coulomb interaction counteracts to the suppression of the persistent current that arises due to the presence of the delta-barrier, in agreement with [3]. Further work is in progress.

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[1] K. Jauregui, PHD-Thesis, Universität Hamburg 1995, (PTB-Bericht PTB-PG-7, ISBN 3-89429-665-8 (Physikalisch-Technische Bundesanstalt Braunschweig)) and references therein.

[2] F. Kusmartsev, J. Phys. Condens. Matter **3**, 3199 (1991). N. Yu and M. Fowler, Phys. Rev. B **45**, 11795 (1992).

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COURANT PERMANENT DE QUELQUES ÉLECTRONS EN INTERACTION

Jusqu'à 3 électrons interagissants entre eux et confinés dans un anneau unidimensionel sont étudiés à l'aide de diagonalisations numériques. Ce système dans la limite de l'intéraction forte s'apparente à un rotateur rigide. Le courant permanent d'électrons sans spin dans un anneau sans impureté ne dépend pas de l'intéraction. Par contre, la périodicité du courant de N électrons avec spin est modifiée et prend la valeur $h/(eN)$ à la limite du rotateur rigide. L'introduction d'une barrière delta dans ce model *continu* détruit l'invariance par translation. Des résultats préliminaires de ce cas indiquent que le courant d'électrons sans spin augmente parallèlement à une augmentation de l'intéraction.