The spin–singlet and spin–polarized incompressible states at filling factor 2/3: what is their physical nature?

Karel Výborný and Daniela Pfannkuche
1st Institute of theoretical physics, University of Hamburg, Jungiusstr. 9, D–20355 Hamburg, Germany

The concept of composite fermions provides very illustrative models for many of the incompressible fractional quantum Hall (FQH) states [1]. The ground states of electrons at some particular fractional filling factors are mapped onto integer–filling–factor states of composite fermions (CF) and this idea can be used e.g. to explain the existence of gap of the FQH states. This mapping is very powerful, yet the analogy between Landau levels occupied by electrons and Landau levels occupied by composite fermions is by far not complete.

We study the incompressible ground states at filling factors $\nu = \frac{2}{3}$ and $\frac{2}{5}$ obtained by exact diagonalization of few–electron systems in a rectangle with periodic boundary conditions and focus on the spin–resolved electronic density–density correlation functions. We highlight the differences between the FQH states (interpreted as integer–filling CF states) and their integer–filling electronic counterparts. Also we stress the differences between the states at $\nu = \frac{2}{3}$ and $\nu = \frac{2}{5}$ which, from the viewpoint of CFs, differ only in the direction of the effective magnetic field.

A detailed investigation of the $\nu = \frac{2}{3}$ singlet state suggests that it comprises of pairs of electrons of unlike spin which in whole form a state analogous to a completely occupied lowest Landau level (Fig. 1). This conclusion cannot be obtained from the corresponding CF wavefunctions in a straightforward manner. We also address the ambiguity in the interpretation of the polarized $\nu = \frac{2}{3}$ state [2]: either as a $\nu_{CF} = 2$ state or a particle–hole conjugate to the Laughlin state at filling $\nu = \frac{1}{3}$.

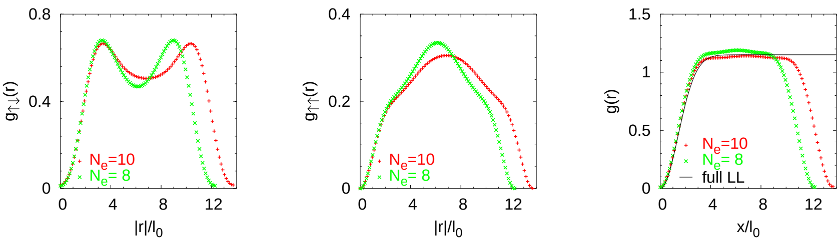

Fig. 1. Correlation functions in the $\nu = \frac{2}{3}$ singlet ground state as calculated with $N_e = 8$ and 10 electrons in a square with periodic boundary conditions (r goes along the diagonal of the square). The strong maximum at $r \approx 3.4\ell_0$ in $g_{\uparrow\downarrow}(r)$ suggests the pairing of electrons of unlike spin (*left*); no similar feature is observed in correlations of like spins (*middle*). The spin–unresolved correlations (*right*) strongly resemble those of the lowest Landau level filled by $N_e/2$ particles.

[1] O. Heinonen: Composite Fermions. World Scientific, Singapore, 1998.
[2] X.G. Wu, G. Dev, and J.K. Jain, *Phys. Rev. B*, **71**, 153 (1993).