

## Electron fluid and quasiparticles in the quantum Hall effect

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**Abstract.** To explain fractional quantum Hall effect, it is necessary to take into account both the interaction between electrons and their interaction with impurities. We propose a simple model, where the Coulomb repulsion is replaced by a short range potential. For this model we are able to find many-body wave functions of the electron system interacting with impurities and calculate the Hall conductivity  $\sigma_{xy}$ . A simple physical picture, arising in the framework of this model, provides the understanding of a general reason for both fractional and integral quantum Hall effect.

In the model, electrons forming a two-dimensional system, is supposed to occupy the first Landau level. The interaction of electrons is regarded as being small compared with the distance between the Landau levels. The radius of interaction is much less than the magnetic length. The following statements have been proved (Pokrovsky and Talapov 1985a,b; Trugman and Kivelson 1985). For the filling  $\nu = 1/m$  of the first Landau level the ground state is nondegenerate and has the wave function  $\psi_0$  proposed by Laughlin (1983). For  $\nu$ , which is slightly less than  $1/m$  the ground state is highly degenerate in the absence of impurities. It can be described as a system of noninteracting quasiholes as proposed by Laughlin (1983). These quasiholes float in the uniform incompressible fluid. Each quasihole has the charge  $|e|/m$ . The total number of quasiholes is  $q = S - mN$ , where  $S$  is a number of states on the Landau level,  $N$  is the number of electrons. The impurities capture quasiholes. If the number of quasiholes  $q$  is less than the number of impurities  $N_i$ , then the ground state becomes nondegenerate. This fact permits us to calculate  $\sigma_{xy}$  (Pokrovsky and Talapov 1985b). Let there be a small electric field  $E$  in the system. In the absence of impurities the electron fluid is at rest in the frame of reference, moving with velocity  $v = cE/H$ . In this frame of reference the impurities move with the velocity  $-v$ , carrying captured quasiholes. Therefore, the quasihole current is  $j_q = (-v)(|e|/m)q$ . Hence, in the initial frame of reference the total current is  $j = Nev + j_q = Sev/m$ . This means that  $\sigma_{xy} = (1/m)(e^2/2\pi\hbar)$ .

**Keywords.** Quantum Hall effect; electron fluid; quasiparticles.

PACS No. 72-15

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