About the paper "TWO-DIMENSIONAL ELECTRONS IN A STRONG MAGNETIC-FIELD"BYCHKOV Yu. A., IORDANSKII S.V., ELIASHBERG G.M (1981)

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In the beginning of 1980 I have met Yu. A. Bychkov (we were co-authors of a couple of articles), who has just read current physics literature (which he did regularly). He told me that after reading an article of H. Fukujama, published in Technical Report ISSP Ser A 993 (1979) (Japan), he has found new field of activity. An article was about Wigner crystal research. This crystal is created by two-dimensional electrons in an extremely strong magnetic field, and energy of interaction with the field is much bigger than energy of Coulomb interactions between electrons. The problem was that Landau levels for electrons in magnetic field have multiple degeneration. This makes considering Coulomb interactions nearly impossible, even by using perturbation theory. Soon, G. M. Eliashberg joined us. With him, we have tried to consider Coulomb interactions for a small number of electrons in the first order of the perturbation theory.

It was discovered, that this problem can be solved analytically only for two or three interacting electrons. For a larger number, you will need to solve secular problem, order of which rises with this number. The only simple solution is when all electrons are on the same Landau level with a fully asymmetric wave function with a constant density that corresponds to a full local filling of the level. The paper [1] was the first attempt to apply the ideas of the perturbation theory for a multi-electron problem. An actual idea had been acknowledged by the physics community, and several articles had appeared on this topic. However, a reasonable calculation method, for obtaining the state with a fractional filling of the Landau level was not created.

Than, we knew nothing neither about the discovery of the Integer Quantum Hall Effect (K. Klitzing.1981), nor about the discovery of a Fractional Quantum Hall Effect (Tsui, Stoermer, Gossard.1982). We have found about it on the Soviet-American symposium in the autumn 1982 in Sweden. A boom in the physics of the two=dimensional electron systems placed in the strong magnetic field has started. Focus was on the search of the energy gap, separating states occupied by the electrons from non-occupied, needed for the existence of the FQHE. An American R. Laughlin (1983) had the most success, constructing multipartical function (Laughlin's function) from the wave functions of the lowest Landau level with the density of the 1/3 of the density of the fully filled quantum level. However, he did not find any proof of existence of the energy gap (see, e.g. [2]).

Physical reason for the appearance of this gap turned out to be linked to thermodynamic instability of states with fractionally filled Landau levels and creation of the vortices. This is because vortex speed of the electrons is followed by the appearance of the magnetic momentum of the current, which decrease free energy in the fixed external magnetic field (we can neglect with weak edge current and magnetic field created by it). Decrease in the free energy of the sample is proportional to the area , but its internal energy is increased as logarithm of its size [3]. This phenomenon (creation of vortex structure) is similar to creation of vortices at rotation of quantum liquid. This way, in a two-dimensional system, periodic vortex lattice appears. Energy gaps in a "vortex crystal"appear only at rational number of flux quantums of the "effective"field (sum of flow of external magnetic field and fluxes of vortices) This gives an explanation about all observed densities in FQHE [3].

Another part of the article [1] was luckier. Electron excitations for fully filled lowest Landau level, when one electron gets excited and goes on the next Landau level with the same direction of spin, or just changed the direction of spin, was studied. Such excitation is neutral, as it is made out of electron and hole. That is why it's momentum has to be conserved, even in external magnetic field. A neutral exciton is formed. For Mott's exciton in a crystal it had been shown by L. P. Gorkov and I.E. Dzyaloshinskiy [4]. Accurate calculations were carried out by I. V. Lerner and Y. E. Lozovik [5]. Our case is a bit different from Mott's exciton and allows direct analytical consideration of wave function of exciton and direct calculation of commutators with Hamiltonian including Coulomb interaction. This gives an expression for energy of such exciton, depending only on its momentum (in both cases of Coulomb and spin exciton). All of this was rather trivial, so in the article only answers for energies are given. Later, approaches found in the article were used for different more complicated excitations.

In conclusion, I would like to say, that publication of the paper abroad in the 80's of the last century was a really hard thing, as an article had been send by mail, which took many months. Our work was published in JETP Letters that, luckily, were often read abroad. C. Kallin and B. Halperin's work [6] on the same topic (exciton) was published 3 years later in Phys. Rev. Unknown to me reviewer pointed out to authors, that main result had already been achieved earlier. Authors had to include reference to our work, but their work was published in Phys. Rev. and later foreign references were, as a rule, on their work only.

My work [7] about QHE, made during symposium in Sweden, was sent from there by mail to Solid State Communications. Editors of the journal, had sent me corrections to USSR by mail, and I've sent replies with occasional people traveling abroad. All of this caused unnecessary delays, and almost cost me my priority. It is good to live in the epoch of emails!

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