Scientific session of the Division of General Physics and Astronomy of the Academy of Sciences of the USSR (30 March 1988)

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A scientific session of the Division of General Physics and Astronomy of the USSR Academy of Sciences dedicated to the twenty fifth anniversary of the Institute of Solid State Physics at the USSR Academy of Sciences was held on March 30, 1988, at the Institute of Solid State Physics of the USSR Academy of Sciences (Chernogolovka, Moscow region). The following reports were presented at the session:

1. Introductory remarks by the Academician A. M. Prokhorov, Secretary of the Division of General Physics and Astronomy of the USSR Academy of Sciences.

2. *Yu. A. Osip'yan.* High-temperature superconductivity in Y–Ba–Cu–O single crystals.

3. *V. A. Grazhulis and V. S. Tsoi.* Low-temperature spectroscopy of metal and semiconductor surfaces.

4. *I. V. Kukushkin and V. B. Timofeev.* Magnetooptics of two-dimensional electrons in the integral and fractional quantum Hall effect regimes.

5. *A. V. Serebryakov.* New technological materials with special physical properties.

A brief summary of one of the reportes is presented below.

I. V. Kukushkin and V. B. Timofeev. *Magnetooptics of two-dimensional electrons in the integral and fractional quantum Hall effect regimes.* The discovery of the integral[1] and fractional[2] quantum Hall effects (QHE) proved an important event in contemporary semiconductor physics. The effect consists of Hall resistance quantization in two-dimensional electron systems at low temperatures in strong magnetic fields. The quantized values of the resistance are determined by universal constants and the filling factor ν of the electronic states. Remarkably, the quantization of the resistance persists at rational values of the filling factor: $\nu = p/q$, where p and q are integers. A microscopic description of the integral and fractional QHE requires knowledge of the density of states of two-dimensional electrons in the presence of disorder. The effect of electron-electron interaction on the electronic energy spectrum must also be taken into account.

All experimental methods based on measurements of such quantities as magnetoconductance, magnetic susceptibility, magnetocapacitance, electronic heat capacity, cyclotron resonance are sensitive only to the properties of electrons near to the Fermi surface. One of the most powerful methods of measuring directly the energy spectrum of two-dimensional electrons, including measurements of the single-particle density of states above the Fermi surface and the splittings between filled levels, is based on recording the radiative recombination of two-dimensional electrons with photoexcited holes. The spectrum of the radiation is determined by a convolution of the distribution functions of two-dimensional electrons and photoexcited holes. We know experimentally that the holes participating in recombination have a very narrow energy distribution. Consequently, the luminescence spectrum directly reflects the single-particle density of two-dimensional electrons.

We have applied the optical spectroscopy method to study the Landau level structure both in silicon metal-insulator-semiconductor structures[3] the single GaAs-AlGaAs heterojunctions. We measured the magnitudes of cyclotron, spin, and intervalley splittings. We have shown that the electron-electron exchange interaction markedly increases the spin and intervalley splittings. For example, in GaAs-AlGaAs heterojunctions the two-dimensional electronic g-factor was enhanced by a factor of 30 when the filling of one electronic spin component was much greater than that of the other. We discovered oscillations in Landau level broadening as a function of the filling factor and demonstrated that this effect is due to screening of the long-period fluctuations of the random defect potential. At integral filling of Landau levels this screening is practically nonexistent and the levels are strongly broadened as determined by the amplitude of the long-period fluctuations. At half-integral filling, electrons are at their most efficient in screening the long-period fluctuations of the random potential; Landau level broadening is then determined by short-period fluctuations and hence reduced.

In the fractional QHE regime we have observed for the first time the splitting of the radiative recombination lines of two-dimensional electrons.[4] The magnitude of the splitting makes it possible to evaluate the jump in the chemical potential of two-dimensional electrons when they condense into an incompressible Fermi liquid. By comparing the magnitude of the chemical potential jump with the activation energy measured under QHE conditions we conclude that the elementary excitations in the incompressible Fermi liquid are, in fact, quasiparticles of fractional charge that are separated from the ground state by an energy gap. We have shown that the condensation of two-dimensional electrons into an incompressible Fermi liquid is characterized by a critical temperature that depends on magnetic field and electron mobility.

[1]K. von Klitzing, G. Dorda, and M. Pepper, Phys. Rev. Lett. **45**, 494 (1980).
[2]D. C. Tsui, H. L. Störmer, and A. C. Gossard, Phys. Rev. Lett. **48**, 1559 (1982).
[3]I. V. Kukushkin and V. B. Timofeev, Zh. Eksp. Teor. Fiz. **93**, 1088 (1987) [Sov. Phys. JETP **66**, 613 (1987)].
[4]I. V. Kukushkin and V. B. Timofeev, Pis'ma Zh. Eksp. Teor. Fiz. **44**, 179 (1986) [JETP Lett. **44**, 228 (1986)].

Translated by A. Zaslavsky

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