PHOTOLUMINESCENCE OF A HIGH MOBILITY 2DEG IN THE FRACTIONAL QUANTUM HALL EFFECT REGIME

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Introduction

The electron-electron interaction strongly modifies the energy spectrum of the two-dimensional electron gas (2DEG) under a perpendicularly applied magnetic field ($B$), in the quantum Hall effect regime [1]. Various anomalies were observed in the PL spectrum at integer and fractional electron filling factors $\nu$. However, PL line splitting due to the e-e interaction at $\nu<1$, could hardly be resolved [2]. The reasons are either the photoexcited hole proximity to the 2DEG (in the case of modulation-doped quantum wells), or the broadening of the 2DEG-acceptor PL band in the case of Be-doped heterojunctions (HJs).

Experimental

We measured the magneto-PL spectra of several modulation doped, ultra-high mobility ($\mu_e > 5 \times 10^6$ cm$^2$/V·sec at 1 K) GaAs/AlGaAs single HJs at $T=1.2-0.3$ K. The 2DEG density varied in the range of $n_{2D}=(0.6-2.7) \times 10^{11}$ cm$^{-2}$. Low-density non-equilibrium electrons and holes were photo-excited at laser energies of 1.58 eV or 1.96 eV. An optical fiber and a polarizer inserted into the He3 cryostat were used for photoexcitation and collection of the circularly polarized PL. The magnetic field varied up to 25T.

Results and Discussion

All studied HJs show PL peak energy and intensity anomalies at $\nu=2$ and 1, similar to those previously reported for such HJs [3]. An abrupt transfer between free exciton and 2DEG-hole PL is observed at $T<2$K. It results from the change in the exciton dissociation rate and the appearance of free holes near the magnetized 2DEG for $\nu<2$.

The strong PL anomalies near $\nu=2/3$ and $1/3$ are clearly observed for the HJs with $n_{2D}=1.9 \times 10^{11}$ cm$^{-2}$ (Fig. 1). These anomalies are seen only at the lowest temperature (0.3-0.4 K) and for HJs with $n_{2D}>1 \times 10^{11}$ cm$^{-2}$. Near $\nu=2/3$, a PL line broadening occurs, and several PL lines can be revealed. The energy separation between the PL lines is $\sim 0.1-0.15$ meV. In the range of $\nu=2/5-1/3$, the PL line splits into several lines with the energy separation of $\sim 0.2-0.3$ meV. It is important to notice that several HJs having various $n_{2D}$ show similar PL structure at $\nu=2/5-1/3$ and 2/3.

Conclusions

The obtained PL spectra clearly show splitting of the 2DEG-hole PL into several lines at fractional filling factor. We attribute this effect to a charge fractionalization of the magnetized 2DEG, when a hole can recombine with a quasiparticles and/or generate quasiholes in the incompressible 2DEG condensate.

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References