Evidence of Quantum Hall Gap Collapse Caused by Tilted Magnetic Field in Photoluminescence Spectra of a GaAs/AlGaAs Triple Quantum Well

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Introduction

The correlation effects in GaAs/AlGaAs quantum Hall triple quantum well were studied using magneto-photoluminescence measurements. One of the important consequences of the electron correlation in MQW is a collapse of the quantum Hall tunneling gaps predicted to occur in coupled QH bilayers in tilted magnetic field B in Ref.[1] and experimentally observed in Refs.[2].

Experimental

The triple quantum well studied here consists of a 22 nm thick GaAs central well and two 10 nm thick lateral wells all separated by 2 nm thick $Al_{0.3}Ga_{0.7}As$ barriers. Symmetric remote Si δ-doping ensures the total electron sheet density $n_s = 7x10^{11}$ cm^{-2} and the low-temperature mobility $\mu = 4x10^5$ cm^2/Vs. The circularly polarized PL measurements are performed at base temperature T~300 mK.

Results and Discussion

Oscillations of the photoluminescence intensity shown in Fig.1, observed in tilted magnetic fields were found corresponding to the tunneling interlayer gap collapses detected in magneto-resistance measurements and predicted to occur in tilted magnetic fields. The obtained experimental data were shown to agree well with the theory developed for double quantum well. This implies that the observed quantum Hall gap collapses are mostly caused by the tunneling between a pair of the quantum wells. Our results reveal a first spectroscopic evidence of the quantum Hall gap collapses. Indications of interlayer correlation effects influencing a character of the inter-Landau level gaps were found.

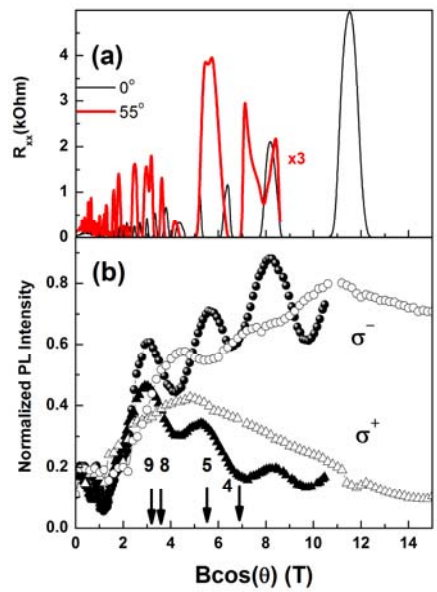

Fig.1. (a) Magnetoresistance traces measured at the temperature T = 50 mK in GaAs/AlGaAs triple quantum well at the tilting angle θ=0° (black line) and θ=55° (red line). (b) σ^+ (triangles) and σ^- (circles) normalized photoluminescence intensities measured at T = 300 mK in GaAs/AlGaAs triple quantum well as a function of the perpendicular magnetic field component at θ=0° (open symbols) and at θ=55° (closed symbols). The positions of the inter-subband quantum Hall gap collapses calculated according to Ref.[1] for the corresponding filling factors are shown by arrows.

Conclusions

The collapses of the quantum Hall tunneling gaps caused by tilted magnetic field were found in GaAs/AlGaAs triple quantum wells independently by magnetotransport and magneto-photoluminescence measurements in accord with the theory developed for double-quantum. This means that the observed quantum Hall gap collapses are mostly due to the tunneling between a pair of the nearest neighbor quantum wells.

Acknowledgement

Financial support from the Brazilian agencies FAPESP and CNPq is gratefully acknowledged. Work at the NHMFL was done under NSF Cooperative Agreement No. DMR-1157490, the State of Florida, and the U.S. Department of Energy.

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