Circularly Polarized Photoluminescence as a Probe of Spin Polarization and Interaction in GaAs/AlGaAs Quantum Hall Bilayers

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Circular-polarization-resolved magneto-photoluminescence was used to probe the spin character of electron and hole states in a GaAs/AlGaAs strongly coupled double-quantum-well system. In the low magnetic field regime shown in Fig.1(b), circular polarization and integrated photoluminescence intensities of the PL lines associated with symmetric and antisymmetric electron states present clear out-of-phase oscillations between integer values of the filling factor *v*. These oscillations are caused by magnetic-field-induced changes in the population of the Landau levels (LLs) near to the Fermi level and may be understood in terms of a simple single-particle model [1]. In strong quantizing magnetic field regime ($\nu < 4$) shown in Fig.1(a), when the cyclotron energy dominates, the electron energy spectrum of this system is composed of four closely spaced LLs and it has spin and pseudospin (associated with layer) degrees of freedom. The interaction among electrons makes them accommodating over the LLs to minimize the total energy and thus, resulting in a new ground state. Direct evidences for interaction effects are: (i) the nonlinear dependencies of the LL energies on the magnetic field resulting in the symmetric-antisymmetric gap shrinkage at $\nu = 3$, (ii) the unexpected behavior of the integrated PL intensity and (iii) the changes in the electron polarization. Our observations indicate to depolarization of the ferromagnetic ground state at $\nu = 2$ due to exchange interaction [2].

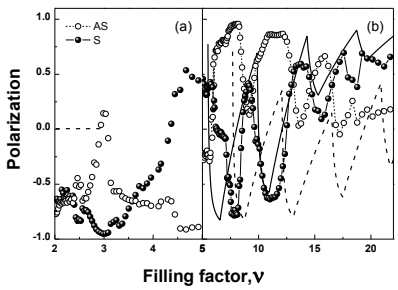

Fig.1. Polarizations of the PL lines assigned to the symmetric (closed circles) and antisymmetric (open circles) optical transitions measured as functions of the filling factor. Dashed line in panel (a) shows expected single-electron behavior, while full and dashed lines in panel (b) were calculated using multi-band k·p method.

[1] L. Fernandes dos Santos,Yu. A. Pusep,L. Villegas-Lelovsky,V. Lopez-Richard,G. E. Marques,G. M. Gusev,D. Smirnov,and A. K. Bakarov,Phy. Rev. B **86**, 125415 (2012).
[2] Yu.A. Pusep, L. Fernandes dos Santos, G. M. Gusev, D. Smirnov and A. K. Bakarov, Phys. Rev. Lett. **109**, 046802 (2012).