Quantum well D^- complexes in a high magnetic field: evidence for their interface nature

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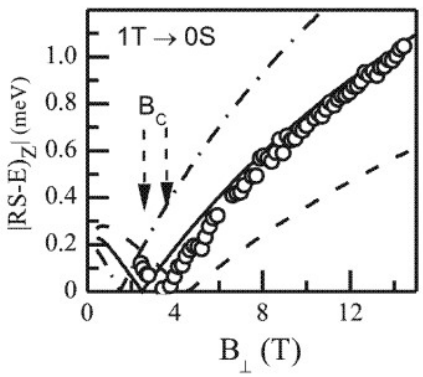
The spectra of excitations in quasi-two-dimensional systems (high quality GaAs/AlGaAs quantum wells) in a high perpendicular magnetic field are considered experimentally and theoretically. By the method of inelastic light scattering in the spectrum of scattered light two lines were observed. The first line is well-known and is identified as arising due to scattering process involving excitation of spin waves (spin excitons). The second line is new and is identified as resulting from the scattering process with the excitation of $\mathbf{D}^-$ complex. All the excitations studied in this work are spin excitations, and quasi-two-dimensional electrons do not change Landau level. $\mathbf{D}^-$ complex is constructed from two quasi-two-dimensional electrons in the quantum well and positively charged donor impurity. The considered excitation corresponds to the spin-flip of one of the electrons accompanied by a change in the Coulomb interaction. Energies of the singlet and triplet states of the complex in the high-field approximation (all electrons are on the lowest Landau level) are calculated taking into account the interaction energies dependence on the well width. The position of impurity inside the well, outside the well or on the well-barrier interface is considered.

The results demonstrate the switch of the ground state for the barrier $\mathbf{D}^-$ complex from the triplet 1T (higher fields) to the singlet 0S (lower fields) which corresponds to zero energy point in Fig.1. Comparison of the calculations performed for different impurity positions and experimental data leads to a firm conclusion that impurities in such quantum well structures are located at the interface.



Theoretical (solid and dashed lines) and experimental (circles) correspond to the energies for the excitations between 1T and 0S D- complexes for the well width 20 nm. Solid line represents the calculated data for the barrier D^- complex and coincides with the experimental results. Dashed lines correspond to the calculations with the positive charge located at a distance of 10 nm from both sides of the barrier.