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The linewidth broadening of exciton resonances in GaAs-based quantum wells

The electron-hole (e-h) pairs in heterostructures with quantum wells (QWs) have been experimentally and theoretically studied for several decades [1]. A quality of grown heterostructures and a precision of experimental techniques are gradually increasing [2] and imply that the nonradiative broadening of the exciton resonances can be reduced to the order and even smaller than the radiative one [3].

In this report, the calculated energies as well as radiative and nonradiative linewidth broadenings of the e-h bound (excitonic) and quasibound (resonant) states in GaAs-based QWs are presented. The resonant ones take place in the continuous spectrum of the in-plane relative e-h motion above the exciton states [4]. To calculate the energies and the nonradiative linewidths, we apply the developed finite-difference algorithm [5, 6] combined with the complex scaling technique [7, 8, 9]. We obtain the energy spectrum of bound and quasibound states of e-h pairs for arbitrary QW widths. This allows us to observe a crossover of energy levels from the model of the 2D exciton in narrow QW to the quantization of the exciton as a whole in wide QW. We determine the nonradiative broadenings of several lowest e-h resonances for different QW widths. We study a dependence of the linewidths of resonant states on the type of the excited state, on the thickness of QW, and confront the calculated data to the analytical results [10]. The estimated nonradiative broadenings are compared to the calculated radiative ones [4]. The radiative linewidth broadenings are obtained based on the exciton-light coupling theory [1]. The numerical results are compared to the data measured in reflectance experiments for high- quality GaAs-based heterostructures with QWs.

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