Giant optical fluctuations in GaAs quantum wells with different widths

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In single GaAs / AlGaAs quantum well (QW) systems with electron concentration $n_s \sim 4 \times 10^{11}$ cm^{-2}, the photoluminescence (PL) of recombination process between quasi-two-dimensional (2D) electrons and photoexcited holes is studied in the vicinity of the electron filling factor $\nu = 2$. Comparative analysis of the PL intensities in the structures with wide ($l = 250$ A) and narrow ($l = 120$ A) QWs allows revealing differences in the character of their giant optical fluctuations (GOF), wherein the PL statistics deviates appreciably from the Poisson description. For a narrow quantum well the GOP effect is observed in a wider range of magnetic fields in the vicinity of $\nu = 2$. However, large-scale macroscopic correlations of 2D PL intensities (as in a wide QW) are not observed. For a wide QW the GOF effect is noticeably more pronounced, but it decreases rapidly as we move away from the point of $\nu = 2$. One can expect, that parameters affecting the PL intensity correlations are the wave function of 2D electrons of the ground subband as well as wave function and concentration of valence holes, both depending of nonequilibrium filling of the first excited subband. It is proposed to associate these differences with a more significant dependence on the concentration of 2D electrons in a wide QW due to the Coulomb interaction under nonequilibrium conditions. The electronic structure of a narrow QW exhibits obviously a spatially inhomogeneous state consisting of local regions characterized by different filling factors. The experimental data indicate that a homogeneous state with $\nu = 2$ in a wide QW is formed at scales significantly exceeding the scale of long-range fluctuations of a random potential, which has properties of an incompressible quantum liquid.