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Barrier potential and magnetic field confinement effects on the Landé *g* factor in a GaAs-(Ga,Al)As cylindrical quantum well wires

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Abstract – We have performed a theoretical study of the barrier and magnetic confinement effects on the Landé *g* factor in GaAs-(Ga,Al)As cylindrical quantum well wires. We consider the annisotropy and nonparabolicity effects by mean of the Ogg-McCombe effective Hamiltonian, which include terms up to fourth order. The present calculations are presented as a function of the strength of the applied magnetic field, aluminun concetration in the barrier material and radius of the cylindrical quantum well wires. Our results are found in good agreement with previous theoretical results.

In order to study the barrier confinement and magnetic confinement effects on the Landé *g* factor in GaAs-Ga$_{1-x}$Al$_x$As quantum well wires under axis-parallel applied magnetic fields, we assume the effective mass approximation and take into account the non-parabolicity and annisotropy of the conduction band in each host material via the Ogg-McCombe effective Hamiltonian,

$$\hat{H} = \frac{\hbar}{2}\hat{\vec{K}}\frac{1}{m(\rho,z)}\hat{\vec{K}} + \frac{1}{2}g(\rho,z)\mu_B B\sigma_z + a_1\hat{K}^4 + \frac{a_2}{l_2^4} + a_3\left(\left[\hat{K}_\rho^2,\hat{K}_\varphi^2\right]_+ + \left[\hat{K}_\varphi^2,\hat{K}_z^2\right]_+ + \left[\hat{K}_z^2,\hat{K}_\rho^2\right]_+\right)$$
$$+ a_4B\hat{K}^2\sigma_z + a_5B\left[\hat{\vec{\sigma}}.\hat{K}_\rho^2,\hat{K}_\varphi^2\right]_+ + a_6B\hat{\sigma_z}\hat{K}_z^2 + V(\rho,z) \quad (1)$$

To consider the aluminum concentration effects we employ the 5-level semiempirical **k**·**p** theory for the Landé *g* factor and effective mass in each host material

$$\frac{g^*}{g} = 1 - \frac{E_P}{3}\left(\frac{1}{E(\Gamma_6^c-\Gamma_8^v)} - \frac{1}{E(\Gamma_6^c-\Gamma_7^v)}\right) - \frac{E_{P'}}{3}\left(\frac{1}{E(\Gamma_7^c-\Gamma_6^c)} - \frac{1}{E(\Gamma_8^c-\Gamma_6^c)}\right) + C', \quad (2)$$

$$\frac{m^*}{m} = 1 + \frac{E_P}{3}\left(\frac{2}{E(\Gamma_6^c-\Gamma_8^v)} + \frac{1}{E(\Gamma_6^c-\Gamma_7^v)}\right) - \frac{E_{P'}}{3}\left(\frac{1}{E(\Gamma_7^c-\Gamma_6^c)} + \frac{2}{E(\Gamma_8^c-\Gamma_6^c)}\right) + C. \quad (3)$$

The Landé *g* factor exhibit a strong dependence on the radius and aluminum concentration. On the other hand, the g factor dependence on the applied magnetic field present an increasing behavior as a radius is increased, which can be explained by the competence between the barrier and magnetic confinements. The *g* factor behavior as a function of the radius are found in very good agreement with previous theoretical results by F. E. López et al. [1] and Kiselev et al. [2] for x=0.35.

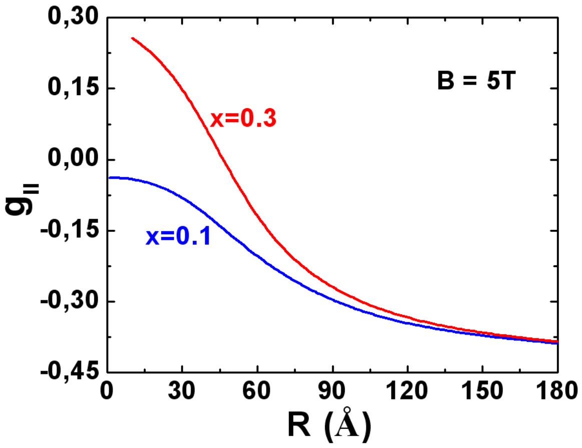

Figure 1: g factor as a function of the radius of the cylindrical quantum well wire for B=5T and two different combinations of the aluminum concentration.

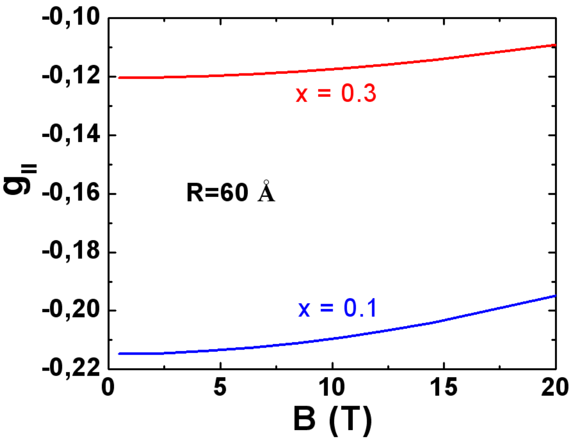

Figure 2: g factor as a function of applied magnetic field for R=60 Å and two different combinations of the aluminum concentration.

[1] F. E. López, B. A. Rodríguez, E. Reyes-Gómez, and L. E. Oliveira, preprint submitted to IOP publishing.
[2] A. A. Kiselev, Ivchenko, Rössler, PRB **58**, 16353 (1998).