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A Second-Quantization Approach to the Analytical Faraday Effect in Graphene

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We investigate coherent single photon traveling in the positive z direction passes through a graphene film subjected to a transverse magnetic field B. Analytical expressions are obtained for the transmission and reflection coefficients by full second-quantized form. Giant Faraday rotations in the infrared regime are generated and measurable Faraday rotation angles in the visible range become possible. For an example, this explains the departure from the semiclassical value for θ_F observed in the right panel in $B \approx 1$ T for $\hbar\omega = 10$ meV ($B \approx 0.5$ T for $\hbar\omega = 30$ meV). If the magnetic field intensity is higher than a given value, we necessarily have $N_F = 0$ (for 0.05 eV this value is about 1.9 T). In this case, the Hall conductivity at $T = 0$ is fully determined by a single type of interband transition, and assuming $E_1(B) \gg \hbar\omega$, we obtain $\theta_F \approx 3 \times 10^{-4}$.

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