Erratum: Quasiequilibrium optical nonlinearities from spin-polarized carriers in GaAs [Phys. Rev. B 77, 085202 (2008)]

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We wish to draw attention to an implicit assumption made in our recent paper, to facilitate the microscopic calculation of the optical susceptibility of interacting and spin-polarized carriers in a semiconductor (GaAs). Our method is based on a Hamiltonian $\widetilde{H}_L$ for heavy and light holes given by:

$$\widetilde{H}_L = \frac{\hbar^2}{2m_0}\left[\left(\gamma_1 + \frac{5}{2}\gamma_2\right)k^2 - 2\gamma_2 k^2 (\hat{\boldsymbol{k}}_z \,.\, \boldsymbol{J})^2\right], \tag{22}$$

where $\hat{\boldsymbol{k}}_z$ is a unit vector in the z direction along which the light propagates, γ_i are the Kohn-Luttinger parameters, and $\boldsymbol{J}$ is the total angular momentum operator. Note that if $\hat{\boldsymbol{k}}_z$ is replaced by $\hat{\boldsymbol{k}}$, we recover the original spherically symmetric two-band Luttinger Hamiltonian,[1] H_L. The assumed Hamiltonian $\widetilde{H}_L$ leads to the observation made in our paper that the maximum spin polarization $\xi_{\max}=5/7$, instead of the established value[2,3] of 0.5 which follows from H_L. However, as explained here, we made this assumption to solve the Bethe-Salpeter equation for the optical susceptibility $\chi^{cv}(k,\omega)$ in the presence of Coulomb interactions and spin polarization. For a particular helicity of the probe light, the spin-quasimomentum correlation[2] resulting from the original H_L, would lead to the following equation [instead of Eq. (17) which ignored this correlation] for the vertex function Γ:

$$\Gamma^{cv}(k,\theta,\phi,\omega) = 1 + \frac{1}{d^{cv}(k,\theta,\phi)}\sum_{\boldsymbol{k}'} \bar{V}_s(k,k')\chi_0^{cv}(k',\theta',\phi',\omega)\Gamma^{cv}(k',\theta',\phi',\omega). \tag{23}$$

In Eq. (23), θ is the polar angle between $\mathbf{k}$ and the z axis, and ϕ is the azimuthal angle. The extra variables of θ and ϕ, compared to Eq. (17), arise due to $d^{cv}(k)$, which would now also depend on θ and ϕ as implied by the spin-quasimomentum correlation. We recall that the screened Coulomb potential $V_s(|\boldsymbol{k}-\boldsymbol{k}'|)$ was replaced by its angle-averaged value $\bar{V}_s(k,k')$ in Eq. (17), to make it possible to solve accurately.[4] Since there is no obvious way to replace $d^{cv}(k,\theta,\phi)$ by an appropriate angle-averaged $\bar{d}^{cv}(k)$, solving Eq. (23) is a formidable problem. Hence it is necessary to neglect the spin-quasimomentum correlation, as is done in Eq. (22), in order to obtain the tractable vertex equation, Eq. (17).

This neglect also induces an artificial crossover in circular dichroism by competing mechanisms of electronic phase-space filling (PSF) corresponding to transitions from the heavy hole and light hole bands.[5] The artificial crossover can be seen by summing the PSF curves corresponding to *hh* and *lh* transitions in Fig. 2(b) of our paper. This crossover from solely PSF is artificial because it would not occur if the full, $\mathbf{k}$-dependent selection rules reflecting the spin-quasimomentum correlation were used, instead of the simplified selection rules in Eq. (1). However, we find from the plasma density dependence that this unavoidable artifact that our simplification introduces, only weakly determines the calculated crossover energy. This is because, as discussed in Sec.III C of our paper, the experimental data[3] requires the crossover to shift to higher energies with increasing density—as shown by our calculation [c.f. Fig. 4(a)], whereas the artificial crossover is expected to be almost independent of density. This follows from the similar density dependences of PSF corresponding to *hh* and *lh* transitions. The density-independent nature of the artificial crossover energy has been verified by us, by summing PSF curves for *hh* and *lh* transitions as in Fig. 2(b), but for a range of other densities. Thus the artifact introduced by $\widetilde{H}_L$ is harmless and does not interfere with the calculation's ability to correctly reproduce the experimental trends.

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