Comment on "Fröhlich Mass in GaAs-Based Structures"

In a recent Letter [1], Faugeras *et al.* investigate the cyclotron resonance (CR) spectra of doped GaAs quantum well structures. From an analysis of their data these authors question the validity of the concept of the Fröhlich interaction and the polaron mass in a real system. It is stated in Ref. [1] that Fröhlich's polaron theory would predict a resonant magnetopolaron coupling near the longitudinal optical-phonon frequency $\omega_{\rm LO}$. Because of the absence of anticrossing at $\omega \approx \omega_{\rm LO}$ in the experimental data [1] for a GaAs/AlAs quantum well, they conclude that the CR spectra "do not show any sign of interaction related to the Fröhlich coupling," and therefore, that "the concept of the polaronic mass, related to this interaction, is no longer effective" (Ref. [1], p. 4). The experimental evidence for the interaction of the electrons with some modes with frequencies close to the transverse optical-phonon frequency $\omega_{\rm TO}$ is attributed in Ref. [1] to the deformation potential. However, the deformation potential, induced by the optical phonons near the center of the Brillouin zone in cubic semiconductors, has only off-diagonal matrix elements involving the heavy and light hole states [2]. Since the optical conductivity in the experiment [1] is due to band electrons, the anticrossing near $\omega_{\rm TO}$ cannot be interpreted in terms of the deformation electron-phonon interaction. Furthermore, the phenomenological dielectric model of Ref. [1] does not predict the anticrossing near $\omega_{\rm TO}$.

In contrast to the statement that "there is no quantum mechanical treatment of the hybrid modes" ([1], p. 1), such a treatment has been performed in Ref. [3]. In that paper we demonstrated [3] that in a quantum well with sufficiently high electron density, mixing of bulklike and interface polar optical phonons with intrasubband plasmons leads to the appearance of hybrid magnetoplasmon-phonon modes, which interact with the electrons. This interaction is the renormalized Fröhlich interaction. One of the frequencies of the hybrid modes, which is close to $\omega_{\rm TO}$ in GaAs, provides a dominant contribution to the CR spectrum. The resulting peak positions, the frequencies of the hybrid magnetoplasmon-phonon modes, as well as the magnitude of the splitting of the CR peaks calculated in Ref. [3] are in good agreement with the experimental data [4].

The resonant magnetopolaron coupling also appears in the recent measurements of the CR spectra for a 13 nm wide GaAs quantum well [1]. Owing to this magnetopolaron effect, the CR peaks split near $\omega_{\rm TO}$ and also change their positions with respect to those obtained without electron-phonon interaction. These splitting and shift of the CR peaks near the TO-phonon frequency predicted in Ref. [3] on the basis of the Fröhlich interaction are clearly seen in Fig. 1. The theoretical peak positions of the CR spectra calculated within the many-polaron approach of Ref. [3] compare well with the experimental data [1], as distinct from the CR energies calculated without electron-phonon interaction, which show no particular features in the region of the optical-phonon frequencies.

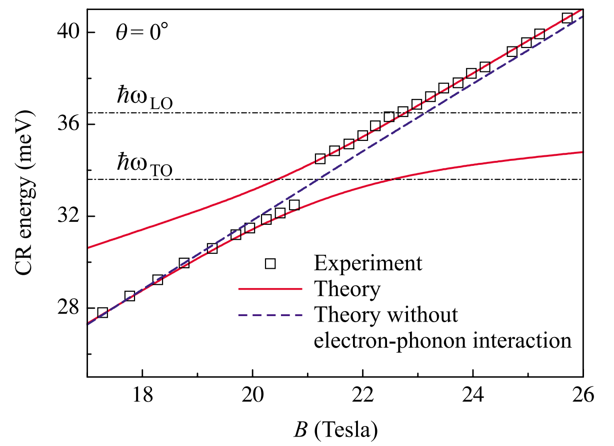

FIG. 1 (color online). Experimental [1] (squares) and theoretical (solid curves) CR energies of a 13 nm width GaAs/AlAs quantum well with the electron density $n_0 = 7 \times 10^{11}$ cm^{-2} in a perpendicular magnetic field. The dashed curve represents CR energies calculated without electron-phonon interaction.

In conclusion, in contrast to the statement of Ref. [1] that the concept of the Fröhlich polaron mass has to be reexamined in a real material, we conclude that this concept is valid and even necessary to interpret the CR spectra of quantum wells, e.g., those studied in Ref. [1].

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[1] C. Faugeras, G. Martinez, A. Riedel, R. Hey, K. J. Friedland, and Yu. Bychkov, Phys. Rev. Lett. **92**, 107403 (2004).
[2] G. L. Bir and G. E. Pikus, *Symmetry and Strain-Induced Effects in Semiconductors* (Wiley, New York, 1975).
[3] S. N. Klimin and J. T. Devreese, Phys. Rev. B **68**, 245303 (2003).
[4] A. J. L. Poulter, J. Zeman, D. K. Maude, M. Potemski, G. Martinez, A. Riedel, R. Hey, and K. J. Friedland, Phys. Rev. Lett. **86**, 336 (2001).

