Comment on "Magnetospectroscopy of Bound Phonons in High Purity GaAs"

In a recent Letter Zhonghui Chen *et al.* [1] claim that they have found evidence for bound phonons in high purity GaAs by analyzing the magnetophotoconductive response of a thin (5 μm) GaAs layer, n-type doped at the level of 5×10^{14} cm^{-3} and epitaxially grown on a GaAs substrate. The approach used by the authors to interpret their results raises various questions which are not addressed in their paper. They observed structures near $\hbar\omega_{\mathrm{LO}}$, the LO phonon energy of GaAs, for *all* values of the magnetic field B, and apparent coupling effects between this structure and the different impurity induced transitions whenever such a transition driven by B coincided with $\hbar\omega_{\mathrm{LO}}$. Their analysis is focused on the signal due to the specific transition $1s \rightarrow (310)$ of the impurity at about $B = 6$ T.

Since the discovery [2] of bound phonons, there has been much debate on their origin and different models have been proposed [2–5]. Although they differ significantly, all agree with the fact that in order to stabilize such a phonon the related impurity transition has to occur at an energy *higher* than that of the pure LO phonon, giving rise to a structure at an energy lower than $\hbar\omega_{\mathrm{LO}}$. While this condition is realized for GaAs at high magnetic fields, it is certainly not fulfilled at low fields [6]. Therefore, the interpretation proposed by the authors cannot explain why they observe a structure near $\hbar\omega_{\mathrm{LO}}$ at low fields (including $B = 0$ T).

The low-temperature conductivity of an n-type layer is strongly temperature dependent, which causes such a layer deposited on a substrate to act as a bolometer. A more realistic way to analyze the response is to calculate the energy absorbed by TO phonons in the doped layer and a thin ($\simeq 5$ μm) layer of the substrate close to the interface, using the complete dielectric response of the structure [7]. This can be written as $A = 1 - R - T$, where R is the reflectivity and T is the transmittivity of the two effective layers. Because of the interplay between transmission and reflection, the maximum heat transfer to the bolometer occurs near $\hbar\omega_{\mathrm{LO}}$. This is explicitly shown in the simulation performed for this structure, with a dielectric function composed of the phonon part with standard parameters for GaAs [8] plus a Lorentzian absorption line varying with the magnetic field as required for the $n = 3$ Landau level, which mimics the intensity and energy position of the $1s \rightarrow (310)$ transition. The results are presented in Fig. 1 and reproduce quite well all of the data reported in Ref. [1], including the observation of a structure near $\hbar\omega_{\mathrm{LO}}$ even at $B = 0$. The relative intensities are not well reproduced since we do not take into account either the magnetopolaron effect which transfers oscillator strengths between different entities or the actual process governing the photoconductivity due to the impurity transition. However, the main experimental features are present.

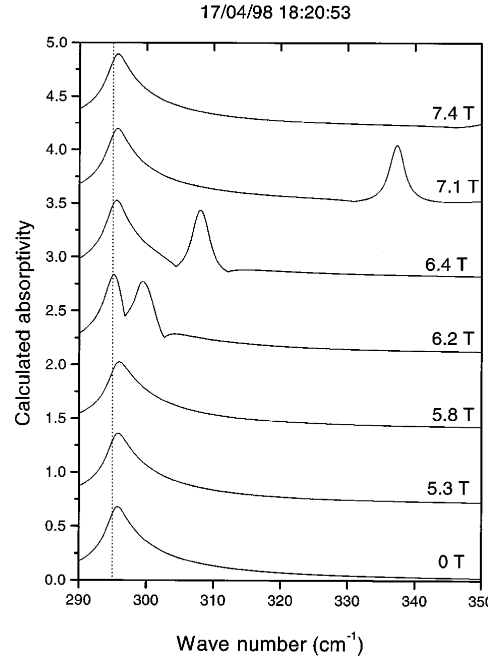

FIG. 1. Calculated photoresponse for different magnetic fields. The dotted line is a guide for the eye. The spectra have been shifted for clarity. The parameters were $\kappa_0 = 12.41$, $\kappa_\infty = 10.6$, damping factor 2 cm^{-1}, $\omega_{\mathrm{TO}} = 273.1$ cm^{-1}, donor resonance width 2 cm^{-1}.

We conclude that the interpretation of data of Ref. [1] can be done without invoking bound phonons, in a more global way, by properly analyzing the nature of the magnetophotoconductivity signal.

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