Comment on "Angular Dependence of the Cyclotron Effective Mass in Organic Superconductors"

Wosnitza *et al.* have reported an anomalous angular dependence of the cyclotron mass m_c in the superconductors (BEDT-TTF)$_2$Cu(NCS)$_2$ and (BEDT-TTF)$_2$NH$_4$-Hg(NCS)$_4$ [1]. Both materials possess a quasi-two-dimensional (2D) Fermi surface. Hence Fermi surface areas measured using the de Haas–van Alphen (dHvA) or Shubnikov–de Haas (SdH) effects will vary as $1/\cos\theta$, where θ is the angle between the normal to the 2D plane and the magnetic field B.

Wosnitza *et al.* reported that m_c, derived from the temperature (T) dependence of dHvA oscillations, had the θ dependence [1] $m_c(\theta)=m_{b0}/\cos\theta+m_{\mathrm{EP}}$, where m_{b0} represents a "band-structure mass" and m_{EP} is an "electron-phonon contribution." Most treatments of electron-phonon interactions (e.g., [2]) lead merely to renormalization of the band mass m_b around the Fermi energy; the band structure is still quasi 2D, and band parameters such as m_c will obey a $1/\cos\theta$ dependence. To test this, we have studied magnetotransport in (BEDT-TTF)$_2$NH$_4$Hg(NCS)$_4$ for a range of θ using fields up to 20 T. We find that m_c calculated from the T dependence of the SdH oscillations does in fact follow a $1/\cos\theta$ dependence, in disagreement with Ref. [1].

SdH oscillations with fundamental field $B_F=566.7$ T (cf. Ref. [1]) were visible above $B\sim5$ T, for $\theta=0°$; $m_c(\theta)$ was estimated from the T dependence of the SdH amplitudes between 0.5 and 5 K using the same formula as in Ref. [1]. However, in our work m_c is the only adjustable parameter; B_F and the Dingle factor were found separately by a direct fit to ten periods of SdH oscillations between 15 and 20 T using the Lifshitz-Kosevitch formula. Particular attention was paid to uncertainties of parameters in the fitting procedure [3]. We obtain $m_c=(2.49\pm0.06)m_e$ at $\theta=0°$, $\sim10\%$ less than the value given by Wosnitza *et al.* [1]. This was also checked by fitting the T dependence of the harmonic ratio (HR). At angles above $\sim40°$, however, our masses become consistent with those in Ref. [1].

Figure 1 shows the θ dependence of m_c/B_F. The advantage of such a plot is that B_F varies accurately as $1/\cos\theta$ [1], so that deviations from the $1/\cos\theta$ dependence of m_c will be seen as departures from a horizontal line; this method also removes errors in θ. The fitted ratio is constant within the errors (Fig. 1, dashed line), as one would expect for a 2D system; our data cannot be fitted using the formula and fit parameters in Ref. [1] (solid line).

Wosnitza *et al.*'s HR vs θ fit for gm_b is excellent; it is the disagreement between their $m_c=2.73m_e$ and $m_bg/2=2.28m_e$ which prompts Wosnitza *et al.* to justify the θ-independent term in m_c. Our $m_c=2.49m_e$ is closer to the HR value. Note that we have also found discrepancies of this size between masses measured using the SdH and HR methods in metallic salts such as (BEDT-TTF)$_2$KHg(NCS)$_4$, suggesting that the difference is not due to superconductivity.

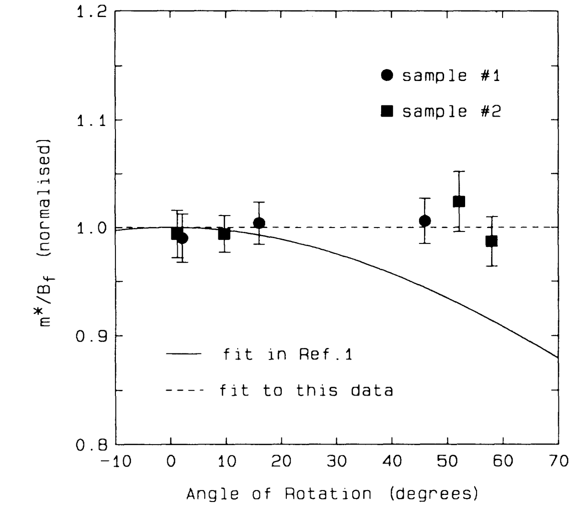

FIG. 1. Angular dependence of m_c/B_F; see text for details.

We believe that the anomalous m_c measured by Wosnitza *et al.* may result from the limited T range used (0.4–1.5 K). We have found that high temperatures are important in accurately determining m_c close to $\theta=0°$. At higher θ the larger m_c leads to a more rapid fall of dHvA amplitude with T, so a restricted T range would then allow an accurate m_c to be obtained. This would explain why our m_c becomes close to that of Ref. [1] at higher θ.

In summary, we believe that there is no experimental or theoretical justification for the angle-independent effective mass component introduced by Wosnitza *et al.*

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