**Introduction**

A technique, we have recently reported,\(^1\) enables angle-resolved mapping of the in-plane Fermi velocity (\(v_F\)) for a quasi-two-dimensional (Q2D) conductor. The new method is based on a magnetic resonance effect in the AC conductivity for in-plane magnetic fields. In this report, we consider the possibility of using this method to probe the normal quasiparticles (QP) in nodal superconductors (SC). The AC conductivity resonance technique is considered as the extension of the DC AMRO technique to high frequencies, such that \(\omega > 1/\tau\). However the dominant QP states are quite different from DC AMRO. In the case of DC AMRO, theoretical studies have shown that the conductivity of a Q2D metallic system is dominated by unusual trajectories near the self-crossing orbit on the Fermi surface (FS) (see Fig. 1(a) and ref. 2). On the other hand, in AC conductivity resonances, the dominant states correspond to vertical open trajectories on opposite (symmetry-equivalent) edges of the FS (see Fig. 1(a) and ref. 1). Thus, by rotating the applied field in the \(xy\)-plane (changing \(\psi\)), one can potentially gain access to information in the normal state concerning the in-plane momentum (\(k_{xy}\)) dependence of the interlayer hopping, QP lifetime (\(\tau\)), and QP density of states (\(m^*\)) (or the Fermi velocity, \(v_F\)). Even more intriguing is the possibility that one might be able to probe the normal QPs that exist along the line-nodes in a non s-wave SC (e.g. \(p\)- or \(d\)-wave). In order to calculate the interlayer AC conductivity numerically, we consider the same model as our previous paper.\(^1\) As a result, we can write the AC conductivity as follows,

\[
\sigma_{zz}(\omega, B) \propto \int_0^{2\pi} d\phi \frac{1-i\omega\tau}{(1-i\omega\tau)^2 + (\omega\tau)^2} \tag{1}
\]

\[
v_F = \sqrt{v_{F,\|}^2 + v_{F,\perp}^2}; \quad v_F = \frac{d\psi}{d\phi} \tag{2}
\]

where \(\omega = eBv_F(\phi)\sin(\phi); \quad \hbar = eBa(\phi)\hbar\) (see Fig. 1(b)).

**Results and Discussion**

The left figure in Fig. 2 shows the model of the \(k\)-dependent QP states, e.g. (a) elliptic QP states and \(v_F\) for normal state and (b) 4-nodal QP states and \(v_F\) for SC state so that the model may represent \(\kappa-(ET)_2\)Cu(NCS)\(_2\). The calculated AC conductivity is shown in the middle figure for different field orientations in the \(xy\)-plane. The peaks in the conductivity correspond to the AC resonance. We determine the resonance fields, \(B_{\text{res}}\), from the peak positions. Each AC conductivity trace has only a single peak, since the resonance is governed entirely by the extremal perpendicular velocity (\(v_{F,\perp}^{\text{ext}}\)). The right figure shows a polar plot of \(B_{\text{res}}\) versus \(\psi\). In the case of (a) normal state, \(B_{\text{res}}\) also shows a two-fold symmetry because of the two-fold symmetry of the angle-dependent Fermi velocity. However, in the case of (b) SC state, \(B_{\text{res}}\) shows a four-fold symmetry since the resonance is dominated by the normal QPs at the line-nodes. Consequently, using this technique, we predict that it may be possible to measure both \(v_F\) and \(\tau\) associated with the normal QP at the nodes of a \(d\)-wave superconductor such as YBCO or \(\kappa-(ET)_2\)Cu(NCS)\(_2\). Moreover, we may be able to confirm the symmetry of the superconducting gaps.

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**References**
