LANDAU QUANTIZATION WITHIN THE CDW GAP OF Per$_2$M(mnt)$_2$ Where $M = \text{Au, Pt}$

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With their unusually low transition temperatures, organic charge-density wave (CDW) materials of the composition (Per)$_2$M(mnt)$_2$ with $M = \text{Au and Pt}$ provide an exciting opportunity to study how a CDW groundstate is modified by a magnetic field. We have previously shown that the Pauli paramagnetic limit of the $M = \text{Au}$ system is reached at $B_p \sim 37$ T, above which an inhomogeneous phase likely develops in which the up- and down-spin components of the CDW nest independently and interfere with each other [1]. These measurements required the use of the dilution fridge in the 45 T hybrid magnet. However, there still existed the need to investigate how the gap develops at lower magnetic fields, following some problems in the analysis of Ref. [2]. We found that the conductivity is highly non-linear and dominated by the sliding mode of the CDW collective mode to temperatures as high 4 K. Sadly, by not changing the measuring current at any point during the experiment, the authors of Ref. [2] did notice this effect [3,4]; hence, they make no statements pertaining to such an effect in their published manuscripts. In addition to this, they also attempted to obtain the CDW gap from the slope of an Arrhenius plot of the conductivity too close to the transition temperature, where the gap is strongly dependent on temperature. As a consequence, they obtained an estimate of the gap that is unrelated to the actual CDW gap $2\Delta$.

We found that a careful treatment of the CDW gap at low magnetic fields leads to quite a different conclusion. In fact, a finite electric bandwidth orthogonal to the chain direction (leading to warping of the 1D Fermi surface sheets) leads to the formation of Landau subbands within the gap, which alter the manner in which the activation gap changes in field [5]. Depending of the value of the effective mass of the Landau subbands, the activation gap can initially increase with magnetic field. Figure 1 shows a schematic of the dispersion of the bands orthogonal to the CDW chain direction upon formation of the CDW for different values of the parameter $\alpha = 2t_b/\Delta (a-c)$ and different values of the magnetic field (d and e). $B_L$ is the quantum limit above which Landau levels can no longer exist do open orbits.

Figure 2 shows the activation gap for $M = \text{Au}$ (a) and Pt (b) estimated by using small currents (to limit the CDW collective mode contribution to the conductivity) and by taking the slope of Arrhenius plots not to close to the transition temperature. The solid lines show fits to the Landau subband model, including the effects of Zeeman splitting of the Landau levels. The fit is excellent for $M = \text{Au}$, proving the first direct estimates of transfer integrals of the electronic structure. The small value of $t_b$ suggests that field-induced CDW phases cannot occur, contrary to recent claims [3,4]. The poor agreement in the case of $M = \text{Pt}$ is due to the magnetism of the dimerized Pt spins. These are likely to be responsible for additional structure in the threshold electric field in case of $M = \text{Pt}$, which was wrongly interpreted as field-induced CDW transitions.

**Figure 1:** A schematic of the electronic dispersion orthogonal to the CDW chains as described in the text.

**Figure 2:** The measured activation gap $E_g$ (circles) compared to model calculations (lines).

### References