Evidence for Field-Induced Excitonic Correlations and Topological Insulating state in α-(BEDT-TTF)$_2$I$_3$ under Pressure

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The search for emergent phenomena linked to electronic correlations and topology is at the forefront of modern condensed-matter physics. Our NMR study reveals key insights on the magnetic correlations of the quasi-2D massless Dirac fermions in the organic conductor α-(BEDT-TTF)$_2$I$_3$ under applied out-of-plane magnetic field (B). First, our NMR shift and relaxation-rate data combined with Korringa's model show that a quasi-relativistic zeroth Landau level appears at the Fermi energy, in line with earlier transport and calorimetric studies reporting emergent quantum limit at low temperature (T) [1-3]. Second, we detect a growing spin polarization and gap opening upon cooling, consistent with the recently discovered signatures of topological counter-propagating edge states tied to a spin-polarized zeroth level [4] – characteristic features of a so-called zero-Chern-number ($\nu = 0$) quantum Hall (QH) topological insulating state [5]. Third, at lower T, an anomalous B-tunable increase emerges in the NMR relaxation rate $1/T_1T$, which is shown by numerical calculations to correspond to the B-enhanced excitonic fluctuations growing prior to a condensation in the bulk of the topological insulator [6]. Our results suggest that excitonic dynamics may play more substantial roles than expected in generic Dirac-Weyl materials, and can coexist with QH ferromagnetism, a hypothesis widely discussed theoretically [7] but yet to be confirmed experimentally.

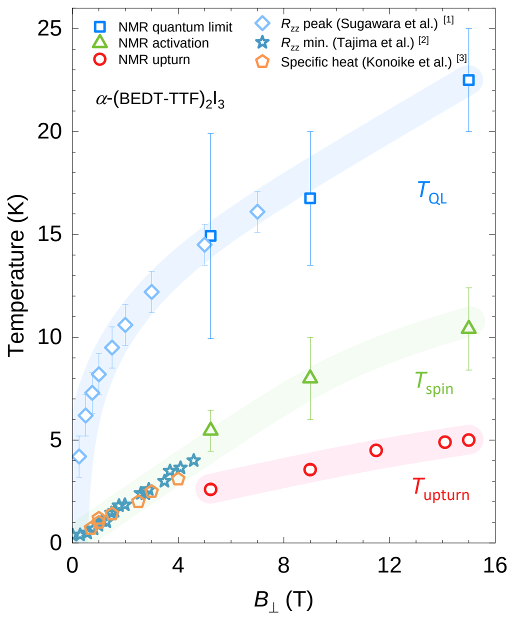

Fig. 1. T-B phase diagram for out-of-plane field in pressurized α-(BEDT-TTF)$_2$I$_3$. Characteristic scales – T_{QL}: quantum limit, T_{spin}: spin-gap opening, and T_{upturn}: $1/T_1T$ upturn.

References

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