Effects of Zero-Mode Landau Level on Transport Property in an Organic Massless Dirac Fermions System α-(BEDT-TTF)$_2$I$_3$ under high pressure

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Zero-gap state with the Dirac cone type energy dispersion has been found in an organic conductor α-(BEDT-TTF)$_2$I$_3$ under high hydrostatic pressures.[1–5] This is the first two-dimensional zero-gap state discovered in bulk crystals with layered structure. We find out a characteristic feature of bulk zero-gap system in the out-of plane magnetoresistance at low temperatures. When magnetic field (B) was applied along normal to the 2D plane, the magnetoresistance (M) was decreased as a function of $M \propto B^{-1}$. This result strongly suggests that this material is a truly zero-gap conductor with the Dirac cone type energy dispersion. In the zero-gap system, N=0 Landau level called zero-mode appears in E=0 under the magnetic field. According to the realistic theory, the negative out-of-plane magnetoresistance which obeys $M \propto B^{-1}$ law is associated with an increase of the density of states which is proportional to the strength of magnetic field on zero-mode Landau level.[6] The effect of zero-mode conduces to the peculiar phenomena in the in-plane magnetoresistance and the Hall resistance.

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