# Transport Properties of Massless Dirac Fermions System in an Organic Conductor α-(BEDT-TTF)$_2$I$_3$

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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$_3$ (Fig.1) under high hydrostatic pressures. This is the first two-dimensional (2D) zero-gap state discovered in bulk crystals with layered structure. In contrast to graphene, the Dirac cone in this system is highly anisotropic as shown in Fig. 2. The present system, therefore, provides a new type of massless Dirac fermions with anisotropic Fermi velocity. From the galvanomagnetic measurements, the density and mobilities of electrons and holes were determined in the temperature region between 77 K and 2 K. In this region, the carrier density ($n$) depends on temperature ($T$) as $n \propto T^2$ and decreases by about four orders of magnitude. On the other hand, the sheet resistance per BEDT-TTF layer ($R_S$) stays almost constant in the region. The value is written as $R_S=g(h/e^2)$ in terms of the quantum resistance $h/e^2$=25.8 kΩ, where $g$ is a parameter that depends weakly on temperature. We find a characteristic feature of bulk system in out-of-plane magnetoresistance effect. When magnetic field ($B$) was applied along normal to 2D plane, the magnetoresistance ($M$) was decreased a function of $M \propto B^{-1}$. This result strongly suggests that this material is a truly zero-gap conductor with Dirac cone type energy dispersion. In the zero-gap system, $N$=0 Landau level called zero-mode appear at Dirac point ($E$=0) under the magnetic field. The negative out-of-plane magnetoresistance is associated with the increasing density of state which is proportional to the strength of magnetic field on zero-mode Landau level.

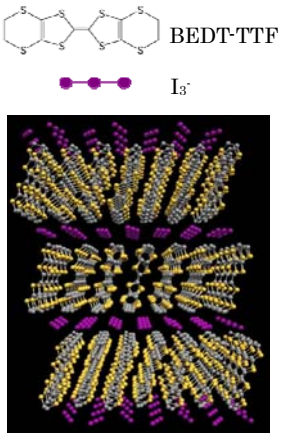


**Fig. 1:** Crystal structure of an organic conductor α-(BEDT-TTF)$_2$I$_3$.

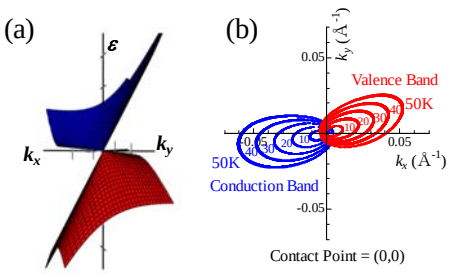


**Fig. 2:** (a) Band structure and (b) energy contours near contact point. They are calculated using the parameters for p=0.6GPa in ref. [*S. Katayama, et al., J. phys. Soc. Jpn. 75 (2006) 054705*]. Note that the origins of the axes are taken at the position of the contact point.