Transport Phenomena in Organic Zero-Gap Conductors

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Since Novoselov et al. and Zhang et al. have experimentally demonstrated that graphene is a zero-gap system with massless Dirac particles, it has fascinated physicists as a source of exotic system and/or new physics. Recently, on the other hand, a new type of massless Dirac fermions state was realized in a quasi-two-dimensional (2D) organic conductor α-(BEDT-TTF)$_2$I$_3$ (BEDT-TTF=Bis(ethylenedithio) tetrathiafulvalene) (Fig. 1) under high-pressures. This is the first 2D zero-gap state discovered in bulk crystals with layered structures. In contrast to the case of 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. This system shows remarkable transport phenomena characteristic to electrons on the Dirac cone-type energy structure. The carrier density written as $n \propto T^2$ is a characteristic feature of 2D zero-gap structure. On the other hand, the resistivity per layer (sheet resistance R_S) is given as $R_S = h/e^2$ which is independent of temperature. The effect of magnetic fields on samples in the zero-gap system was examined. The difference of zero-gap conductors from usual conductors is the appearance of a Landau level called zero mode at the contact points when magnetic fields are applied normal to the conductive layer. Zero mode Landau carriers give rise to remarkable magnetotoransport phenomena.

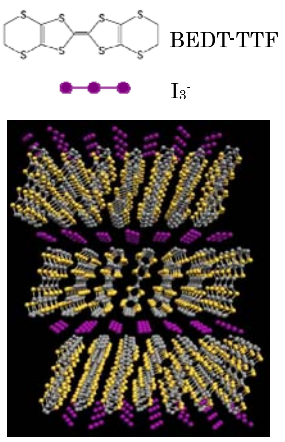

Fig. 1: Crystal structure of an organic conductor α-(BEDT-TTF)$_2$I$_3$.

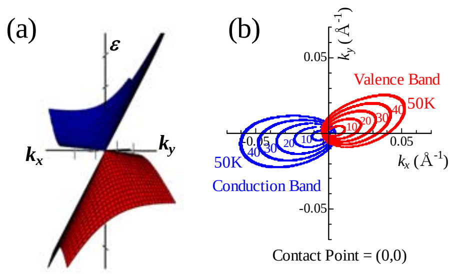

Fig. 2: (a) Band structure and (b) energy contours near contact point. They are calculated using the parameters for p=0.6GPa in ref. [*S. Katayama, et al., J. phys. Soc. Jpn. 75 (2006) 054705*]. Note that the origins of the axes are taken at the position of the contact point.