

# Quantum liquid of vortices in the quasi-two-dimensional organic superconductor $\kappa$ -(BEDT-TTF)<sub>2</sub>Cu(NCS)<sub>2</sub>

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## Abstract

We present magnetic torque measurements on the quasi-two-dimensional organic superconductor  $\kappa$ -(BEDT-TTF)<sub>2</sub>Cu(NCS)<sub>2</sub> at low temperature  $T/T_c \simeq 0.01$  [Sasaki *et al.*, Phys. Rev. B, **57**, 10889 (1998)]. The irreversible field  $H_{\text{irr}}$  lies far below the upper critical field  $H_{c2}$  even at  $T \simeq 0$ . In the magnetic field region,  $H_{\text{irr}} \leq H \leq H_{c2}$ , a vortex liquid state exists even at  $T \simeq 0$ , resulting from the quantum fluctuations instead of the contribution of the thermal one at higher temperature. This finding is explained as the quantum vortex liquid state driven by the quantum fluctuations from the different theoretical models. In the liquid state, de Haas - van Alphen oscillations are observed, and  $H_{c2}$  is defined by the appearance of the additional damping on the oscillation amplitude.