Dirac Fermions Detected via Quantum Oscillations

T. Terashima,[1] H. T. Hirose,[1] D. Graf,[2] Y. Ma,[3,4] G. Mu,[3,4] T. Hu,[3,4] K. Suzuki,[5] S. Uji,[1] and H. Ikeda[5]

1. NIMS, Japan; 2. NHMFL, FSU; 3. SIMIT, China; 4. CENSE, CAS, China; 5. Ritsumeikan U., Japan

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Since their discovery in 2008, the iron-based superconductors have been studied extensively because of their high superconducting transition temperatures (T_C). Despite the fact that the T_C record of 56 K is held by a 1111-type iron arsenide, little is known about the electronic structure of these compounds. These experiments on CaFeAsF revealed the electronic structure (i.e. the Fermi surface) of a parent 1111 compound, a compound that becomes superconducting upon doping, thus providing valuable insight into how superconductivity emerges in this family of 1111-type iron-based superconductors.

This three-nation collaboration performed angular-dependent electrical transport measurements on CaFeAsF in magnetic fields up to 45T and at temperatures down to 0.3K. *Quantum oscillations were clearly observed, revealing that the Fermi surface consists of both electron and hole cylinders. The carrier density was found to be anomalously low, and the electron carriers were found to possess a nontrivial Berry phase of π. This indicates that these electrons are relativistic quasiparticles, that is, Dirac fermions.*

These results proved a first picture of the electronic structure of a parent compound of 1111-type iron-based superconductors. Furthermore, they suggest a new avenue to explore Dirac-fermion physics in iron-based superconductors.

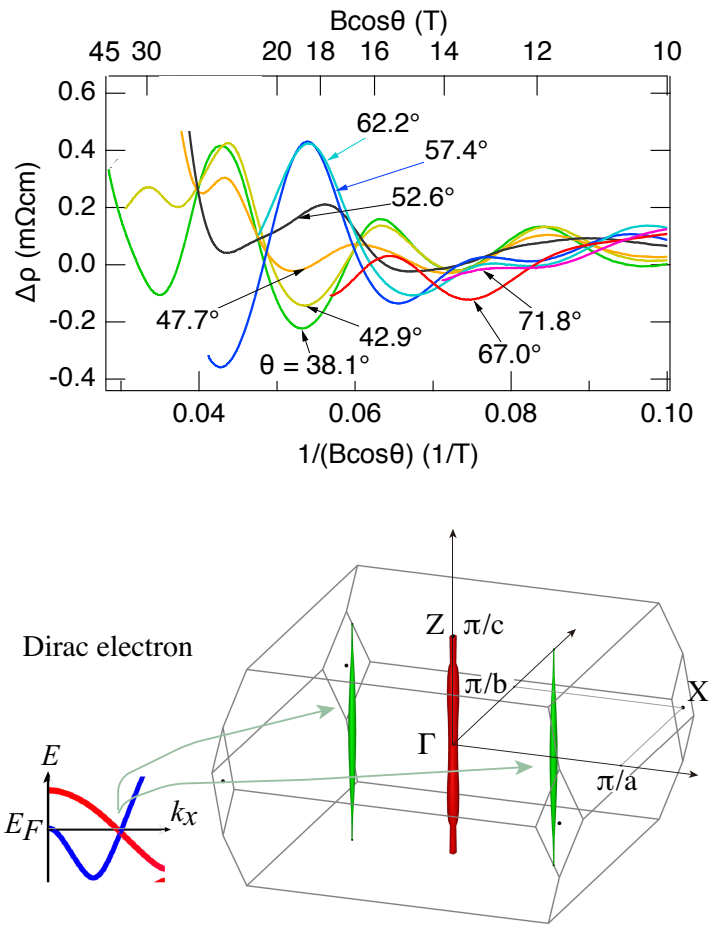

Figure: ***(Top)*** *Quantum oscillations in CaFeAsF, observed as oscillations in the electrical resistivity plotted against 1/(Bcosθ) (bottom axis), where B is magnetic field and θ is the angle between the magnetic field and the crystalline c axis.* ***(Bottom)*** *Fermi surface of CaFeAsF, which represents the momenta of the highest-energy electrons in the material. The left inset shows a part of the electronic band dispersions, showing a linear dependence of the electon's energy versus momentum. These Dirac electrons exist where the blue and red bands cross to produce the green electron cylinders of the Fermi surface.*

Facilities and instrumentation used: DC Magnet User Facility: 45 Tesla, 32 mm Bore Hybrid Magnet, He-3 Cryogenic System.

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