Aharonov-Bohm oscillations in Dirac semimetal Cd_3As_2 nanowires

With the support by the National Natural Science Foundation of China, the research team led by Prof. Yu Dapeng (俞大鹏) at the State Key Laboratory for Mesoscopic Physics, Department of Physics, Peking University, reported the Aharonov-Bohm oscillations in individual single-crystal Cd_3As_2 nanowires, which was published in *Nature Communications* (2016, 7: 10769).

Three-dimensional Dirac semimetals, a three-dimensional analogue of graphene, are unusual quantum materials with massless Dirac fermions, which can be further converted to Weyl fermions by breaking time reversal or inversion symmetry. Nontrivial surface states with arc-like Fermi surface are theoretically predicted on the surface of Dirac semimetals. Revealing the exotic surface states via transport measurements is very important for further low-dissipation electronics applications. We employed the Aharonov-Bohm (A-B) effect of individual nanowires with large surface to volume ratio to explore the transport properties of the nontrivial surface states. As the mean free path of the carriers is comparable with the perimeter of the nanowire, the electron wave is confined in the finite boundary condition along the nanowire perimeter. Consequently, the surface energy bands are enforced into discrete subbands due to the quantum confinement. As sweeping the magnetic field parallel to the nanowire direction, the density of states at the Fermi level is periodically altered as each subband crosses the Fermi energy, and the oscillating period is described by the $\mathbf{\Phi}/\mathbf{\Phi}_0$, where $\mathbf{\Phi}$ is the magnetic flux enclosed by the path of the surface carriers and $\mathbf{\Phi}_0 = h/e$. We observed a π A-B effect that the conductance oscillations peak at odd integers of $h/2e$ with a period of h/e, providing transport evidence of the topological surface states of Cd_3As_2 nanowires. The A-B oscillations are tunable by altering the Fermi level of the nanowire via gate voltage, giving deeper insight of the 3D Dirac semimetal with Dirac fermion bulk states and Fermi arc surface states.

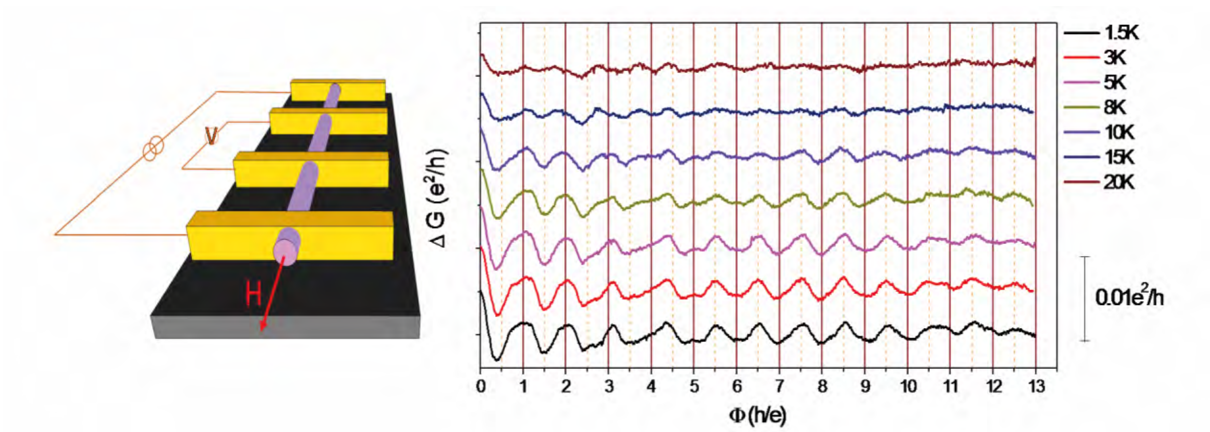

Figure Schematic diagram of the four-terminal device with an applied magnetic field aligned with the length. Oscillating conductance is expressed as a function of magnetic flux in unit of h/e at variable temperatures.