Giant magnetoresistance of Dirac plasma in high-mobility graphene

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The most recognizable feature of graphene's electronic spectrum is its Dirac point, around which interesting phenomena tend to cluster. At low temperatures, the intrinsic behaviour in this regime is often obscured by charge inhomogeneity but thermal excitations can overcome the disorder at elevated temperatures and create an electron–hole plasma of Dirac fermions. The Dirac plasma has been found to exhibit unusual properties, including quantum-critical scattering and hydrodynamic flow. However, little is known about the plasma's behaviour in magnetic fields. Here we report magnetotransport in this quantum-critical regime [1]. In low fields, the plasma exhibits giant parabolic magnetoresistivity reaching more than 100 per cent in a magnetic field of 0.1 tesla at room temperature. This is orders-of-magnitude higher than magnetoresistivity found in any other system at such temperatures. We show that this behaviour is unique to monolayer graphene, being underpinned by its massless spectrum and ultrahigh mobility, despite frequent (Planckian limit) scattering. With the onset of Landau quantization in a magnetic field of a few tesla, where the electron–hole plasma resides entirely on the zeroth Landau level, giant linear magnetoresistivity emerges. It is nearly independent of temperature and can be suppressed by proximity screening, indicating a many-body origin. Clear parallels with magnetotransport in strange metals and so-called quantum linear magnetoresistance predicted for Weyl metals offer an interesting opportunity to further explore relevant physics using this well defined quantum-critical two-dimensional system.

References

[1] Na Xin, et al., Nature 616 (2023) 270-274

Figures

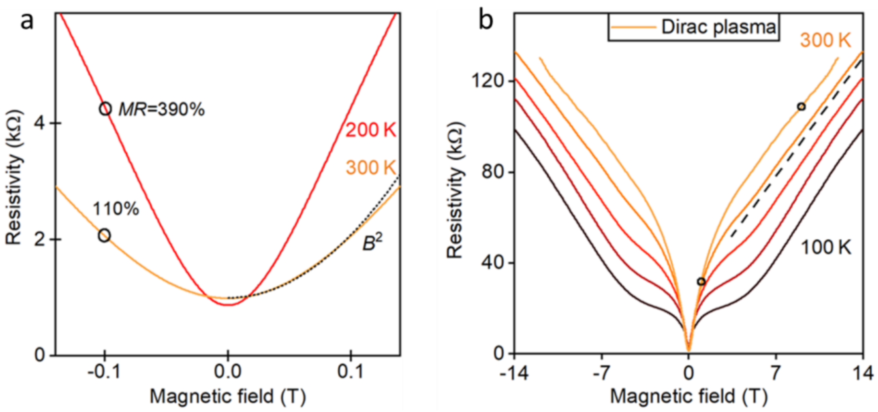

Figure 1: Magnetoresistance behaviour of Dirac plasma. (a) Resistivity of the compensated Dirac plasma in small magnetic fields at representative temperatures. (b) Linear magnetoresistance in quantizing fields at representative temperatures.