The origin of linear magnetoresistance—exotic or classical?

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New materials sometimes exhibit spectacular resistance phenomena, though the explanation does not always prove to be exotic. Physicists from the Nijmegen High Field Magnet Laboratory (HFML) and the ETH in Zürich have demonstrated that a simple physical model is sufficient to explain the phenomenon of linear magnetoresistance. They published their results this week in an Editor's Suggestion article in *Physical Review Letters*.

Measuring the electrical resistance of a material in a magnetic field (the magnetoresistance) is often a first step on the road to discovering new electronic properties. Since the rise of graphene in 2005, many new materials with unconventional properties have been discovered, including topological insulators, and Weyl and Dirac semi-metals. These materials exhibit a linear scaling of their energy with momentum, a so-called dispersion relation in which electrons in a solid behave as massless particles (similar to light particles, so-called photons). Such novel electronic properties are interesting for potential applications in information and optoelectronic technologies. In many of these materials, the resistance is found to increase linearly with the magnetic field – a phenomenon we call linear magnetoresistance (LMR).

'Simple' and general explanation for linear magnetoresistance

Researchers from the High Field Magnet Laboratory (HFML) - a partnership between Radboud University and the FOM Foundation - and ETH Zurich have now measured the resistance of an ultraclean GaAs (Gallium arsenide) quantum well which does not possess such a linear energy relation yet. They have found a strong LMR similar to the one found in the materials highlighted above: topological insulators, Weyl and Dirac semi-metals. The origin of the LMR in this case is likely related to small density variations throughout the solid which cannot be avoided in conventional material growth techniques. This leads to a contribution of a linear Hall resistance caused by the Lorentz force in a magnetic field on a moving electron on the measured magnetoresistance. This discovery teaches us an important lesson: that exotic explanations for spectacular phenomena are not always the answer.

More information: Linear magnetoresistance in a quasi-free two dimensional electron gas in an ultra-high mobility GaAs quantum well. arxiv.org/abs/1611.04857

Provided by Radboud University

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