Researchers answer long-standing question in the field of condensed matter physics

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Northeastern University Physics professor Sergey V. Kravchenko along with colleagues Svetlana Anissimova (Northeastern University), A Punnoose (City College if the City University of New York), AM Finkelstein (Weizmann Institute of Science, Israel) and TM Klapwijk (Delft University of Technology, Netherlands), has published an important new paper in the August issue of *Nature Physics* which answers a long standing question in the field of condensed matter physics.

The discovery of the metal-insulator transition (MIT) in two-dimensional electron systems by Kravchenko and colleagues in 1994 challenged the veracity of one of the most influential conjectures in the physics of disordered electrons by Abrahams, Anderson, Licciardello and Ramakrishnan (1979) which stated that “in two dimensions, there is no true metallic behavior.”

However, the 1979 theory did not account for interactions between electrons. In this new paper, Kravchenko and colleagues investigate the interplay between the electron-electron interactions and disorder near the MIT using simultaneous measurements of electrical resistivity and magnetoconductance.

The researchers show that both the resistance and interaction amplitude exhibit a fan-like spread as the MIT is crossed. From this data, the researchers have constructed a resistance-interaction flow diagram of the MIT that clearly reveals a quantum critical point, as predicted by the recent two-parameter scaling theory by two of the authors (A. Punnoose and A.M. Finkelstein). The metallic side of this diagram is accurately described by the renormalization-group theory without any fitting parameters. In particular, the metallic temperature dependence of the resistance sets in when the interaction amplitude reaches a value in remarkable agreement with the one predicted by theory.

"To the best of our knowledge, this is the first observation of the temperature dependence of the strength of the electron-electron interactions," said Kravchenko. "We found that the interaction grows in the metallic phase as the temperature is reduced and is suppressed in the insulating phase."

"Whether or not the electrons can conduct in two dimensions at very low temperatures is a question that has been hotly debated for more than a decade," said Kravchenko. "We now know that, because of the interactions between them, they can, and we have a theory that quantitatively and qualitatively explains things."

Source: Northeastern University

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