# Point-contact spectroscopy deepens mystery of heavy-fermion superconductors

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Theoretical understanding of heavy-fermion superconductors has just slipped a notch or two, says a team of experimentalists.
Researchers from the University of Illinois at Urbana-Champaign and Los Alamos National Laboratory recently used a sensitive technique called point-contact spectroscopy to explore Andreev reflection between a normal metal and a heavy-fermion superconductor. Conventional theories cannot account for their data, the scientists report.

"According to conventional theories, the Fermi velocity mismatch between a normal metal and a heavy-fermion superconductor is too large for Andreev reflection to occur," said Laura Greene, a Swanlund Endowed Chair in physics at Illinois. "But we can clearly and reproducibly measure it as a matter of course."

Andreev reflection is a particle-hole conversion process that occurs at the interface of a normal metal and a superconductor. Using point-contact spectroscopy, Greene and postdoctoral research associate Wan Kyu Park obtained measurements of Andreev reflection at the interface of a normal metal (gold) and the heavy-fermion superconductor CeCoIn5 (cerium-cobalt-indium-five).

Andreev reflection can be better understood by drawing an analogy to light, Greene said. When light is incident on glass, some of the light is reflected due to the difference in index of refraction between air and glass, and some is transmitted into the glass. The index of refraction is essentially the velocity difference: light travels slower in glass than in air.

Shining light on a diamond, which has an index of refraction larger than glass, causes more light to be reflected (one of the reasons diamonds appear to glow). The larger the velocity mismatch, the more light will be reflected.

Similarly, when a metal and a superconductor are in good electrical contact and have different Fermi velocities (the speed of electrons at the Fermi energy), some of the electrons will be reflected in a normal fashion. The larger the mismatch, the more electrons will be reflected and the less transmitted.

The Andreev reflection process requires at least some penetration of the electrons into the superconductor, Greene said. If the Fermi velocities are quite disparate, then there is a large fraction of normal reflection and less of a chance for Andreev reflection.

Conventional theory dictated that all of the reflection between a normal metal and a heavy-fermion superconductor would be normal and there would be no Andreev reflection.

"Our measurements prove that existing theories can't account for Andreev reflection between normal metals and heavy-fermion superconductors," said Greene, who will present the team's findings at the spring meeting of the American Physical Society, to be held in Los Angeles, March 21-25.

"The bottom line is, we can understand Andreev reflection occurring between a normal metal and a superconductor, but we can't understand it occurring between a normal metal and a heavy-fermion superconductor," Greene said. "We need a whole new theoretical formulation to explain this phenomenon."

In addition to Greene and Park, the research team included physicists

John Sarrao and Joe Thompson at Los Alamos. Tony Leggett (Macarthur Professor of Physics at Illinois), his graduate student, Vladimir Lucik, and an undergraduate student in Greene's group, Justin Elenewski, are collaborating on this experimental effort in investigating new theoretical frameworks to account for these results.

Source: University of Illinois at Urbana-Champaign