Searching for a single-electron source of standard quantized current

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(PhysOrg.com) -- “More than fifteen years ago, efforts were made to come to some kind of practical and standard realization of single-electron sources of quantized current. However, it was too difficult to combine the wanted magnitude of current with its accuracy,” Dmitri Averin tells *PhysOrg.com*. “The higher the current, the lower the accuracy.”

Some, though, believe that it is possible to revive the idea of a standard quantized current. Averin, a scientist at Stony Brook University, in Stony Brook, New York, worked with a team led by Jukka Pekola at the Helsinki University of Technology in Finland to develop a new source of quantized current based on a hybrid single-electron transistor. “Using a simple structure that has been overlooked, we are revising an old discussion,” Averin says.

Single-electron devices remain popular subjects of study as science and technology continues to shrink ever smaller. Understanding current quantization is an important step in the development of single-electron devices for metrology. In the work reported in *Physical Review Letters*: “Nonadiabatic Charge Pumping in a Hybrid Single-Electron Transistor,” Averin and Pekola present a theory of a pumped hybrid single-electron transistor which they hope will further the development of the quantum standard for electric current.

Already, there are standards for quantized (limited by quantum mechanical rules) voltage and resistance. “But there is not an explicit

quantum standard of current," Averin explains. "A standard on quantized current would help us close the metrological triangle: Current is related to voltage, which is related to resistance, which is related back to current. This is important from a fundamental physics point of view."

Averin and Pekola speculate in their paper that a controlled manipulation of individual electrons in a hybrid transistor could be the key to a quantized current that is up to metrological standards. The hybrid single-electron transistor is one that involves tunnel junctions between normal metal and superconductor, and can be operated as charge turnstile. "We pump electrons for a certain time, and count how many are pumped. It is a simple structure, and there is hope of a larger amount of current from such structure."

Right now, the pumping idea for the hybrid transistor device has been tested only in a few first experiments. "Pekola's team in Finland is working on this," Averin says. "Developing such a transistor as a metrological device would take some time, but there is a basis for trying to improve the accuracy of current quantization."

"The point of this particular paper was to see whether, in principle, this device would be capable of reaching a level of precision sufficient from a metrology point of view," Averin continues. "And, in principle, this pumped hybrid transistor should be capable."

In the end, Averin hopes that this work will lead to a single-electron quantum current standard, and one that can contribute to the understanding of fundamental physics. "With a metrological current standard, it would allow us to see whether the definitions of electric quantities we have in physics are consistent."