Large charge quanta in superconductor/semiconductor/superconductor junctions

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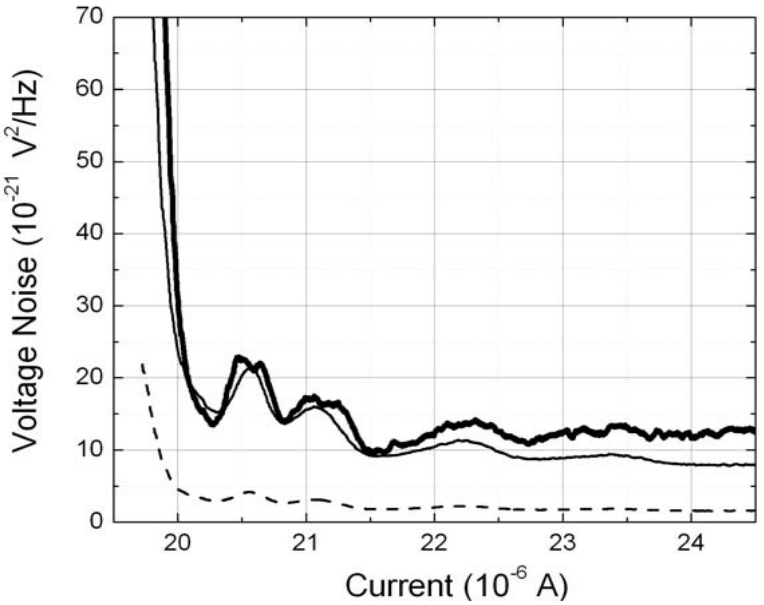
In contrast to what happens in a normal metal such as aluminum, in a superconducting wire electricity flows without dissipating heat, even if a short section of the wire is replaced with an adequate semiconductor. Since in a semiconductor electrons move individually whereas in a superconductor they travel in pairs, the charge transfer at the semiconductor/superconductor junction is a complex process, in which individual electrons in the semiconductor side are reflected at the junction several times before they finally enter the superconductor.

It has been predicted that those multiple reflections should also affect the temporal fluctuations of the average current, and since these fluctuations, or *noise*, often limit the performance of electronic devices, it is essential to determine that intrinsic noise.

We have demonstrated experimentally that the noise of superconductor/semiconductor/superconductor devices can be explained by the existence of large charge quanta[1], as if the amount of charge, ***q***, transferred were much larger than the electron charge, ***e***. Our results open the possibility of designing new devices that will test systematically existing theories and that may lead to new electronic applications.



Dependence of noise on current, measured at 1.2 K. The thick solid line is the experimental curve. The dashed line is the calculated noise assuming a charge equal to e, while the thin solid line considers a charge $q \approx 6e$, a value predicted by theory.

1. F. E. Camino *et. al.*, cond-mat/0406650

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Education:

The main contributor to this work has been a graduate student (Fernando Camino), with the assistance of an undergraduate student (Chui Woo) and the guidance of a former postdoctoral fellow (Vladimir Kuznetsov). Camino is now a research associate in Prof. V. Goldman's Stony Brook group. Woo, a female student who has received this year's Stony Brook award to the best graduating physics student, is starting graduate school at Duke University this fall.

Societal Impact:

The realization of electronic devices that combine the properties of superconductor and semiconductor materials is very appealing; however, knowing the intrinsic limits that nature may impose is essential to assess their practicality. And the more we know about the electron-transport mechanisms the easier it will be to design electronic devices for the benefit of society. Our results have elucidated those limits and will allow to design devices that test systematically existing theories and may lead to new applications.