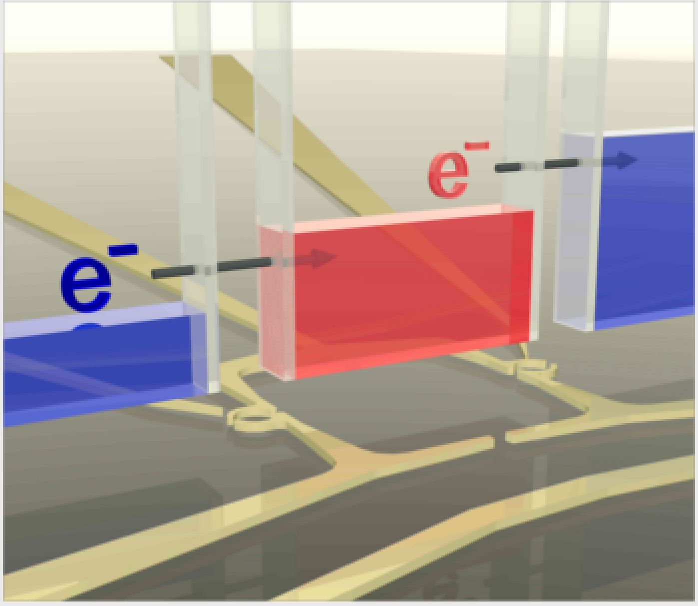
## Experimental Realization of a Quantum Dot Energy Harvester




Article: published in Physical Review Letters by Rafael Sánchez, IFIMAC researcher and member of Department of Theoretical Condensed Matter Physics.

We demonstrate experimentally an autonomous nanoscale energy harvester that utilizes the physics of resonant tunneling quantum dots. Gate-defined quantum dots on GaAs/AlGaAs high-electron-mobility transistors are placed on either side of a hot-electron reservoir. The discrete energy levels of the quantum dots are tuned to be aligned with low energy electrons on one side and high energy electrons on the other side of the hot reservoir. The quantum dots thus act as energy filters and allow for the conversion of heat from the cavity into electrical power. Our energy harvester, measured at an estimated base temperature of 75 mK in a He3/He4 dilution refrigerator, can generate a thermal power of 0.13 fW for a temperature difference across each dot of about 67 mK. [Full article]

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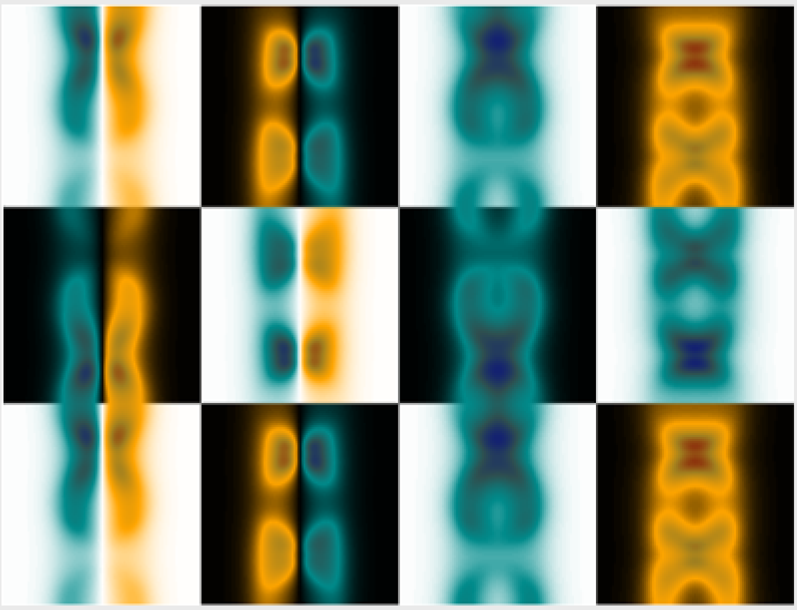
## Reversible Thermal Diode and Energy Harvester with a Superconducting Quantum Interference Single-electron Transistor



Articles: published in Applied Physics Letters by Rafael Sánchez, IFIMAC researcher and member of Department of Theoretical Condensed Matter Physics.

The density of states of proximitized normal nanowires interrupting superconducting rings can be tuned by the magnetic flux piercing the loop. Using these as the contacts of a single-electron transistor allows us to control the energetic mirror asymmetry of the conductor, thus introducing rectification properties. In particular, we show that the system works as a diode that rectifies both charge and heat currents and whose polarity can be reversed by the magnetic field and a gate voltage. We emphasize the role of dissipation at the island. The coupling to substrate phonons enhances the effect and furthermore introduces a channel for phase tunable conversion of heat exchanged with the environment into electrical current.

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A Protein-based Junction Serves as a Current Switch


Articles: published in Angewandte Chemie by Juan Carlos Cuevas and Linda A. Zotti, IFIMAC researchers and members of Department of Theoretical Condensed Matter Physics.

Proteins are key biological molecules that are responsible for numerous energy conversion processes such as photosynthesis or respiration. In recent years, proteins have been investigated in a new setting, namely in solid-state electronic junctions, with the goal of understanding the charge transfer mechanisms in these biomolecules, but also with the hope of developing a new generation of bio-inspired nanoscale electronic devices. Now, a new step towards this goal has been reported in a piece of work published in Angewandte Chemie by a collaboration between the group of David Cahen in the Weizmann Institute of Science (Israel) and the IFIMAC researchers Carlos Romero-Muñiz, Juan Carlos Cuevas, and Linda A. Zotti. In this work, these researchers show that a redox protein, cytochrome C, can behave as an electrically driven switch when incorporated in a solid-state junction with gold electrodes. By changing the external bias voltage in the junction, it was shown that the relevant molecular orbitals of the protein can be brought in and out of resonance with the chemical potential of the electrodes, which leads to the current-switch behavior. Showing transition from off- to on- resonance can be very challenging and this is the first time it has been achieved for proteins within the same working junction. Extensive ab initio DFT calculations revealed that the charge transport proceeds through the heme unit in these proteins and that the coupling between the protein’s frontier orbitals and the electrodes is sufficiently weak to prevent Fermi level pinning. The on-off change in the electrical current was shown to persist up to room temperature, demonstrating reversible, bias-controlled switching of a protein ensemble, which provides a realistic path to protein-based bioelectronics. [Angewandte Chemie – full article]

References

A Solid-State Protein Junction Serves as a Bias-Induced Current Switch, Jerry A. Fereiro, Ben Kayser, Carlos Romero-Muñiz, Ayelet Vilan, Dmitry A. Dolgikh, Rita V. Chertkova, Juan Carlos Cuevas, Linda A. Zotti, Israel Pecht, Mordechai Sheves, David Cahen. Published in Angewandte Chemie International Edition, Volume 58, Issue34, Pages 11852-11859, August 19 (2019). [URL]