

Highlights

Superconductivity — 2017

0- π controllable thermal Josephson junction

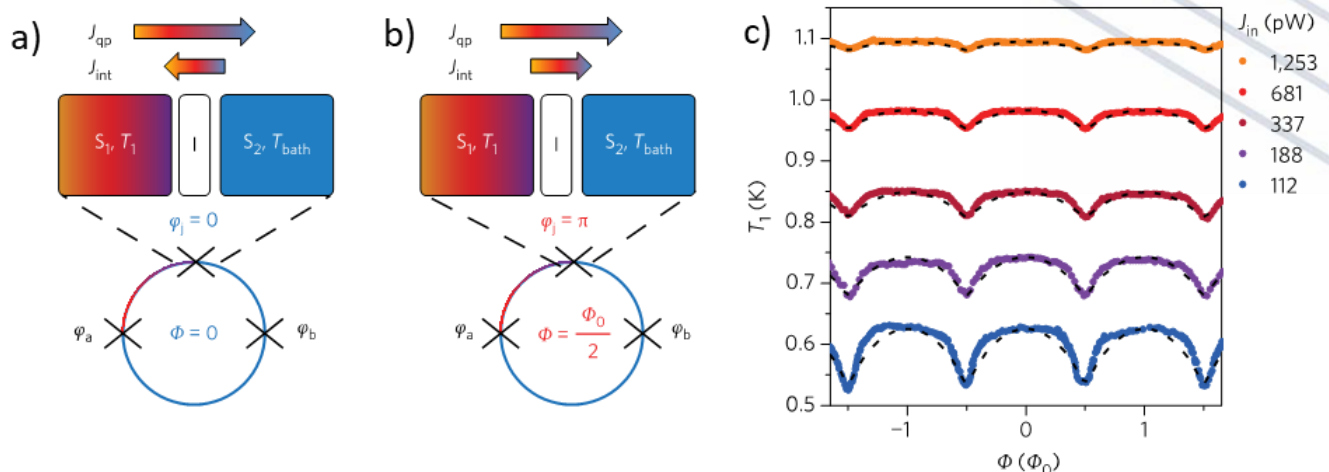
A. Fornieri¹, G. Timossi¹, P. Virtanen¹, P. Solinas² and F. Giazotto¹

¹NEST, Istituto Nanoscienze-CNR and Scuola Normale Superiore, Piazza S. Silvestro 12, I-56127 Pisa, Italy

²SPIN-CNR, Via Dodecaneso 33, I-16146 Genova, Italy

NATURE NANOTECHNOLOGY 12, 425 (2017)

Two superconductors coupled by a weak link support an equilibrium Josephson electrical current that depends on the phase difference φ between the superconducting condensates. Yet, when a temperature gradient is imposed across the junction, the Josephson effect manifests itself through a coherent component of the heat current that flows opposite to the thermal gradient for $|\varphi| < \pi/2$. The direction of both the Josephson charge and heat currents can be inverted by adding a π shift to φ . In the static electrical case, this effect has been obtained in a few systems, for example via a ferromagnetic coupling or a non-equilibrium distribution in the weak link. Here, we report the first experimental realization of a thermal Josephson junction whose phase bias can be controlled from 0 to π . This is obtained thanks to a superconducting quantum interferometer that allows full control of the direction of the coherent energy transfer through the junction. This possibility provides temperature modulations with an amplitude of ≈ 100 mK and transfer coefficients exceeding 1 K per flux quantum at 25 mK. Then, this quantum structure represents a fundamental step towards the realization of caloritronic logic components such as thermal transistors, switches and memory devices. These elements, combined with heat interferometers and diodes, would complete the thermal conversion of the most important phase-coherent electronic devices and benefit cryogenic microcircuits requiring energy management, such as quantum computing architectures and radiation sensors.



a) Scheme of the temperature-biased tunnel junction 'j' between two superconductors S_1 and S_2 embedded in a three-junction SQUID. When the flux Φ threading the superconducting loop is set to 0, the phase difference $\varphi_j = 0$ and the coherent component of the electronic heat current J_{int} flows opposite to the thermal gradient. b) When $\Phi = \Phi_0/2$, $\varphi_j = \pi$ and J_{int} flows parallel to the thermal gradient. c) Magnetic flux modulation of S_1 temperature (T_1) for several working temperatures (associated to the injected power J_{in}). The temperature oscillations stem from modulation of the phase-coherent heat power.