Tunneling spectroscopy of individual Andreev Bound States in a carbon nanotube

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Many experiments have demonstrated that when non-superconducting nanostructures such as nanotubes, nanowires, ferromagnet, molecules, etc. are connected to superconducting electrodes, they can nevertheless sustain a supercurrent. In spite of the diversity of these systems, their behavior is explained by a single theoretical concept, that of Andreev Bound States (ABS). These ABS are entangled time-reversed electronic states confined to the nanostructure which can convey Cooper pairs across the nanostructure in response to a superconducting phase difference. In spite of a long history and of a large number of experiments supporting the concept, individual ABS had yet to be observed directly in a spectroscopy experiment.

By performing tunneling spectroscopy in a nanotube connected to superconducting electrodes, we have achieved such direct observation of individual ABS. This ABS spectroscopy turns out to be a very precise tool to analyze the electronic state of the nanotube, and in particular of its spin state. In particular, this method can provide valuable information on nanotubes which are well coupled to the leads, in which usual Coulomb blockade spectroscopy is washed out.