Title:	Electrical Transport Characteristics of superconducting point-contacts
Authors:	Kumar, Ritesh
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Abstract:	Mesoscopic junctions between normal metals and superconductors are often used as a tool for extracting energy, momentum, and spin-resolved spectroscopic information about the Fermi surface of metals and the amplitude and symmetry of the superconducting energy gap of superconductors. The technique is commonly known as point contact spectroscopy (PCS). When the size of such a junction (a point contact) between two metals is comparable to the mean free path of the electrons, under the application of a voltage, the electrons either accelerate freely within the contact region (ballistic) or dissipate energy through inelastic scattering processes at the contact (thermal). In the ballistic regime, non-linearities in the current-voltage characteristics can be probed to spectroscopically investigate the interaction of the electrons with various excitations, like the phonons in a metal, magnons in a magnet and Bogolibuons in a superconductor. In the thermal regime, non-linearities may emerge from Joule heating of the point contacts. In an intermediate regime, where both ballistic and thermal features appear, the point contact spectra between normal metals and superconductors could mimic certain exotic spectral features that are theoretically predicted to emerge only for unconventional superconductors. Such “unconventional” features include multiple conductance dips and a large zero-bias conductance exceeding the limit of conventional Andreev reflection. Within a network resistor model, we have theoretically studied the role of non-ballistic transport characteristics for the emergence of such spectra when the superconductors are conventional in nature. We have also reproduced the theoretically calculated “unconventional” spectra in experiments using metallic point contacts between silver (Ag), a normal metal and niobium (Nb), a conventional superconductor. For the measurement of the transport characteristics of ballistic and non-ballistic superconducting point contacts we have constructed a broadband point contact spectroscopy (PCS) probe that works down to 290 mK. This probe has a reliable transfer mechanism for tip and sample exchange at low temperatures. The sample holder is equipped with high-frequency connectors making it suitable for conventional low-frequency (<1 kHz) and high-frequency (200MHz) measurements. The PCS probe module is directly attached to the He-3 pot of a He-3 based refrigerator. The probe has been carefully designed to minimize the mechanical vibration at the tip and sample space. The sample and tip holders in the probe go inside a 7 Tesla superconducting magnet dipped in liquid helium for high-field experiments. We have used the home-built PCS probe to study the superconducting properties of Srintercalated Bi2Se3, a candidate topological superconductor. Bi2Se3 is a topological insulator and upon Sr- intercalation, it superconducts below Tc 2:9K at ambient pressure. Srintercalated Bi2Se3 is especially interesting because it also displays a pressure induced reentrant superconducting phase where the high-pressure phase shows almost two times higher Tc than the ambient superconducting phase. Interestingly, unlike the ambient phase, the pressureinduced superconducting phase shows strong indication of unconventional superconductivity. However, since the pressure-induced phase remains inaccessible to the traditional spectroscopic i techniques, the detailed study of the phase remained an unattained goal. Based on our subkelvin PCS experiments, we have shown that the high-pressure superconducting phase of Sr- Bi2Se3 can be realized under a mesoscopic point contact, where transport spectroscopy can be used to probe the nature of superconductivity. We discovered that the point contact junctions on the high-pressure phase show an unusual response to the magnetic field supporting the possibility of unconventional superconductivity.
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