Quantum Conductors as Josephson Junctions

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Abstract. In recent years the proximity effect, i.e., the transfer of superconducting properties to normal metals, has been quantitatively understood in terms of Andreev bound states. Such states are formed, when quasi-particles are confined between two superconductor/normal-metal interfaces. I will discuss several experimental realizations of such an arrangement in metals, metal-semiconductor hybrids, and carbon naotubes. If the proximity region is a diffusive normal metal the spectrum of Andreev levels displays a minigap. For temperatures comparable to or smaller than this minigap the current phase relation (CPR) of the junction develops higher harmonics. At higher temperatures the CPR is sinusoidal, but irradiation with microwaves results again in the occurence of higher harmonics. This effect can be understood in terms of a non-equilibrium distribution of quasi-particles.

If the proximity region is a ferromagnet, the spin-splitting of Andreev levels leads under certain conditions to a sign inversion of the CPR. Such junctions are called pi-junctions and they lead to a peculiar half-integer flux quantization when embedded into a superconducting loop. If the proximity region is a ballistic InAs quantum well, the spectrum of Andreev levels is expected to be discrete. The supercurrent is suppressed both in perpendicular and parallel magnetic fields. Several mechanisms for the suppression in the parallel field case are discussed.