Seminar

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Cooper pair pumps for detection of Berry phase and for metrology

Controlled manipulation of Cooper pairs in multi-junction circuits is an interesting topic from several points of view. First, adiabatic and coherent charge transport in a multi-dimensional parameter space is a fundamentally interesting problem [1], where the pumped charge is closely related to the Berry phase [2]. Second, from the metrological point of view, a Josephson junction based charge pump can possibly deliver a much larger electrical current in pumping than a device based on similar normal tunnel junctions. Third, manipulation of the Cooper pair pumps relies largely on the same principles in control and measurement as the quantum bit circuits do, which as such makes these devices to be of general interest.

Experimentally we have till now studied three kinds of Cooper pair pumps. The first one is a conventional one-dimensional Josephson junction array, initially introduced by Geerligs et al. [3], where charge is controlled by gates connected to individual islands between junctions [4]. A much more promising circuit is the one where charge is transported by a combined flux and gate control, the device coined “sluice” [5]. The island in a sluice is connected to leads through SQUID loops. Synchronized flux and voltage signals are applied whereby the Josephson energies of the SQUIDs and the gate charge are tuned adiabatically. This device avoids, up to a certain level, leakage, i.e., errors due to higher order tunnelling events because of this temporal control of Josephson coupling. A third type of a device, an array-sluice, works with the same principle with three control parameters as the basic sluice-circuit, but suppression of the leakage can be improved significantly.

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