Competition between Coulomb blockade and multiple Andreev reflection

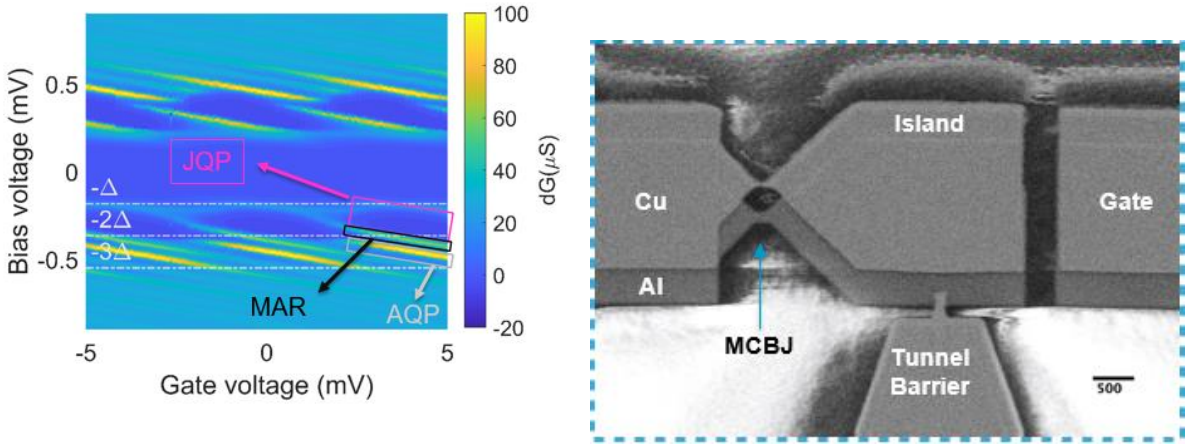
ES6 Laura Sobral Rey, Konstanz University, Germany

An island connected to two leads by tunnel barriers (TB) has discrete energy levels, quantized in units of the elementary electron charge e. This energy is defined as the charging energy of the device $E_C = e^2/2C$, being C the capacitances of all the elements coupled to the island. If besides this there is an extra lead coupled to the island (a gate electrode), it is possible to modulate the current that passes through. This device is known as a single electron transistor (SET). The current on the SET will be zero until the bias voltage overcomes two times the E_C. In our experiments, we study what happens if there is a ballistic contact instead of one of the TB. In other words, we measured atomic contacts in series with a TB. In our case, the tunnel barrier is a very thin oxide, and the quasiparticle junction is a mechanically controlled break junction (MCBJ).

On the other side, it is also very interesting what would happen if instead of normal metals we use superconductors. Then different types of transport are possible: Cooper pair (CP) tunnelling and Andreev reflections (AR). That is why in our experiments we use a combination of normal and superconducting materials, in particular a SSN disposition of materials (superconducting lead + superconducting island + normal lead).

In a normal state, when the MCBJ is totally open, the SET shows classical Coulomb blockade (CB) diamonds. As the break junctions closes, the conductance on the device increases, the E_C decreases, and progressively CB vanishes. After coming below the resistance quantum, CB totally disappears. In the superconducting state, if the MCBJ is totally broken, electronic transport is only possible after overcoming the threshold of the gap Δ and the CB. As the break junction is being closed, the Coulomb blockade also vanishes at some point, but in the intermediate states, AR and CP transport are enhanced.

However, the most interesting advantage of such a SET is that it allows to study new processes in the strong coupling regime. In particular, we could measure a very particular type of transport, called multiple Andreev reflection (MAR) and that implies the transmission of three quasiparticles. The energy window where MAR can happen is very small and normally very hard to get, but it is possible to adjust thanks to the high sensibility of the MCBJ. The position and intensity of the peak, together with simulations, assure us that we are actually monitoring this process.



Bias vs Gate voltage map, showing JQP, AR and MAR processes (left) and SEM picture of a sample showing the different parts (right)