Floquet engineering the interference between Cooper pairs in four-terminal Josephson junctions

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I will present the recent Harvard group experimental data [1] on four-terminal Josephson junctions evaporated on a sheet of graphene gated away from the Dirac point, thus realizing a two-dimensional (2D) metal connected to four superconducting leads. Overall, the Harvard group experiment is evidence for interplay between the time-periodic Floquet dynamics and the interference between the “standard” three-terminal quartets and the novel four-terminal split quartets [2-6].

The limits of weak [4] and strong [5-6] coupling between the 2D metal and the superconductors will be discussed, and it will be shown that the experiment can consistently be described by a multilevel quantum dot formed in between the contacts on the sheet of graphene. Two physical mechanisms will be discussed:

(i) Quantum superpositions in the Floquet-Andreev bound state dynamics for a 0D quantum dot [5].

(ii) A novel interference phenomenon for the Rabi resonance in a multilevel quantum dot coupled to four superconducting leads, already in the adiabatic limit [6].

The above item (ii) turns out to be more relevant than (i) because of the very low bias voltage and symmetric couplings to the four superconducting leads.

Finally, I will present two slides on a new proposal [7] inspired by unpublished experimental data in the Weizmann Institute group [8]. Ultra-long distance non-locality and quantum correlations of the quartets and octets are conjectured in a three-terminal Josephson junction containing two quantum dots, separated by distance which is orders of magnitude larger than the zero-energy coherence length, as in the Tomasch effect.

These recent theoretical and experimental results [1-8] demonstrate some of the basic phenomena that can emerge in practise, if one wants to quantum-engineer semi-conducting and van-der-Waals multiterminal superconducting hybrids in 0D or 2D geometries.


