Contribution ID : **10**

Type : **not specified**

Multimode photon-assisted tunnelling in superconducting quantum circuits

Friday, 5 February 2016 11:30 (15)

Among the most exciting recent advances in the field of superconducting quantum circuits is the ability to coherently couple microwave photons in low-loss cavities to quantum electronic conductors [1]. These hybrid quantum systems hold great promise for quantum information processing applications, and they enable the exploration of new physical regimes of light-matter interactions.

The physics of a tunnel junction illuminated by a purely classical microwave field has been understood since the 1960's with the classic work of Tien and Gordon [2]. This situation is equivalent to simply having an ac bias voltage across the conductor, and the resulting modification of the current is known as photon-assisted tunneling. Despite the word "photon" in the effect's name, in this standard formulation there is nothing quantum in the treatment of the applied microwave field.

If the cavity is not driven, the cavity-plus-conductor setup realizes another well-studied quantum transport problem: dynamical Coulomb blockade (DCB) [3,4]. Here, the cavity acts as a structured electromagnetic environment for the junction, one that can absorb (and at non-zero temperature, emit) energy from tunnelling electrons.

In stark contrast to standard DCB, in Ref. 5 we considered a non-equilibrium environment produced by preparing a microwave cavity in a non-classical ("quantum") state. The cavity effectively acts as an ac voltage bias across the conductor; by maintaining the cavity in a non-classical state, the junction is exposed to a non-trivial microwave field. We considered stationary, single-mode non-classical microwaves (e.g. squeezed states, Fock states), in the experimentally-relevant situation where a superconducting microwave cavity is coupled to a conductor in the single electron tunneling regime.

We found that the conductor functions as a non-trivial probe of the microwave state: the emission and absorption of photons by the conductor is characterized by a non-positive definite quasi-probability distribution which is related to the Glauber-Sudarshan P-function of quantum optics. These negative quasi-probabilities have a direct influence on the conductance of the conductor, and the non-classicality of the microwave field may be inferred directly from features in the current-voltage characteristic.

Here we consider the behaviour of a quantum conductor in the presence of stationary, but multimode, structured microwave field environments. We show how the statistics of these microwave fields, including their correlations and entanglement, impact the current and current noise of the coupled conductor. We describe how the statistics of the multimode microwave fields can be inferred through transport measurements alone.

1. K. D. Petersson et al., Nature 490, 380 (2012).
2. P. K. Tien and J. P. Gordon, Phys. Rev. 129, 647 (1963).
3. M. H. Devoret et al., Phys. Rev. Lett. 64, 1824 (1990).
4. S. M. Girvin et al., Phys. Rev. Lett. 64, 3183 (1990).
5. J.-R. Souquet, M. J. Woolley, J. Gabelli, P. Simon, and A. A. Clerk, Nature Communications 5, 5562 (2014).

Primary author(s) : Dr WOOLLEY, Matt (UNSW Canberra)

Presenter(s) : Dr WOOLLEY, Matt (UNSW Canberra)

Session Classification : Contributed talk