Quantum electrons driven by quantum microwaves

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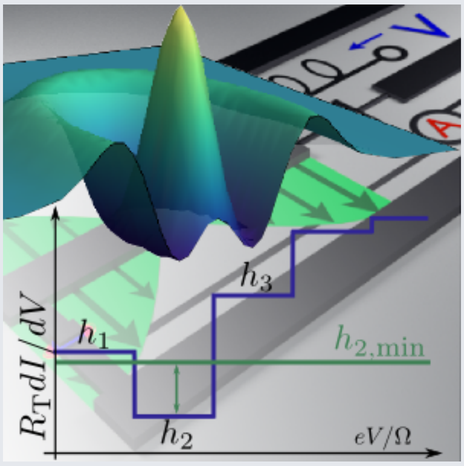
Among the most basic questions in quantum electronic transport is what happens when a quantum conductor is driven by an ac voltage. We recently addressed theoretically what happens when this ac voltage is itself truly quantum mechanical in nature (being described by for example a squeezed state or a Fock state). Experimental systems exist that could realize such a situation: by coupling a tunnel junction to a superconducting microwave cavity. We show that the current of the conductor has signatures that directly reflect the non-classical nature of the driving microwaves. In that sense, a measure of an electric current can be used a detector of the quantum nature of the microwave optical electric field. Such feature is illustrated in the figure where we illustrate a Fock state with two microwave photons in the cavity which entails a strongly non-monotonic dependence of the differential conductance of the tunnel junction with the bias voltage. Moreover, the transport is naturally associated with quasi-probabilities that can become negative.



Differential conductance dI/dV versus dc bias voltage V for a tunnel junction coupled to a microwave cavity initially prepared in the Fock state n=2. The striking signature of a non-classical state here is the strongly non-monotonic dependence of the first few conductance plateaus on voltage; in particular, the height of the second plateau (h2) is smaller than the first (h1). This is in one to one correspondence in the Fock state with exactly two photons in the cavity

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