Full counting statistics of quantum shot noise in superconducting contacts containing Yu-Shiba-Rusinov states

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A partly superconducting (SC) junction can host different types of charge transport mechanisms. In addition to the transport of one single electron-like quasiparticle (QP), such an electron can also be reflected back from the SC as a hole creating a Cooper pair. This process is called Andreev Reflection (AR) and includes the transport of two total charges at once. Between two SCs, this process can occur sequentially leading to multiple AR (MAR), where more than two charges are transported at once. The number of transferred charges can be characterised by the Fano Factor (*F)* which depends on the current and the shot noise (= fluctuations of the current). In SC junctions, the Fano Factor can be super-Poissonian ($F>1$), indicating that the charge number is larger than one because of (M)AR [1]. In contrast, resonant tunnelling results in a so-called sub-Poissonian ($F<1$) Fano Factor, where the interpretation of the Fano Factor as effective charge breaks down.

A magnetic impurity imbedded on a SC surface results in so-called Yu-Shiba-Rusinov bound states in the SC gap where the density of states is otherwise zero. Such a bound state inside the SC gap heavily alters the transport properties of the respective junction, namely quasiparticle and (M)AR tunnelling can be resonant at the YSR bound state energy [2].

Recent shot noise measurements of such systems including YSR bound states reveals resonant tunnelling and a transition from super- to sub-Poissonian Fano Factor [3]. The question arises which charge transport mechanism is now dominant in a regime where (M)AR can lead to an increased Fano Factor, while resonance generally decreases the Fano Factor. With the help of the full counting statistics (FCS), we can extract the quasiparticle and (M)AR contributions of the current and compare the respective components. We present a detailed study on the FCS of a normal-superconducting (NS) and superconducting-superconducting (SS) junction containing YSR bound states using a generalised Keldysh-Action approach [4].

References:

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