Full Counting Statistics for Unconventional Superconductor Junctions

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Noise and current measurements are key tools for studying mesoscopic systems, revealing insights beyond conductance alone. For instance, noise measurements show that transport carriers in conventional superconductors have charge 2e. The noise power also depends on junction type, distinguishing different transport processes. Existing theories focus primarily on zero temperature shot noise in tunnel junctions with conventional superconductors, where transport is carried by quasiparticles and Cooper pairs.

Here we develop a full counting statistics theory for unconventional superconductor / normal metal junctions of different types, incorporating the effect of thermal noise on the differential Fano factor, the ratio of differential noise power and conductance. In these junctions there is a third type of transport mechanism, surface Andreev bound states. Our study reveals that junctions with dispersionless surface Andreev bound states exhibit negative differential Fano factor at finite temperatures. In contrast, in the presence of dispersive surface Andreev bound states, the noise power always increases with voltage, but there are local minima in the differential noise at those voltages corresponding to the extrema of the surface Andreev bound state spectrum. For normal metals and conventional superconductors the voltage dependence of the differential Fano factor is similar in all types of junctions, including tunnel junctions and diffusive barriers. However, significant differences arise with unconventional superconductors, making distinct junction types valuable tools for identifying pairing symmetries. Our results highlight the importance of finite temperature effects in noise power measurements for potential unconventional superconductors, offering new means to determine pairing symmetries in topological superconductors.