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Noise Enhancement by Limited Resolution

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Investigating current distributions has been attracted much attention in mesoscopic systems. In particular, the current noise, which is the variance of distribution, has been extensively studied as well as the average current. For example, the equilibrium noise is used in thermometry[1,2,3], and the nonequilibrium noises contribute to our understanding the low-energy excitations of the systems[4] and to the establishment of the steady-state fluctuation theorem[5]. However, there is a discrepancy between theory and experiment in the noise measurements at very low temperatures: The measured noises are often larger than those expected from theories[2,3,4,5]. The deviation becomes prominent with decreasing temperatures, which implies unidentified noises in the measurements emerging only at very low temperatures.

In this study, we show that the limited resolution inevitable in actual current measurements is a possible noise source. To investigate the resolution effects on the current statistics, we propose the two point measurement statistics with limited resolution, which is an extension of what Esposito *et al.* proposed[6] and is described by a positive operator-valued measure. Using this method, we calculate the cumulant generating function of current through a resonant level coupled to two reservoirs. It is found that while the averaged measured current is not affected by limited resolution, the measured noise can be larger than the intrinsic noise accompanied by the excess noise production. The noise enhancement by limited resolution is not considered in previous theories, then may account for the discrepancy. With the detailed analysis of the equilibrium noise, we also find that the universal deviation from the Johnson-Nyquist relation between current and noise appears at very low temperatures, which is consistent with the experiments[2,3].

[1] D. R. White, R. Galleano, A. Actis, H. Brixy, M. De Groot, J. Dubbeldam, A. L. Reesink, F. Edler, H. Sakurai, and R. L. Shepard, *Metrologia* **33**, 325 (1996).
[2] M. Hashisaka, Y. Yamauchi, S. Nakamura, S. Kasai, K. Kobayashi, and T. Ono, *J. Phys.: Conf. Ser.* **109**, 012013 (2008).
[3] R. A. Webb, R. P. Giffard, and J. C. Wheatley, *J. Low. Temp. Phys.* **13**, 383 (1973).
[4] Y. Yamauchi, K. Sekiguchi, K. Chida, T. Arakawa, S. Nakamura, K. Kobayashi, T. Ono, T. Fujii, and R. Sakano, *Phys. Rev. Lett.* **106**, 176601 (2011).
[5] S. Nakamura, Y. Yamauchi, M. Hashisaka, K. Chida, K. Kobayashi, T. Ono, R. Leturcq, K. Ensslin, K. Saito, Y. Utsumi, and A. C. Gossard, *Phys. Rev. Lett.* **104**, 080602 (2010).
[6] M. Esposito, U. Harbola, and S. Mukamel, *Rev. Mod. Phys.* **81**, 1665 (2009).