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Current noise enhancement by quantum effects of a charge resolution limit

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Current measurement is a useful tool to understand the intrinsic properties of nanoscale systems.In addition to the current average, the current noises have been extensively studied in past two decade. In particular, the nonequilibrium shot noise and the equilibriumJohnson-Nyquist noise are truly instrumental. They weresuccessively utilized for confirming the fractional charge of the excitation in fractional quantum Hall edge states, for measuring the Kondo correlationsin quantum dot systems,and for the thermometry.In contrast to the good agreement of theory and experiment, however, wealso observed the disagreement atvery low temperatures and low voltages in various nanoscale systems, *i.e.* unexpected anomalous noise enhancement.

Here we consider the puzzle byidentifying the properties of the potential noise source in the simple framework of intrinsic and extrinsic noise.The disagreement abruptly disappears with a slight increase in temperature or voltage, which apparently indicates that the anomalous enhancement is caused by an unknown intrinsic mechanism. On the other hand, the anomalous noisealso shows signs of being extrinsic;it appears in equilibrium, andseems to violate the Johnson-Nyquist relation that holds for the intrinsic mechanism. Accordingly, the anomalous noise shows thenature of intrinsic and extrinsicsources.

One possiblenoise source is the actual measurement of current*per se*; in light of the inevitable presence of an extrinsic resolution limit, the intrinsic current is affected by the measurement in a quantum-mechanical manner, which can lead to the mixed nature. Here we theoretically study the influence of acharge resolution limit on the observed current distribution, using an extension of the full counting statistics. It is shown that the resolution limit gives rise to noise enhancement prominent only at low temperatures and low voltages. The relative error of the measured noise is universally scaled by a single parameter. The resolution effects are truly quantum-mechanical because it disappears in the classical limit where the Planck constant approaches the zero. Our findings also offer a qualitative explanation of the disagreement between experiment and ideal theory observed in the noise measurements.

Biography:

Yasuhiro Yamadais a research fellow of the department of physics at Osaka University.He received the B. E. and M. E. degrees in applied physics from Osaka University in 2006 and 2008, respectively. He received the Ph.D. degree in physics from Kyoto University in 2011 for his work on the nonequilibrium interplay between the Kondo and the superconducting correlations in a quantum dot system. He joined the department of applied physics at the University of Tokyo as a research fellow in 2011. His current research interests include quantum correlation effects in nonequilibrium systems, quantum measurement effects, dissipation engineering, feedback control of quantum systems, dynamical phase transitions, and transient quantum dynamics in photovoltaics.