Shot Noise in Coulomb Blockade Metallic Quantum Dot Structures: Monte-Carlo Simulation versus Master Equation Solution

B. H. Giang[1], **P. T. Anh**[2],
N. V. Hung[3], **and V. L. Nguyen**[4]

Abstract: We systematically study the shot noise of current through different Coulomb blockade metallic quantum dot (QD) structures, using the standard master equation approach and Monte-Carlo simulation.

For the structure of single metallic QD, coupling to two ferromagnetic leads, the study is focused on the case of anti-parallel alignment of lead magnetizations with an electron accumulation in the dot. The noise is calculated as a function of the spin polarization in a full range of frequency as well as bias voltage. Along with the chemical potential shift and tunnel magnetoresistance the noise is shown to oscillate as the spin polarization varies. Both the Coulomb interaction and the spin can suppress the noise, making the Fano factor smaller than the Poissonian value.

For structures of two QDs, coupled in series or in parallel, the asymmetrical character and the inter-dot coupling are the most important factors, affecting the current and noise behaviors. While for the structure of two QDs coupled in series, the noise is shown always to be sub-Poissonian even in a negative differential conductance regime, it may becomes super-Poissonian in the strongly asymmetrical structure of a dot coupled with an electron box. The inter-dot capacitance can drive the conduction (including noise) characteristic, changing it between two limits of single QD structures.

The master equation is in principle an exact method, allowing us to calculate the noise in the full range of frequency. In practice, however, it is impossible to solve exactly this equation, taking into account all possible states, particularly, at large bias voltages. The Monte-Carlo simulation, on the contrary, is easily treated at large bias voltages, but it fails to deal with the low frequency limit. In all the cases, when both methods are available [Nguyen et al., Appl. Phys. Lett. 2005, 87, 123107], the noises calculated by the master equation and Monte-Carlo simulation, are practically coincident.

[1,2,3,4] Theoretical Department, Institute of Physics, VAST
P.O. Box 429 Bo Ho, Hanoi 10000, Vietnam
nvlien@iop.vast.ac.vn