【Grant-in-Aid for Scientific Research (S)】

Science and Engineering (Mathematical and Physical Sciences)

Title of Project : Microscopic Understanding and Control of Nonequilibrium Spin Transport in Mesoscopic Systems

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Research Area : Quantum transport
Keyword : Mesoscopic systems, Kondo effect, Spintronics, Nonequilibrium, Fluctuation

【Purpose and Background of the Research】

There are large variety of materials around us such as magnets, metals, insulators, semiconductors, and so on. We tactically combine them to make the best of the materials in our world, on which modern technology is founded.

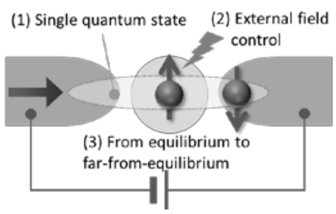
Material properties are mostly determined by the behavior of numerous electrons inside them. Solid state physics is a research field to clarify how electrons interact each other in solids. Especially, two degrees of freedom of electrons, namely the electric charge, which carries electric current, and the spin, which causes magnetism, are the most important. To microscopically understand how these two cooperate each other to yield unique physical properties of various materials is an ultimate goal of solid state physics. Above all, spin-dependent transport, such as Kondo effect and giant magnetoresistive effect, plays an important role in promoting our understanding of solids.

So far, the spin-dependent transport has been addressed in macroscopic systems that contain numerous spins. However, recently, nanofabrication technique enables us to address quantum transport in very small solid state devices, so called "mesoscopic systems".

In this research project, we address spin-dependent transports in mesoscopic systems in order to clarify elementary processes of electron transport to cover from the equilibrium regime to the strongly nonequilibrium one.

【Research Methods】

We investigate mesoscopic systems, where even a single charge and spin of electrons can be controlled in various ways (see Figure). In addition to conventional conductance, we focus on the current noise, or the current fluctuation around its time-averaged value. By looking at it, unique information of transport dynamics can be obtained, which would be never possible in conventional conductance measurement. To this end, we use our home-made high precision noise measurement system, which we have successfully developed for these several years.



【Expected Research Achievements and Scientific Significance】

The uniqueness of the present research project lies in the application of the current noise measurement to elucidate nonequilibrium spin-dependent transport in mesoscopic systems. Current noise in mesoscopic transport is an interesting and timely topic, which becomes experimentally feasible these days through the progress of nano-fabrication technique and high-speed electronics.

Our research project to focus on the current fluctuation will clarify unexplored microscopic aspects of various spin-dependent transports such as the Kondo effect and thus will contribute to solid state physics. Moreover, it will also promote our understanding and controlling of the spin transport in terms of spintronics, where nonequilibrium spin transport plays a key role.

【Publications Relevant to the Project】

・Y. Yamauchi, K. Sekiguchi, D. Chida, T. Arakawa, S. Nakamura, K. Kobayashi, T. Ono, T. Fujii, R. Sakano, "Evolution of the Kondo effect in a quantum dot probed by shot noise", *Physical Review Letters* **106,** 176601-1-176601-4 (2011).

・T. Arakawa, Y. Nishihara, M. Maeda, S. Norimoto, K. Kobayashi, "Cryogenic amplifier for shot noise measurement at 20 mK", *Applied Physics Letters* **103,** 172104-1172104-4 (2013).

【Term of Project】 FY2014-2018

【Budget Allocation】 149,600 Thousand Yen

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