

Development of a nano-SQUID and its application to quantum information

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【Outline of survey】

A SQUID is one of the most sensitive detector for magnetic field. Our goal is to develop ultra small SQUIDS and to apply them to the following research subjects.

- ① Detection of single spin and study of relaxation process of spin using nano-SQUID whose size is less than μm .
- ② Implementation of quantum entanglement between a SQUID-qubit and a spin-qubit.

We will fabricate a coupling system between semiconductor-2DEG or quantum dots and a nano-SQUID which is fabricated by mechanical etching using focused ion beam or by a previous Josephson-junction method. The spin detection can be made through the high-speed measurement of the maximum supercurrent in a nano-SQUID. For the second subject we will first develop a nano-SQUID embedded with a quantum dot and confirm its qubit operation. Then quantum entanglement is achieved by a direct coupling between a superconducting flux qubit and the nano-SQUID or by a coupling between them through a LC-resonator.

【Expected results】

There are very few experiments on the detection of single spin or spin relaxation process. Nano-SQUID system that we work on will clarify physical origin of spin relaxation process in various kind of systems like quantum dot, graphene or 2DEG. The nano-SQUID thus is a very strong tool to contribute on the development of spintronics and spin-qubit. The coupling between different kind of qubits (like a flux qubit and spin one) is the basis for the quantum interface which is one of the key technologies for the future quantum information network.

【References by the principal investigator】

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- S. Sasaki, S. Kang, K. Kitagawa, M. Yamaguchi, S. Miyashita, T. Maruyama, H. Tamura, T. Akazaki, Y. Hirayama, and H. Takayanagi, “Non-local Control of the Kondo Effect in a Double Quantum Dot - Quantum Wire Coupled System”, Phys. Rev. B Rapid Commun. **73** (2006) 161303-1 - 161303-1 (R).

【Term of project】 FY2008—2012

【Budget allocation】

160,100,000 yen (direct cost)

【Homepage address】

<http://www.rs.kagu.tus.ac.jp/~takalab/>