Current-phase relation of a superconducting atomic point contact

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In a superconducting quantum point contact (QPC), Cooper pairs are thought to be transferred via a few channels that are characterized by a set of transmission coefficients. Indeed, the current-voltage characteristics and the current-phase relation of the single-channel QPC have been calculated as a function of the transmission coefficient. However, the experimental verification of the relation is yet to be done. We have made an experiment that allows to determine both the transmission coefficients and the current-phase relation: A device we made was a dc-SQUID composed of a superconducting atomic point contact and a tunnel junction, and the transmission coefficients and the current-phase relation of the point contact were determined by analyzing the I-V characteristics and the magnetic field dependence of the critical current, respectively. The current-phase relation became clearly non-sinusoidal when the transmission coefficients approached unity. In order for the quantitative explanation of the experimental results, we have to take into account the effect of the thermal fluctuation, and also have to assume a correction factor to the theory of the critical current. We also note that the SQUID behaves as a ratchet and the locking ratchet effect, i.e., the voltage rectification in the presence of ac current was really observed.