凝縮系物理学ゼミナール

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場所：理学部5号館　413号室

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「Crossed Andreev reflection and elastic cotunneling through a quantum dot」

Advances in nanotechnology enable us to fabricate nanoscale three terminal systems in which two normal metals contact one superconductor. When the distance between two contacts is smaller than the coherence length of the superconductor, a nonlocal electron transport occurs [1, 2]: an electron coming from a normal metal is converted to a hole in the other normal one, which gives rise to a negative nonlocal conductance. This so-called crossed Andreev reflection (CAR) is a nonlocal version of the Andreev reflection. In CAR, spatially separated spin-entangled electron pairs are generated in the two normal metals, which may be useful for quantum entangler devices. Since CAR competes with elastic cotunneling (EC), which is a direct electron transport process between the normal metals, it is a major issue that CAR dominates EC in the nonlocal transport. It has been also reported that the Coulomb interaction may strongly affect CAR [3, 4].

In this study, we theoretically investigate CAR and EC through a quantum dot (QD) coupled to two normal and one superconducting leads in both equilibrium and nonequilibrium cases. In equilibrium case, we find that CAR can dominate EC in asymmetric coupling cases. With increasing the Coulomb interaction at the QD, EC becomes dominant instead of CAR and the zero-bias anomaly in the nonlocal conductance is observed due to the Kondo effect. Even in the strong Coulomb interaction regime, however, we also find that the curve of the nonlocal differential conductance significantly changes with increasing bias voltage between the normal leads, and shows the sign change in some specific nonequilibrium conditions. We elucidate that the sign change, which indicates the alternation of the dominant transport process, is caused by the enhancement of CAR due to the cooperation between the Kondo/proximity effects at finite bias.

[1] J. M. Byers *et. al.*, PRL **74**, 306 (1995). [2] G. Deutscher *et. al.*, Appl. Phys. Lett. **76**, 487 (2000). [3] S.Russo *et. al.*, PRL **95**, 027002 (2005). [4] J. Brauer *et. al.*, PRB **81**, 024515 (2010).