

Novel phase modulation of magnetoresistance oscillations in Kondo/superconducting hybrid loops

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Hybrid structures composed of a magnetic metal and a superconductor have attracted great attention for their importance in technical applications as well as their rich fundamental physics [1]. Thanks to recent progress in micro-fabrication techniques, the interface between a superconductor and a magnetic metal film can be specifically controlled to achieve high transparency. In an interface with very high transparency (high conductance), the superconducting pair correlations can penetrate into a normal metal and give rise to the proximity effect. For a magnetic metallic film in contact with superconductor, the existence of the superconducting proximity effect is still in debate [2].

To elucidate this problem we have fabricated a mesoscopic hybrid loop consisting of a dilute magnetic AuFe wire and a superconducting Al wire, and have studied magnetoresistance under dc bias current through the sample. The samples were fabricated by multi-level e-beam lithography and lift-off process. The AuFe films of 26 ppm Fe impurity concentration were made by implanting Fe ions into gold films. In measurements of the resistance of the AuFe wire, we have observed logarithmic temperature dependence, which is a sign of the Kondo effect. Remarkably we have observed the Aharonov-Bohm type magnetoresistance oscillations which arise from phase-coherent transport in the AuFe Kondo wire in the vicinity of a superconducting Al film.

We have also found that the phase of the magnetoresistance oscillations is sensitive to the dc current which is applied between two-terminals of the hybrid loop. As the dc current is increased, the change of the phase of the magnetoresistance oscillations initially increases. However, the change of the phase is larger by a factor of 50 than the expected amount estimated from a simple picture of the current-induced magnetic flux through the hybrid loop. When the dc current is increased above a certain critical value, the change of the phase starts to decrease with dc current.

In this paper, we report our study on the phase-coherent transport in Kondo/superconducting hybrid loops. We have observed magnetoresistance oscillations and novel phase modulation by dc current. The properties of the magnetoresistance oscillations are associated with interplay between the spin-flip scatterings in a Kondo wire and the Andreev-reflection at the AuFe/Al interfaces.

References

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