Magnetic proximity effect in superconductor/ferromagnet van der Waals heterostructures: dependence on the number of superconducting monolayers

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Magnetic proximity effect is well-studied in the heterostructures with the large number of monoatomic layers. For example, if the S layer is proximitized by a thin-film metallic ferromagnet and the S/F interface is fully transparent, the effective exchange field in the S layer is $h_{eff} = \nu_F\, d_F\, h/(\nu_S\, d_S + \nu_F\, d_F)$[1]. In this case there will be classical suppression of the order parameter by an effective exchange field, induced in the superconductor by ferromagnet, and one can see a DOS with Zeeman splitting.

Considering van der Waals S/F heterostructures, the effects of hybridization of electronic spectra turn out to be important due to the low number of monoatomic layers. Consequently, the superconducting state of such structure appears to be greatly modified compared to the case of the thin-film heterostructure [2].

In this work we report how the behavior of the superconducting state depends on a change in the number of monolayers. We investigated the evolution of the behavior of the superconducting order parameter as a function of the exchange field of the ferromagnet and as a function of the chemical potential of the ferromagnet. It is shown that these dependencies have a highly non-monotonic character, which directly reflects the physical mechanism of the proximity effect in such systems. Moreover, the limiting form of the dependence of the order parameter on the exchange field for a large number of superconducting layers is discussed.

Spin splitting of the electronic LDOS is also investigated. Analogously to the behavior of the superconducting order parameter this splitting is strongly different from the well-known picture of Zeeman-split superconducting LDOS. This unusual spin splitting of the LDOS can be observed experimentally upon varying the gate potential applied to the F-layer. The behavior of the superconducting order parameter can also be obtained from the LDOS observed experimentally via scanning tunneling microscopy (STM) technique.

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