Resonant indirect interaction in system with linear spectra

I.V. Krainov [1],I.V. Rozhansky [1,2], N.S. Averkiev [1], E.Lähderanta [2]

[1]Ioffe Physical technical institute, Polytekhnicheskaya, 26, St Petersburg, 194021, Russian Federation

[2]LappeenrantaUniversity of Technology, P.O. Box 20, FI-53851, Lappeenranta, Finland

The magnetic properties of graphene-based nanostructures are in the focus of modern solid state physics. Along with the fundamental research interest, graphene layers and carbon nanotubes doped with magnetic impurities are considered highly attractive for potential spintronic applications.

Investigation of the ferromagnetic interaction between the magnetic defects is of fundamental interest in terms of the microscopic mechanism of magnetic ordering. In metals and diluted magnetic semiconductors the key mechanism leading to ferromagnetic ordering is indirect exchange between magnetic ions mediated by delocalized free carriers. This interaction is described by RKKY theory [1]. The RKKY theory gives the interaction energy of two magnetic impurities by means of the second order perturbation theory. We have shown that whenever the magnetic ion possesses a resonant localized state to attract the free carrier, the indirect exchange becomes strongly enhanced. The appropriate treatment of the phenomena requires non-perturbative approach. The appropriate extension of the RKKY theory for semiconductor nanostructures with magnetic impurities interacting via remote conducting channel was developed in [2,3].

Unlike the studied case of semiconductors, graphene features linear energy spectrum for the free carriers. In this work we study the interaction of magnetic impurities located on graphene or carbon nanotube. There is no direct exchange interaction between the magnetic impurities due to the large distance between them, but a small distance from the grapheme sheet provides a tunnel coupling of the electron gas with the localized states of the defects and gives rise to indirect exchange interaction.

We performed the calculation of the indirect exchange interaction using the method developed in [2,3]. The resonant enhancement of the indirect exchange interaction occurs whenever the impurity bound state energy lies below the Fermi level of the electron gas. The maximum enhancement is expected if the bound state energy coincides with the Fermi level of the electron gas.

I.V. Krainov is grateful to the Dynasty Foundation for the financial support.

Bibliography

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