RKKY interactions in uniaxially strained graphene

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Abstract

The ease with which the physical properties of graphene can be tuned suggests a wide range of possible applications. Recently, strain engineering of these properties has been of particular interest [1]. Possible spintronic applications of magnetically doped graphene systems have motivated recent theoretical investigations of the Ruderman-Kittel-Kasuya-Yosida (RKKY) exchange interaction between localized moments in graphene [2]. In this work a combination of analytic and numerical techniques are used to examine the effects of uniaxial strain on such an interaction.

A range of interesting features are uncovered depending on the separation and strain directions, and on how the localized magnetic impurity connects to the graphene lattice. For substitutional impurities we see a range of amplification and suppression effects as a function of strain, which maintain the sublattice dependent sign rules for the interaction in unstrained graphene (Fig 1). These features suggest that the strength of the interaction between two moments can be tuned or even switched on and off by minor levels of strain [3]. For adsorbed impurities a further range of features, including significant modification of the decay rate and the possibility of changing the sign of the interaction, are predicted [4].

In all cases, mathematically transparent expressions describing these features are derived which allow reliable predictions in agreement with numerical calculations. Since a wide range of effects, including overall moment alignment and magnetotransport response, are underpinned by such interactions, the ability to manipulate the coupling by applying strain may lead to interesting spintronic applications.

References

[1] V. M. Pereira and A. H. Castro Neto, Phys. Rev. Lett., **103** (2009), 046801
[2] e.g. S. Saremi, Phys. Rev. B, **76** (2007), 184430, S. R. Power and M. S. Ferreira, Crystals, **3 (**2013), page. 49-78 and references within.
[3] S. R. Power, P. D. Gorman, J. M. Duffy and M. S. Ferreira, Phys. Rev. B **86** (2012), 195423.
[4] P. D. Gorman, J. M. Duffy, M. S. Ferreira and S. R. Power, *in preparation.*

Figures

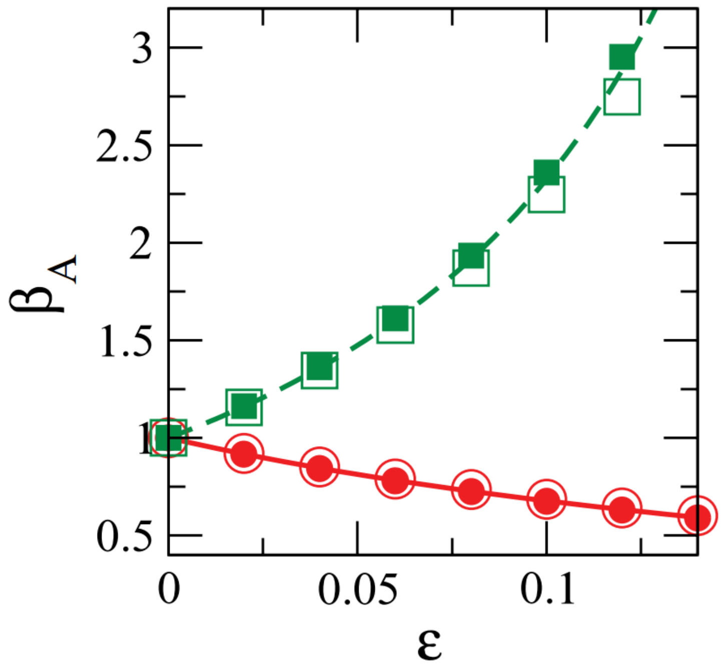

Fig 1: Ratio (β_A) of strained and unstrained magnetic coupling between two substitutional magnetic impurities as a function of uniaxial strain (ε). The magnetic impurities are a fixed distance apart in the armchair direction. Numerical results are shown for strains applied parallel (red circles) and perpendicular (green squares) to this separation direction where suppression and amplification of the coupling are observed. The lines represent analytical predictions of the same quantities. Adapted from Ref [3].