Critical temperature of two-dimensional hydrogenated multilayer graphene-based diluted ferromagnet

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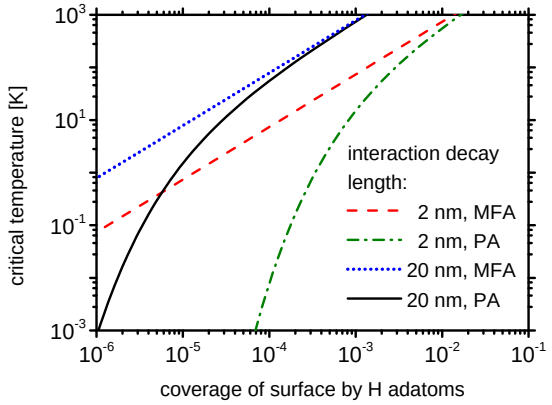
Hydrogenated graphene constitutes a promising platform for future spintronics devices [1], thus it attracts increasing attention [2]. One of the natural goals to achieve in such system is the ferromagnetic ordering of localized magnetic moments. As predicted theoretically [3], the long-range ferromagnetic interaction emerges between localized magnetic moments provided by hydrogen atoms deposited over carbon atoms of one sublattice of multilayer graphene.

The aim of the paper is to present the results of numerical calculations of critical temperature of diluted ferromagnet based on multilayer graphene with H adatoms at the surface, over carbon atoms of one sublattice [4]. The calculations of critical (Curie) temperature of continuous phase transition are based on Pair Approximation (PA) for diluted ferromagnetic systems with long-range interactions [5]. For comparison, the results yielded by Mean Field Approximation (MFA) are also presented. The interaction of the form $J(r) \propto (1/r)\exp(-r/\lambda)$ with characteristic exponential decay length λ is assumed. The exponential attenuation can be expected in the presence of disorder in the system.



Critical temperature as a function of surface coverage with H adatoms for two interaction decay lengths. Results of MFA and PA (for Heisenberg coupling) are compared.

The wide range of adatom concentrations and attenuation lengths is considered. The dependence of critical temperature on both quantities id thoroughly analysed. In particular, a highly non-linear dependence of critical temperature on impurity concentration (surface coverage by H atoms) is predicted, as illustrated in the figure. Moreover, it is demonstrated that MFA, commonly applied to systems with long-range interactions, heavily overestimates the critical temperature values compared to PA. In addition, PA is capable of taking into account the interaction anisotropy in spin space, ranging from anisotropic Ising to isotropic Heisenberg couplings. Thus, the importance of such anisotropy can be discussed.

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[1] W. Han, R. K. Kawakami, M. Gmitra, J. Fabian, *Nat. Nanotechnol.* **9**, 794807 (2014).
[2] D. Soriano, D. V. Tuan, S. M.-M. Dubois *et al.*, *2D Mater.* **2**, 022002 (2015).
[3] M. Moaied, J. V. Alvarez, J. J. Palacios, *Phys. Rev. B* **90**, 115441 (2014).
[4] K. Szałowski, arXiv:1603.03810 (2016).
[5] K. Szałowski, and T. Balcerzak, *J. Phys. Soc. Jpn.* **83**, 044002 (2014).