Disorder-enhanced p-wave superconductivity in graphene

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Abstract

Graphene has a rich superconductivity phase diagram, which includes spin-singlet regions with p+ip orbital symmetry [1]. In the presence of a magnetic field, the resulting p-wave superconducting vortices are predicted to host elusive zero-energy Majorana modes [2]. Disorder is known to enhance superconductivity via the emergence of superconducting islands around impurities in cuprates [3], which suggests the intriguing possibility to tailor p-wave superconductivity in graphene via similar means. Here, we propose a new real-space numerical procedure which treats the superconducting order parameters as uniform in the bulk and non-uniform in the vicinity of the impurities, amenable to large-scale simulations [4] (10^7 unit cells) while capturing the essential spatial modulation of the order parameters. We apply the methodology to metal-coated plasmon-mediated superconducting graphene with both s-wave and p-wave order parameters (associated with their respective electron-electron interaction constants g_0 and g_1). We find a rich collection of behaviours (Figure 1), including regions where only p-wave superconductivity is enhanced (in green) and a curve in g_0,g_1 space where the order parameters change abruptly in the presence of disorder.

References

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2. D. A. Ivanov, Phys. Rev. Lett. 86, 268 (2001)
3. Leroux, M. et al. Proc. Natl. Acad. Sci. 116.22 (2019) 10691-10697
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Figures

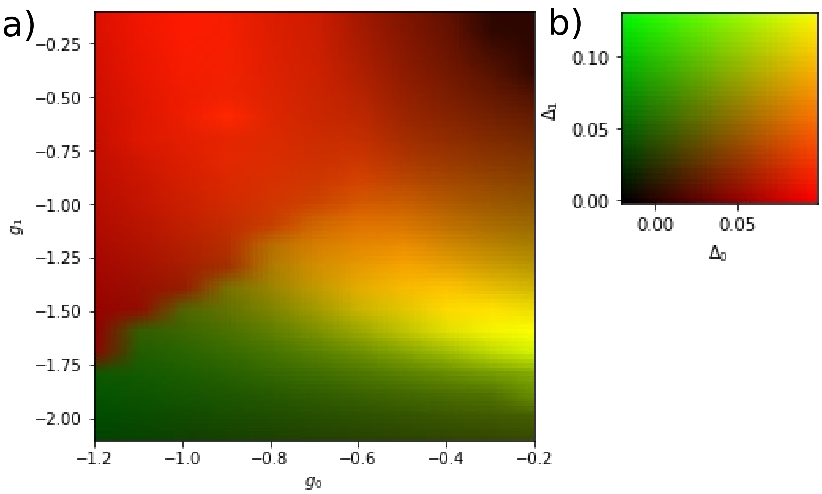

Figure 1: a) *Enhancement of s-wave (red) and p-wave (green) superconducting order parameters as a function of the interaction constants. b) 2D color scale of a)*