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Self-consistency in giant superconducting lattices with spectral methods

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In most physical scenarios, disorder usually hinders the desired physical properties of the system. In some cases, however, exactly the opposite is true. The presence of impurities in superconductors can be responsible for tipping the scales over to certain types of order, and even to increase the critical superconducting temperature of the material [1]. The increasing interest in the study of disordered superconductors is prompting the development of increasingly sophisticated numerical tools to better understand these phenomena.

From a theoretical standpoint, the mean-field approach to superconductivity relies on solving a self-consistent equation for the superconducting order parameters. In a lattice with impurities, the lack of translation invariance means that the self-consistent equation has to be satisfied at each point in the lattice, severely limiting the system sizes that one is realistically able to study. This is usually enough to compute the local density of states (LDoS) around an impurity, but high-resolution quantum transport simulations require much larger lattices.

We propose a method based on the Chebyshev-Bogoliubov formalism [2,3] that reduces the computational effort of satisfying the self-consistent equations to an O(1) procedure. Although the number of equations may still be large, it does not scale with the system size. We used this method with KITE [4] to calculate the full non-perturbative self-energy of superconducting graphene of mixed s-wave and p-wave symmetry with non-magnetic impurities [5] in a lattice with millions of atoms.

References

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Figure 1. (a) figure caption; (b) figure caption (use Times New Roman 9)

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