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Magnetic and superconducting correlation in monolayer and twisted bilayer graphene

Using exact quantum Monte Carlo method, we identify the phase diagram of the half filled, the lightly doped and heavily doped graphene, which shows a rather rich physical properties. At half filling, the system is driven to a Mott insulator with antiferromagnetic long range order by increasing interaction, and a transition from a d+id pairing to a p+ip pairing is revealed, depends on the next-nearest hoping and the electronic fillings. We also examine the recent novel electronic states seen in magic-angle graphene superlattices. From the Hubbard model on a double-layer honeycomb lattice with a rotation angle θ=1.08, we reveal that an antiferromagnetically ordered Mott insulator emerges beyond a critical Uc at half filling, and with a small doping, the pairing with d+id symmetry dominates over other pairings at low temperature. The effective d+id pairing interaction strongly increase as the on-site Coulomb interaction increases, indicating that the superconductivity is driven by electron-electron correlation. Our non-biased numerical results demonstrate that the twisted bilayer graphene share the similar superconducting mechanism of high temperature superconductors, which is a new and idea platform for further investigating the strongly correlated phenomena.

References

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Figures

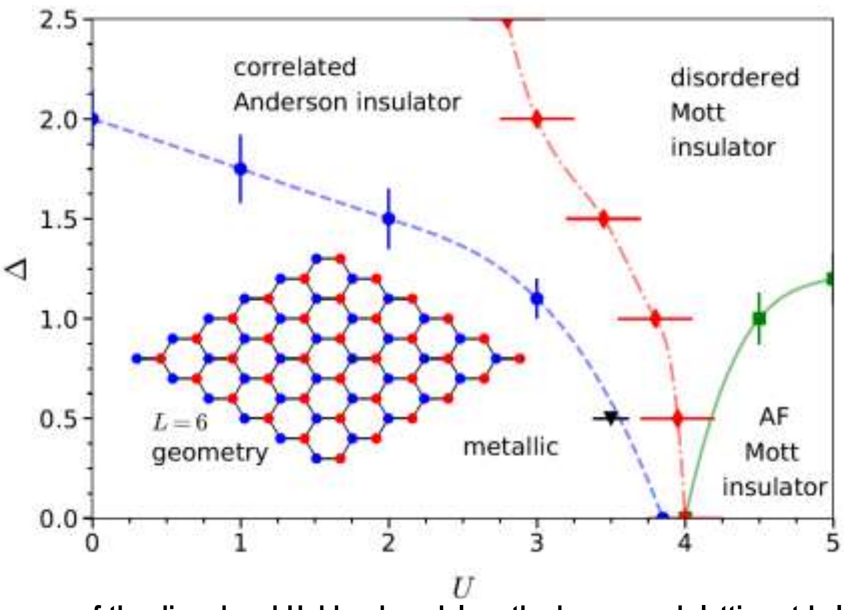

Figure 1: Phase diagram of the disordered Hubbard model on the honeycomb lattice at half-filling. Δ labels the disorder strength and U represents the local Coulomb repulsion.

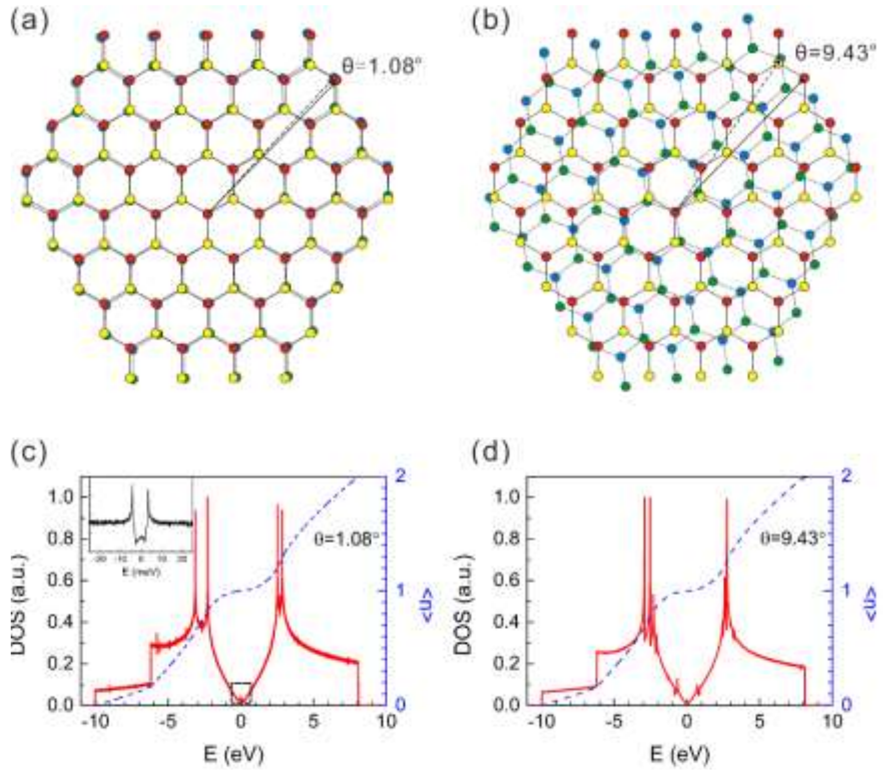

Figure 2: (a) Sketch of TBG with Ns=192 sites at $\theta = 1.08^{\circ}$ and (b) $= 9.43^{\circ}$, and not all interlayer hoppings are depicted due to their complex; The DOS with $\theta = 1.08^{\circ}$ (c) and $\theta = 9.43^{\circ}$ (d).

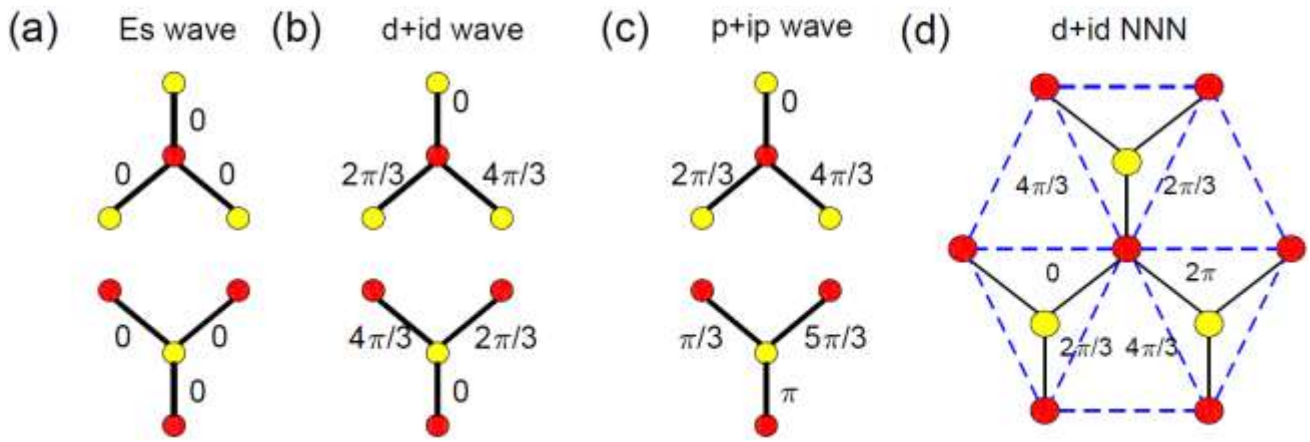

Figure 3: Phases of the pairing symmetries of (a) extensive-S (b) d+id (c) p+ip and (d) d+id wave with next nearest neighbour.