A sheet of graphene – quantum field in a discrete curved space

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The effective (Hubbard-type) Hamiltonian for electrons living in a sheet of graphene describes the dynamics of a fermionic quantum field in a discrete space – the graphene honeycomb lattice. As this space does not need to be flat the system offers a fascinating tool for studying and simulating the impact of non-trivial geometries (curved and defective graphene sheets) on the quantum fields living in it.

Local and global deformations as well as defects of the lattice can be mapped onto curvature and torsion in an analog model based on differential geometry in a continuous space (like e.g. in General Relativity). This opens new analytical and numerical ways to calculate material properties of graphene in the nano and mesoscale. For instance, a single defect leads to a long-range rearrangement of the lattice atoms with important consequences for the electronic wave functions resulting in scattering-on-a-defect effects, analogous to scattering on a curved geometry.

A general correspondence between the lattice and differential geometry is conceptually established but a precise language allowing for effective and reliable calculations is still under development with much space for improvements, tests and fresh ideas.

We present main ideas constituting this analogy.

References

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