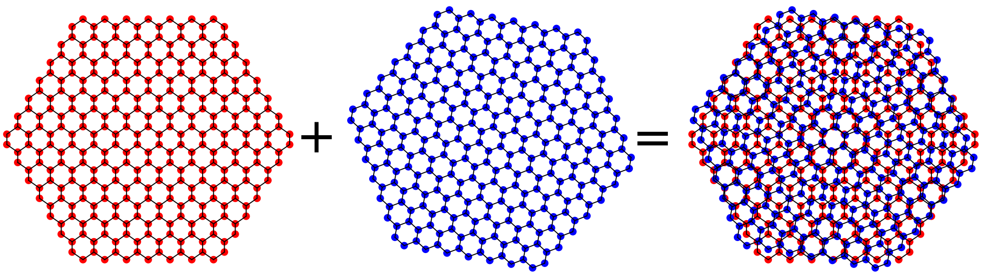
Master project: <u>Electronic structure of twisted bilayer graphene systems</u>

Background: Graphene is an artificial two-dimensional material made of carbon atoms that form a hexagonal lattice. Electrons moving in this lattice have many unusual properties: For example, they are described by the Dirac equation, which was originally invented for relativistic electrons (i.e., electrons moving close to the speed of light), where the speed of light is replaced by a material-specific Fermi velocity. This allows to observe "relativistic" electron behaviour in a laboratory setting, which is very different from most metals or semiconductors. For the past decade, much research has been devoted to study the unusual properties of graphene structures and maybe even use them in technological devices.

A system of considerable current interest are two graphene sheets stacked on top of each other. The lattice structure of these two sheets may be twisted with respect to each other, hence this setup is called "twisted bilayer graphene". Here, it turns out that interactions between the electrons are very important and give rise to a number of interesting phenomena such as superconductivity. From a theoretical point of view, it is very challenging and interesting to describe such interacting systems. There are now many additional systems that are beginning to be explored in experiments, for example, with three or four layers of graphene or other two-dimensional materials.



Project proposal: The aim of this project is to derive and implement an effective model for electrons in twisted bilayer graphene and compute the electronic band structure. You will develop a theoretical model that applies for small twist angles between two graphene sheets, perform numerical calculations of the band structure, and determine quasiparticle properties as a function of system parameters like the twist angle.

A basic knowledge of quantum mechanics and solid-state physics is necessary. Work on this project will require some numerical work, where the choice of programming language and platform is left to you. Office space in the physics department is available.

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