Master 2 theoretical internship proposal

Subject: Shear phonons in graphite and their coupling to electronic excitations
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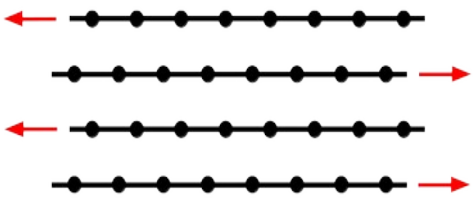
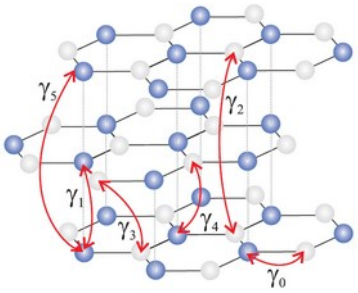
The graphite crystal represents a stack of rigid graphene monolayers bound by Van der Waals forces. The shear phonon mode corresponds to the neighboring layers oscillating in the opposite directions (see the figure). Phonons are typically probed by Raman spectroscopy [1], and the observed spectrum of the shear phonon mode [2] has a peculiar Fano shape which arises due to quantum interference when a discrete mode is coupled to a continuum of excitations [3]. In the case of graphite, the continuum was suggested to originate from electronic excitations [2].



A recent experiment at the LNCMI Grenoble has shown that the shape of the shear phonon peak strongly changes with the magnetic field. The preliminary explanation of this result is that the magnetic field quantizes the electronic bands of graphite into Landau levels, so the structure of the electronic excitation continuum is modified. To put this explanation on a firm ground, we have to construct a quantitative theory of this effect .

The goal of the internship is to calculate the coupling of the shear mode phonons to the electronic excitations in a magnetic field using the tight-binding model of Slonczewski, Weiss, and McClure, represented here in the figure (taken from Ref. [4]). When the coupling is found, we can proceed to the calculation of the Raman spectrum similarly to Ref.[5].



This internship work can be continued as Ph.D.

Necessary background: quantum mechanics, solid state physics

Bibliography: [1] A. C. Ferrari and D. M. Basko, *"Raman spectroscopy as a versatile tool for studying the properties of graphene"*, Nature Nanotechnology **8**, 235 (2013).
[2] P. H. Tan et al., *"The shear mode of multilayer graphene"*, Nature Materials **11**, 294 (2012).
[3] U. Fano, *"Effects of Configuration Interaction on Intensities and Phase Shifts"*, Phys. Rev. **124**, 1866 (1961).
[4] M. Orlita, and M. Potemski, *"Dirac electronic states in graphene systems: optical spectroscopy studies"*, Semicond. Sci. Technol. **25**, 063001 (2010),
[5] P. Kossacki et al., *"Electronic excitations and electron-phonon coupling in bulk graphite through Raman scattering in magnetic field"*, Phys. Rev. B **184,** 235138 (2010).