Proposition de thèse en cotutelle franco-canadienne:

Nom du directeur ou directrice de thèse (en France): **Kamran Behnia**
Nom du co-encadrant (au Canada): **Louis Taillefer**

Laboratoire de rattachement (en France): **Laboratoire de Physique et d'Étude des Matériaux (ESPCI- CNRS-PSL University)**
Laboratoire de rattachement (au Canada): **Institut Quantique (Université de Sherbrooke)**
Titre du projet: **L'effet Hall thermique des phonons dans les isolants crystallins**

Thermal Hall effect in ordinary crystalline insulators

Discovered almost two decades ago [1], the phonon Hall effect has attracted much attention in recent years [2]. There is now a long list of insulators in which the effect has been experimentally observed and an ample literature of theoretical proposals [3]. The recent observation of phonon thermal Hall effect in elemental [and non-magnetic] insulators (phosphorus [4], silicon [5] and germanium [5]) indicates that this is a common phenomenon, implying a fundamental flaw in our understanding of heat propagation in insulators.

The aim of the present thesis project is to investigate the thermal Hall response in silicon in which theory, starting from first principles, has been able to give a quantitative account of longitudinal thermal conductivity. Our experimental aim is to document the evolution of the signal as a function of the angle between three vectors, the applied heat current, the magnetic field and the temperature gradient. A second focus of investigation is to explore the correlation between the amplitude of the signal and the crystallinity of the samples. These are time-consuming measurements requiring a high level of resolution in detecting small temperature gradients. But we can do them [6].

The two collaborating groups (Taillefer's in Sherbrooke and Behnia's in Paris) have demonstrated expertise in measuring the thermal Hall effect in quantum materials. The candidate will be selected most probably among EDPIF students following a M2 training (stage) period.

Acquisition of a geometric phase induced by Born-Oppenheimer approximated atomic wavefunctions is well-known in molecular physics [7] but barely known, let alone explored, among condensed-matter physicists. Provided anharmonicity, such a field-induced phase ($\sim$ milli-radians in 10 T) can provide an account of the order-of-magnitude of the maximum observed signal [8]. The mean free path of phonons becomes comparable to the sample size at cryogenic temperatures in silicon. Therefore, such a scenario would imply the possible propagation of phase-related phenomena over macroscopic distances.

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