THE FLOW OF INTERACTING PHONONS THROUGH NANOWIRES, NANOTUBES, AND MOLECULAR JUNCTIONS

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Understanding thermal transport at the nanoscale is a very important problem. With the continued miniaturization of electronic devices, heat dissipation is a major limiting issue for future technological developments [1]. At the same time, nanostructuring can lead to materials with desirable thermoelectric transport properties, a fundamental one being their thermal conductivity [2].

But technology is not the only driving force behind research in this area. A lot of interesting fundamental physics emerges in the study of the thermal conduction properties of these systems. In this talk, we will focus on phonon conduction, and the effect of many-body phonon interactions on the thermal conductivity and conductance of suspended nanowires, nanotubes and molecular junctions. For each of these systems, a different theoretical approach has been developed to explain and in some cases predict experimental results.

We will start from the simplest of these approaches [3,4], which gives a good account of experimental measurements in semiconductor nanowires [5]. Then we will discuss the more complex problem of thermal conduction in single walled carbon nanotubes, graphene, and graphite. We will see how the character of the 3-phonon scattering process in these systems results in extremely long phonon mean free paths and thermal conductivities [6,7]. Subsequent experimental results have confirmed findings from the theoretical study [8,9].

Finally, we will introduce a new technique, based on non-equilibrium Green's functions, that allows to study the quantum mechanical many-body problem of interacting phonons flowing through generic, atomically described, anharmonic structures. This technique is applied to investigate a simple model molecular junction. We will show important quantum mechanical effects taking place in the anharmonic scattering process, which are very different from classical predictions.

References

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