Hydrodynamic behavior in thermal transport.

F. X. Alvarez. Universitat Autònoma de Barcelona. Catalonia. Spain

Abstract

Recent experiments in heat transport on silicon using ultrafast laser heating techniques have shown significant discrepancies with Fourier like behaviour[1-3]. The interpretations of these results using only a ballistic to diffusive transition of the carriers have shown to be unfruitful.

The reason behind this anomalous behaviour seems to be double. On one side, the different phonons on the distribution have mean free paths that can span several orders of magnitude. On the other side momentum conserving collisions (normal scattering) imposes some restrictions on the propagation of phonons that can be very important at some temperatures. In these cases hydrodynamic-like behavior can be observed.

Kinetic-Collective Model (KCM) is an approach developed understand the role of normal collisions on heat transport[4,5]. The model splits the heat flux in two regimes, a kinetic where each carrier is independent of the rest and a collective where all carriers move collectively. KCM can give a deeper insight to describe thermal transport at reduced time and size scales where discrepancies respect to classical kinetic behaviour are expected to be larger.

In the framework of KCM, two new terms including memory and nonlocal effects appear in the heat equation[6,7]. We use these new terms to interpret some of the complexities of the recent experiments on ultrafast and reduced scale heating and show that their observations could be indicating the presence of hydrodynamic behavior.

References

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