

## **Dynamical Thermal Conductivity and Phonon Hydrodynamics in Suspended Graphene Ribbons**

In the context of on-chip thermal management and other energy harvesting applications, the ability to understand and tailor steady-state thermal conductivity in bulk and nanostructured semiconductors is of fundamental importance. An approach based on relaxation time approximation (RTA) is known to underestimate thermal conductivity in materials like graphene where momentum-conserving normal processes play a dominant role. To study the effect of normal scattering on thermal conductivity in graphene ribbons, we used Allen's modified Callaway model to solve phonon Boltzmann transport equation (pBTE) which uses a variational approach based on full phonon dispersion calculated from first principles [J2]. However, with the recent rise in clock frequencies in modern microprocessors and terahertz sensing applications, understanding dynamical (frequency response of) thermal conductivity is pivotal. We solved time-dependent pBTE in Fourier domain to compute thermal conductivity of monolayer graphene ribbons in response to a rapidly time-varying temperature field [J7]. Our calculations revealed that dynamical thermal conductivity resembles a low-pass filter behavior with cutoff frequencies ranging from 100 MHz to 10 GHz, controlled by temperature and ribbon width. This behavior is analogous to the frequency dependence of electrical conductivities predicted by Drude model, except with much smaller cutoff frequencies. We also found that the resistive and non-resistive part of thermal conductivity exhibit different cutoff frequencies. The frequency window between this dual cutoff coincides with the frequency where second sound (wave-like properties) can be observed. Dynamical thermal conductivity can also be used as a platform for phonon lifetime spectroscopy in frequency-dependent measurements.