QUANTIZED PHONON SPECTRUM OF SINGLE-WALLED CARBON NANOTUBES

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Carbon nanotubes display a phonon spectrum that directly reflects their unique size and geometry: the high-energy phonons are roughly two-dimensional, while the low-energy phonons can either be one-dimensional (in isolated nanotubes) or three-dimensional (in nanotube bundles). We have probed the phonon energy spectrum of bundles of single-walled carbon nanotubes (SWNTs) by measuring their temperature-dependent specific heat[1]. The data provide direct evidence that the individual tubes' phonon spectrum is quantized due to their small radii. In addition, the specific heat is a sensitive probe of the mechanical coupling between neighboring tubes in SWNT ropes. The measured specific heat is consistent with a tube-tube coupling that is much weaker than would be expected from simple comparison to graphite. This weak coupling has implications for both the mechanical and thermal properties[2] of SWNT bundles. In addition, this work shows that fundamental studies of phonons in the quantum limit[3] are applicable to these materials at reasonable temperatures.

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