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 heat1. 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 properties2 of SWNT bundles. In addition, this work shows that fundamental studies of phonons in the quantum limit3 are applicable to these materials at reasonable temperatures.

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