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Collective Vibrational Effects in Carbon Nanotube Coils

Carbon nanotubes (CNTs) are tiny hollow cylinders made of carbon. Raman spectroscopy is one of the most widespread techniques for the analysis of CNT, as it can identify their microscopic structure. In particular, much attention is paid to the low frequency region where the radial breathing mode peak is observed. For isolated tubes, a single peak is observed with a frequency that is inversely proportional to the tube's diameter. When identical CNTs are packed into bundles their vibrational properties were predicted to change and additional low-frequency modes were expected in the Raman spectrum [1]. However, the experimental study of collective vibrations has been limited due to the difficulty in obtaining homogeneous chirality bundles. Here, we present a Raman study of the collective vibrational modes arising from homogeneous bundles formed by a SWCNT coil. A defect-free coil forms a bundle with a single chirality CNT in the radial shape [2,3]. In such coils we observe two breathing-like modes (BM), in contrast to the single radial breathing mode characteristic for isolated tubes. We investigate the exciton-phonon coupling for these modes with resonant Raman spectroscopy finfing the same resonance energy for both BM peaks. Additionally, we study the diameter dependence of vibrational coupling by analyzing different coils and other bundling geometries. We compare our experimental findings with theoretical lattice dynamics of infinite bundles of identical nanotubes. These results provide an insight into intra-tube lattice dynamics in carbon nanotubes bundles for better understanding of collective vibrational effects.

References

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Figures

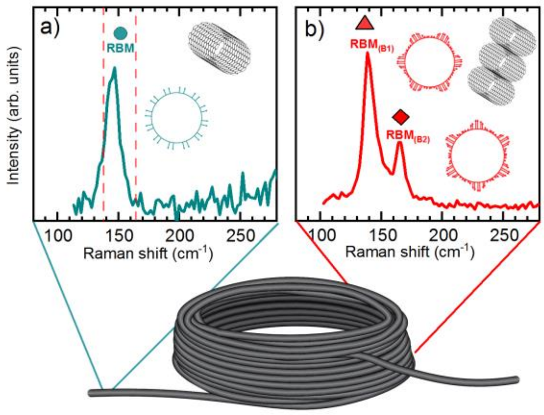

Figure 1: Raman spectroscopy of the Radial breathing modes of carbon nanotube coil. a) Raman spectra for tail and coil (isolated vs bundles effects). The peaks originating from collective vibrations are observed by $RBM_{(B1)}$ and $RBM_{(B2)}$.