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Universal response of single-wall carbon nanotubes to radial compression

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Since the early 90's, the electronic and structural properties of single-wall carbon nanotubes (SWNTs) have been thoroughly investigated. Regarding SWNT mechanical properties, most of the attention has been given to their large resistance to axial tension, even though several electromechanical effects have been observed on radially compressed SWNTs, such as the predicted [3], and recently observed [2], metal-insulator transition. A universal and consistent understanding of the mechanical properties of SWNT under radial compression is also still missing: for instance, reported values of the radial Young modulus E_r vary by up to three orders of magnitude.

The present work [1] brings a unifying picture to the process of radial compression/deformation of SWNTs, where experimental data are analyzed through a rescaling model yielding a universal-type behavior. Specifically, we find that the quantity $Fd^{3/2}(2R)^{-1/2}$, where F is the force applied by an AFM tip (with radius R) and d is the SWNT diameter, is a universal function of the compressive strain (see Fig. 1). Such universality is reproduced analytically in a model where the graphene bending modulus is the only fitting parameter. The application of the same model to the radial Young modulus E_r leads to a further universal-type behavior (see Fig. 2) that explains the large variations of the SWNTs E_r reported in the literature. Finally, the implications of such universal-type behavior to nanometrology are briefly discussed.

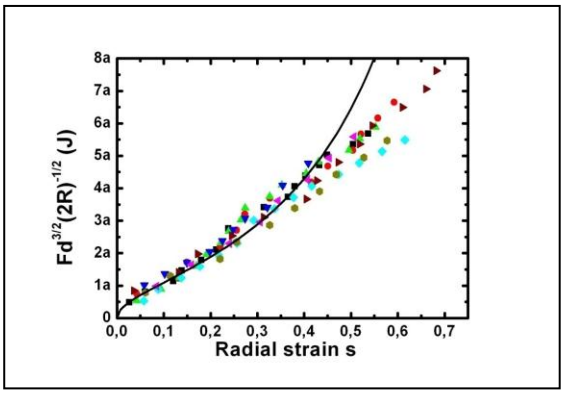

Figure 1: $Fd^{3/2}(2R)^{-1/2}$ versus strain

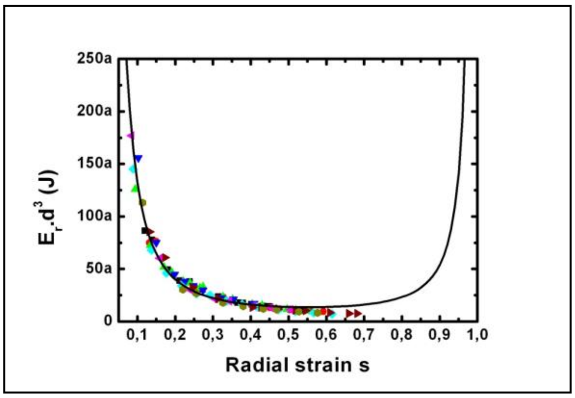

Figure 2: $E_r.d^3$ versus strain

References

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[3] M. S. C. Mazzoni and H. Chacham, Appl. Phys. Lett. 76, 1561 (2000).
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