Mechanical properties of fluctuating graphene

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Abstract
Bendable membranes (with bending rigidity comparable to their thermal energy) exhibit entropic effects in the form of out of plane fluctuations that bring out exotic mechanical properties such as size dependent elastic constant and negative thermal expansion coefficient [1]. Graphene is the nature's thinnest elastic membrane. It is highly bendable, stiff and anharmonic. Therefore the above mentioned phenomena should apply to it.
In this work we measure, by means of indentation experiments, the dependence of the elastic modulus of graphene both as a function of controlled induced defects [2] and a as a function of external strain [3]. Our results support renormalization of the elastic constants of graphene at room temperature.
We experimentally observe that graphene stiffens up to the double of its initial value when low densities of carbon vacancies are induced. It also presents a substantial increase in Young´s modulus at high external strains. We attribute these observations to the suppression of out of plane oscillations both by defects and strain.
Finally, we report experimental and theoretical evidence that point out that the negative expansion coefficient of graphene decreases in absolute value as a function of the irradiation dose supporting again the suppression of out plane oscillations with punctual defects.

References

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