Unique structural properties of graphene

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Graphene is an excellent example of a crystalline membrane. Its measured in-plane and out of plane stiffness imply that suspended graphene is in the extremely anharmonic limit. A number of structural properties of anharmonic membranes depend on the experimental setup, such as sample size, temperature, pre-existing stresses, and other.

We analyze the way in which anharmonic properties determine the (negative) thermal expansion coefficient of graphene, and induce a softening of the elastic constants. We discuss recent experiments which show that the Young modulus of graphene is enhanced in irradiated samples with a finite concentration of vacancies.

Graphene has additional low energy electronic excitations, which couple to the structural deformations. We discuss the relation between structural ripples and charge puddles, and the softening of the elastic properties induced by electron-hole pairs.

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