Thermal fluctuation of graphene: origin of ripples

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We use nonperturbative renormalization group techniques to calculate the momentum dependence of thermal fluctuations of graphene, based on a self-consistent calculation of the momentum-dependent elastic constants of a tethered membrane [1,2]. In the infrared limit, such tethered membranes are known to exhibit highly unusual properties, such as anomalous fluctuations with a large anomalous exponent, a negative Poisson's ration and non-linear stress-strain relations. We analyse the membrane fluctuations and find a sharp crossover from the perturbative to the anomalous regime. Our results are for all momenta in excellent agreement with Monte Carlo results [3] for the out-of-plane fluctuations of graphene, and we give an accurate value for the crossover scale. Our work is the first renormalization group analysis to compute the membrane fluctuations at finite momenta and strongly supports the notion that graphene is well described as a tethered membrane. We find a simple and natural interpretation of ripples in free standing graphene. The characteristic scale of the ripples coincides with the Ginzburg scale of the non-linear elasticity of the membrane.

References

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