Upper limit of spin relaxation in suspended graphene

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Over the years, graphene has emerged as an excellent transport of spin information, with ballistic transport possible over tens of microns in the cleanest samples. However, in such samples spin lifetimes are on the order of 10 ns, far below original predictions [1,2].

In this work, we use a combination of molecular dynamics and quantum transport simulations to examine spin relaxation in suspended graphene. In the absence of extrinsic sources of disorder, corrugations due to thermal fluctuations are the only source of spin relaxation. Our simulations yield spin lifetimes between 1−10 ns, and both the magnitude and the scaling with carrier density are well explained by a theory of spin dynamics in a random spin-orbit field [3,4,5].

Prior work estimated spin lifetimes on the order of μs to ms in corrugated graphene, based on out-of-plane corrugations with length scales around 25 nm [5]. Meanwhile, our simulations reveal that while the height profile of suspended samples varies over tens of nm, similar to experiments, the local curvature shows variations on the scale of ~1 nm (see Figure 1 below). Our results suggest that it is these ultra-short-range variations in curvature that may serve as a limit on spin transport in otherwise defect-free graphene.

References

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Figures

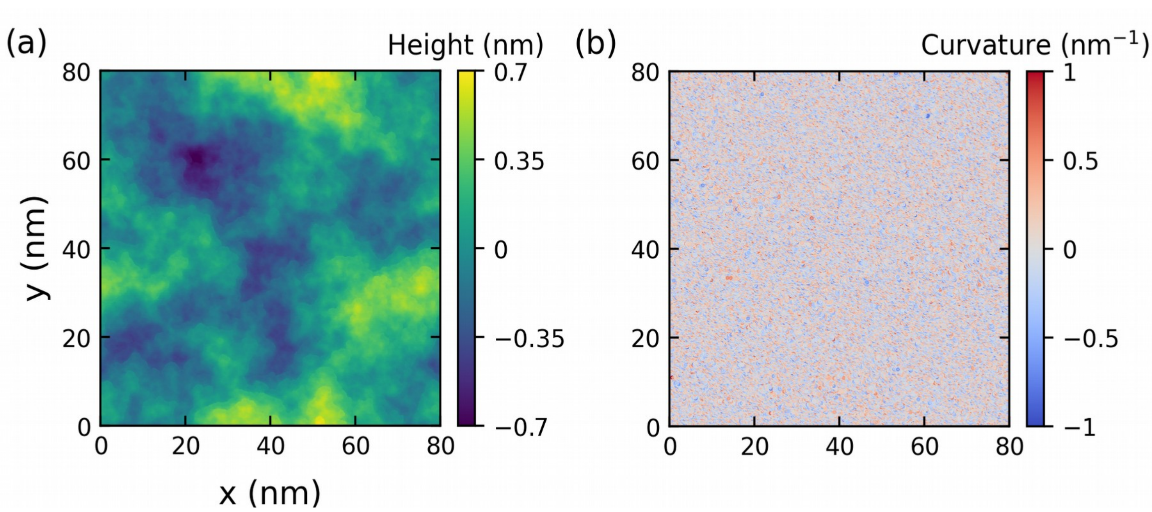

Figure 1. (a) Height profile of a suspended graphene sample, generated via molecular dynamics. The height varies over a scale of tens of nm. **(b)** Local curvature of the same sample, indicating variations in corrugation on the scale of ~1 nm.