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Measuring graphene's bending stiffness MELINA BLEES, ARTHUR BARNARD, SAMANTHA ROBERTS, JOSHUA W. KEVEK, Laboratory of Atomic and Solid State Physics, Cornell University, ALEXANDER RUYACK, Cornell University, JENNA WARDINI, Oregon State University, PEIJIE ONG, Cornell University, ALIAKSANDR ZARETSKI, Florida International University, SIPING WANG, Cornell University, PAUL L. MCEUEN, Laboratory of Atomic and Solid State Physics, Kavli Institute at Cornell for Nanoscale Science, Cornell University — Graphene's unusual combination of in-plane strength and out-of-plane flexibility makes it promising for mechanical applications. A key value is the bending stiffness, which microscopic theories and measurements of phonon modes in graphite put at κ_0 =1.2 eV.[1] However, theories of the effects of thermal fluctuations in 2D membranes predict that the bending stiffness at longer length scales could be orders of magnitude higher.[2,3] This macroscopic value has not been measured. Here we present the first direct measurement of monolayer graphene's bending stiffness, made by mechanically lifting graphene off a surface in a liquid and observing both motion induced by thermal fluctuations and the deflection caused by gravity's effect on added weights. These experiments reveal a value $\kappa_{\rm eff}$ =12 keV at room temperature — four orders of magnitude higher than κ_0. These results closely match theoretical predictions of the effects of thermally-induced fluctuations which effectively thicken the membrane, dramatically increasing its bending stiffness at macroscopic length scales. [1] A. Fasolino et al., Nat. Mater. (2007) [2] D. R. Nelson and L. Peliti, J Physique (1987) [3] F. L. Braghin and N. Hasselmann, Phys Rev B (2010)

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