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Free-standing thermalized graphene: a hard/soft hybrid[1]

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Understanding deformations of macroscopic thin plates and shells has a long and rich history, culminating with the Foeppl-von Karman equations in 1904. These highly nonlinear equations are characterized by a dimensionless coupling constant (the "Foeppl-von Karman number") that can easily reach vK = 10^7 in an ordinary sheet of writing paper. Since the late 1980's, it has been clear that thermal fluctuations in microscopically thin elastic membranes fundamentally alter the long wavelength physics, leading to a negative thermal expansion coefficient, and a strongly scale-dependent bending energy and Young's modulus. Recent experiments from the McEuen group at Cornell that twist and bend individual atomically-thin free-standing graphene sheets (with vK = 10^{13}!) call for a theory of the mechanical deformation of thermally excited membranes with large Foeppl-von Karman number. We present here results for the bending and pulling of thermalized graphene ribbons and tabs in the cantilever mode.

[1]Work done in collaboration with Andrej Kosmrlj.