Nonlinear mechanics of sheets and filaments - interplay betweengeometry and mechanics

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Abstract:

We develop a theory for flexible elastic structures such as thin sheets and braided filaments. By assuming the sheet to deform inextensibly (a good approximation for thin sheets in many applications) we reduce the equilibrium equations rigorously to those of a 'quasi-rod', i.e., an effective one-dimensional elastic body with nonstandard constitutive behaviour. Braided filaments subject to a constant-distance constraint can similarly be reduced to a single rod with additional structure.

Having the equations (an ODE) in an efficient form, we considervarious special solutions of these quasi-rods and use parameter continuation to investigate phenomena such as buckling, (multi)stability, stress localisation and packing under different boundary and loading conditions, thus highlighting the rich interplay between geometry (shape) and mechanics (strength) of these slender structures.

Some applications in biology and materials science will be discussed (e.g., cholesterol ribbons, DNA supercoiling).