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Designing elastic sheets to self-assemble in a viscous environment

SILAS ALBEN, MICHAEL BRENNER, Harvard University — A recent work by Boncheva et al. (Proc. Nat. Acad. Sci. 2005 102: 3924-3929) has raised some basic issues about designable self-assembly within the context of planar elastic sheets which fold into 3D structures under magnetic forces. While being agitated in water, millimeter-scale structures were shown to fold with varying success depending on the locations of magnets on the sheets. Our work considers how to design such structures, an understanding of which will be necessary when moving this process to the micron scale. Among the important parameters are the geometry of the flat sheet, the configurations of the magnets, and the ratios of magnetic to elastic forces. We consider this problem using a numerical model of an elastic sheet, and restrict to the simpler case of electrostatic forces in a quasi-static limit. We identify a simple algorithm for choosing configurations of electrostatic charges, and select ratios of charge strength to elastic energy using physical arguments. We then demonstrate our algorithm on dynamical foldings of a sphere and more general geometries, in the overdamped viscous regime. We also give an asymptotic formula for the elastic energy in the thin-plate limit.

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