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Flatness and Intrinsic Curvature of Linked-Ring Membranes

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Recent experiments have elucidated the physical properties of kinetoplasts, which are chain-mail-like structures found in the mitochondria of trypanosome parasites formed from catenated DNA rings. Inspired by these studies, we use Monte Carlo simulations to examine the behavior of two-dimensional networks ("membranes") of linked rings. For simplicity, we consider only identical rings that are circular and rigid and that form networks with a regular linking structure. We find that the scaling of the eigenvalues of the shape tensor with membrane size are consistent with the behavior of the flat phase observed in self-avoiding covalent membranes. Increasing ring thickness tends to swell the membrane. Remarkably, unlike covalent membranes, the linked-ring membranes tend to form concave structures with an intrinsic curvature of entropic origin associated with local excluded-volume interactions. The degree of concavity increases with increasing ring thickness and is also affected by the type of linking network. The relevance of the properties of linked-ring model membranes to those observed in kinetoplasts is discussed.

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