Shapes of pored membranes

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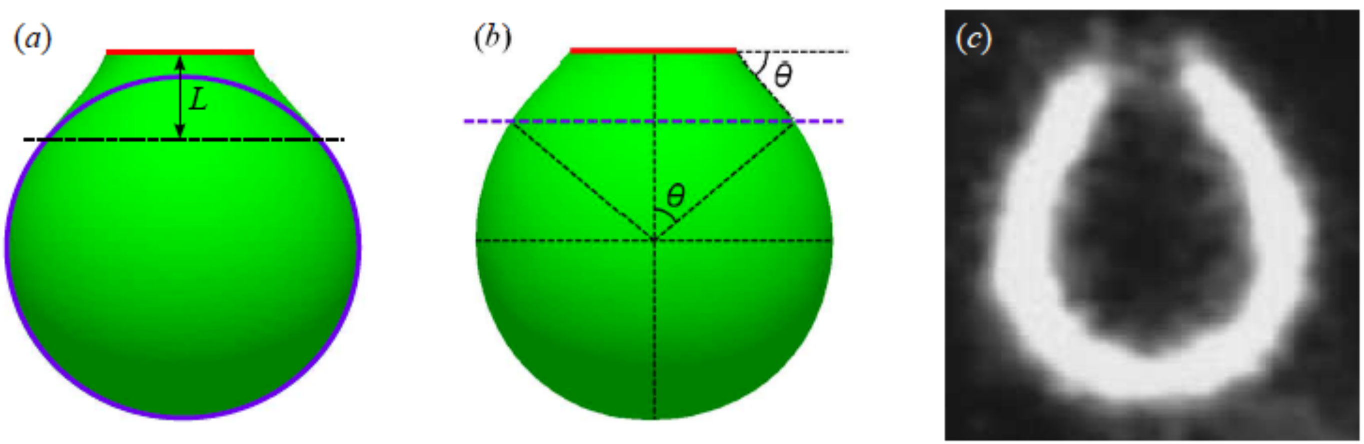
We study the shapes of pored membranes within the framework of the Helfrich theory under the constraints of fixed area and pore size. We show that the mean curvature term leads to a budding-like structure, while the Gaussian curvature term tends to flatten the membrane near the pore; this is corroborated by simulation. We propose a scheme to deduce the ratio of the Gaussian rigidity to the bending rigidity simply by observing the shape of the pored membrane. This ratio is usually difficult to measure experimentally. In addition, we briefly discuss the stability of a pore by relaxing the constraint of a fixed pore size and adding the line tension. Finally, the flattening effect due to the Gaussian curvature as found in studying pored membranes is extended to two-component membranes.



The ground state shapes of a pored membrane generated by Surface Evolver. The red line represents the opening of the membrane. The size of the pore is fixed. In (a) $\kappa_G/\kappa = 0$ and in (b) $\kappa = 2$ and $\kappa_G = -1.5$. The comparison of (a) and (b) shows that the mean curvature term in the Helfrich free energy leads to a budding pore, while the Gaussian curvature term tends to flatten the membrane near the pore. In (a), measured by the radius of the pore, the radius of the sphere $R \approx 4.95$, and the longitudinal size of the budding pore $L \approx 1.22$, which agrees well with our prediction (see Eq. (4)). (c) The shape of a pored fluid membrane from experiment whose radius is about 1 μm. The pore is created by the protein talin.

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