Renormalization and scaling in thermally-fluctuating membranes

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Mechanical properties of freely-suspended two-dimensional materials subject to small or vanishing external tension have been the subject of numerous theoretical and experimental investigations. Crucially, the presence of thermal and disorder-induced ripples is predicted to renormalize the effective elastic parameters, turning them into power-law functions of the wavevector scale. The statistical distribution of ripples, consequently, is scale-invariant in the long-wavelength limit and is controlled by a renormalization-group (RG) fixed point.
This contribution illustrates a perturbative RG calculation of the scaling exponent of clean membranes [1], based on a well-known effective field theory describing out-of-plane flexural phonons coupled by long-range interactions between local Gaussian curvatures. After extension of the problem to a theory of generic D-dimensional membranes, the scaling index is computed at two-loop order within an $\varepsilon=(4-D)$-expansion. Extrapolation to the physical dimensionality $D=2$, gives results numerically close to earlier predictions by the non-perturbative renormalization group and the self-consistent screening approximation.

References

[1] A. Mauri and M. I. Katsnelson, Nucl. Phys. B 956 (2020) 115040