Simulating wrinkled inflatables (and other folded thin shells)

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Inflatables are structures made of flat planar membranes that are sealed or sewn to each other and that assume complex curved shapes once pressurized. The numerical simulation of such structures is particularly challenging due to the presence of wrinkles that form at the locations of the seams : not only do we need to finely discretize the mesh in order to accurately reproduce the geometry of these wrinkles, but we also have to cope with the numerical instabilities that arise in the system.

In this presentation, I will show that relying on tension field theory to convexity the constitutive material law of the membrane material allows us to correctly predict the global shape of the structure, even when we use coarsely discretized meshes. Furthermore, we can subsequently recover the geometry of the missing wrinkles by parametrizing them by an amplitude and phase field that we solve for over the coarse base mesh. This approach allows us to recover complex wrinkle patterns with wavelength much smaller than the resolution of the base mesh while requiring much fewer degrees of freedom that traditional shell solvers. We validate our method by comparing our results to those obtained by both high resolution numerical simulations and physical experiments.