Ultra-thin composite deployable shell structures

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Deployable structures made of only one or two plies of woven carbon-fiber composites, without any mechanical joints, can be folded elastically and are able to self-deploy through the release of elastic strain energy. However, the behavior of these structures is rather poor when they are "designed by intuition": their deployment is unpredictable and the deployed stiffness disappointingly low considering the high performance materials from which they have been made. Because of uncertainty over the actual deformation that the structure will be subject to, intuitive designs tend to be over-conservative with respect to material failure, leaving the structural architecture compromised.

In this talk I will present numerical simulation techniques, with the finite element package ABAQUS/Explicit, that allow us to carry out complete simulations of the folding and deployment of a general elastic thin-shell structure. These simulations are remarkably realistic and capture closely the instabilities, dynamic snaps, and sliding contact events that are associated with folding and deployment. Coupled with an interactive failure criterion in stress-resultant space, these simulations provide a powerful tool to design better performing structures.

I will apply this design approach to a particular type of deployable boom and will show experimental and simulation results for booms with different designs.

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