
Instabilities in Elastomers and in Soft Tissues

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We revisit some examples of instability phenomena in non-linear elasticity, and highlight some striking differences in (theoretical) behavior between models used for the response of (i) rubber-like solids and of (ii) biological soft tissues.

For instance, it is well-known that inflated rubber balloons exhibit limit-point instability whereas inflated bladders do not; the models used in the literature for solids of type (i) versus those for solids of type (ii) confirm this experimental observation. The problem of surface stability (compressed half-space) also displays this tendency: there, models of type (ii) are much more (some, infinitely more) stable than models of type (i).

However it is less known that stability problems with finite size effects may lead to the opposite conclusion. For example, it turns out that a spherical shell subject to external hydrostatic pressure is a lot less stable when the Fung model (archetype of type (ii) models) is used than when the Mooney-Rivlin model (archetype of type (i) models) is used. In passing we note that this result raises a paradox, because in the infinite thickness limit, the shell tends to a half-space (where the Fung model is expected to be much more stable than the Mooney-Rivlin model). We show how to reconcile the conclusions of each stability problem. Other kinds of instabilities are also discussed.

The overall conclusion is that great care must be taken when selecting a strain-energy density function in order to model an elastomer or a living soft tissue, because it might create (or occult) unwanted (or desired) instabilities.