Towards plastic wrinkles

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Abstract

Wrinkles in thin sheets have been the object of numerous investigations in recent decades. Wrinkles are generated by compressing a sheet while it is attached to a compliant substrate, or while it is subjected to a tension or curvature in a transverse direction. One of the drivers for these investigations has been in metamaterials, namely the promise that wrinkles can be used to add structure to an object or its surface in order to modify its behaviour – for example, a suitably wrinkled surface will selectively filter light.

A core focus of research on wrinkles to date has been on prediction of the critical stress for their appearance and the wrinkling pattern when they do appear. Despite success in predicting and controlling these features, an important question remains: which wrinkles are reconfigurable, and which are permanent? If the deformation is purely elastic, then wrinkles indeed disappear if the stresses responsible for their generation vanish. In this talk, we will discuss conditions under which wrinkles in a thin sheet may lead to permanent plastic yielding, both theoretically and in real-world scenarios.

Our approach is based on a combination of direct and indirect damage measurement methods, utilising mathematical models to predict the threshold for yielding of wrinkled sheets in conjunction with an experimental search for signs of damage within a wrinkled sheet. Our long-term goals include both delimiting the parameters for which wrinkles are reversible and reconfigurable, and designing and controlling permanent wrinkles. Relevant applications range from traditional materials such as metals undergoing metal forming to innovative materials used in soft electronics and optical applications.

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