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Mechanics of elastic ellipsoidal shells

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ABSTRACT

Complicated structural features at a much smaller scale than overall structure size form during the deformation of elastic shells under mechanical loading. These features which can be seen by simple experiments in every-day life, as well as in biological and engineering systems, are associated with high energy density and evolve in intricate ways as the shell is further loaded deep into the nonlinear regime. The key challenge in understanding these features is interaction of physics and geometry that leads to a mechanical response which is very different from the response of solid objects. The formation of localized periodic structures in the crushing of a spherical shell, such as a ping pong ball, is well documented in the literature and studies show that spherical shells manifest periodic structures as polygons under point and plate loading. We studied ellipsoidal shells under plate and point indentation and results are presented here. For plate indentation, we present a new instability that is observed in the indentation of a highly ellipsoidal shell. In this phenomenon, above a critical indentation depth, the plate loses contact with the shell in a series of well-defined "blisters" aligned with the smaller radius of curvature. We used detailed numerical model to study this instability and explained it using scaling arguments. We characterized the onset of instability and showed relation between number of blisters and their sizes with indentation depth and geometry of shell. Our study showed that properties of blister are independent of elastic properties of shell itself and this suggests a novel method for simply determining the thickness of highly ellipsoidal shells.