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Deformation and bursting of elastic capsules impacting rigid walls

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Princeton University — From water balloons to cells, eggs and various organs, thin elastic shells enclosing a liquid core, or capsules, are ubiquitous. Yet, despite their prominence, an understanding of how capsules deform and burst under impact is lacking. Here, combining controlled experiments with formal models, we study the deformation of elastic capsules impacting rigid walls. We unravel a strong analogy with liquid drop impact, the shell surface modulus taking the place of the surface tension, albeit the details of the scalings are different. By computing the shell elastic energy during impact and performing a detailed energy balance, we rationalize this analogy and quantitatively predict the capsule maximal deformation for liquids with viscosities up to 1000 cP ($Re > 100$). Unlike drops however, capsules can burst and be pre-stretched. Experiments show a significant shift in the critical burst velocity induced by the pre-stretch, a feature also captured by our model once pre-stretch is included.

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