Materials scientists prove 70-year-old tensile deformation prediction

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The team's experimental setup stretched a thick, soft elastomer — made from silicon rubber — at each of its corners. Under this biaxial tension, the sample's center deformed, breaking the geometrical symmetry and becoming suddenly flat. Credit: Johannes T.B. Overvelde/Harvard SEAS

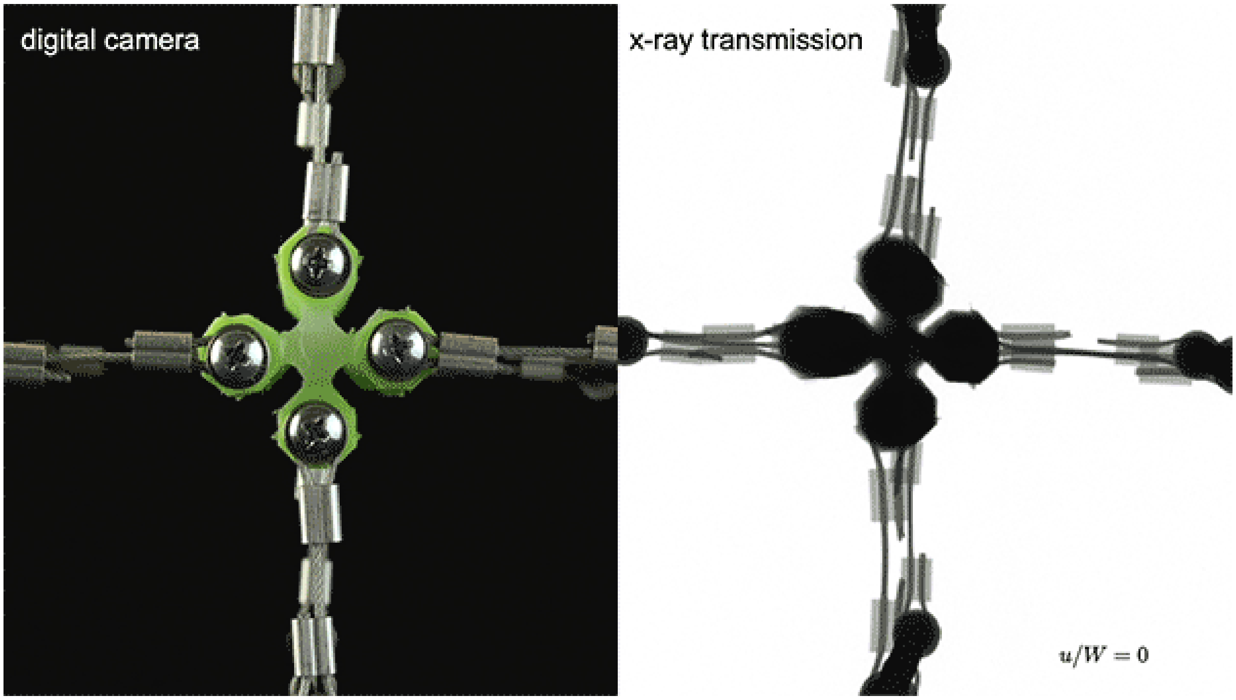
Imagine pulling or compressing a block of soft material—like rubber—equally in all directions. You wouldn't expect the block to deform much because of the nature of the material. However, in 1948, an applied mathematician named Ronald Rivlin predicted that with the right amount of tensile force, a thick cube of soft material would suddenly deform into a thin, flat plate.

For almost 70 years, this prediction remained purely theoretical. Materials scientists, hoping to add the instability to the pantheon of material functionality, were unable to prove the theory experimentally.

Recently, researchers at the Harvard John A. Paulson School of Engineering and Applied Sciences (SEAS) demonstrated for the first time experimentally that Rivlin was right. Using tensile—stretching—forces, the team triggered this instability in a centimeters-thick elastomer block, deforming it into a flat surface.

"We knew that this instability existed but no one was able to show it," said Katia Bertoldi, John L. Loeb Associate Professor of the Natural Sciences at SEAS and senior author of the paper. "We were able to identify a configuration that can be tested experimentally."

"This research uncovers a type of instability that can be triggered in soft, elastic bodies, and widens the design space for new architected materials that use instabilities to change or enhance their functionality," said Johannes T. B. Overvelde, first author of the paper and former graduate student at SEAS. "With this instability, we can create materials that can suddenly switch between behaviors by using simple triggers to change their geometry."



A soft architected material that, due to the tension instability, undergoes a pattern transformation when biaxially stretched. Credit: Johannes T.B. Overvelde/Harvard SEAS

More information: Johannes T. B. Overvelde et al. Tensile Instability in a Thick Elastic Body, *Physical Review Letters* (2016). DOI: 10.1103/PhysRevLett.117.094301

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