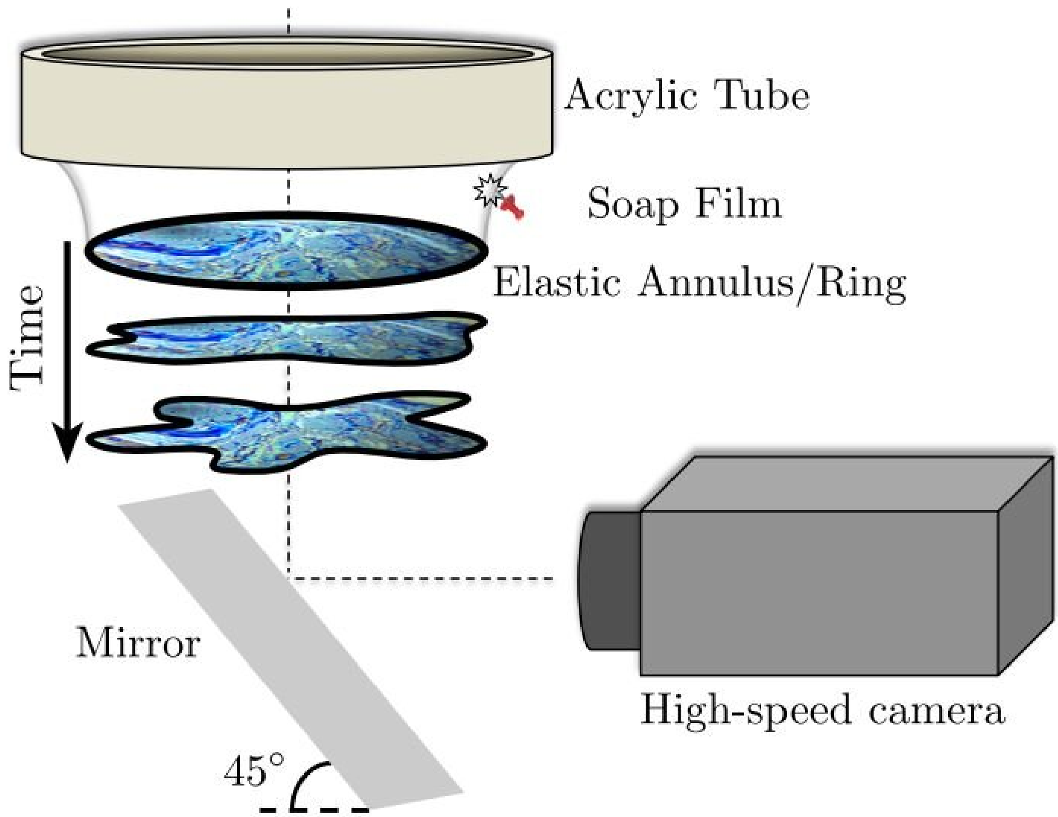
Counting kinks in a collapsing ring to predict stability

May 20 2020, by Bob Yirka



General principle of the experiment: a closed elastic object (a ring or annulus) is held within a soap film. At t = 0, the outer soap film is broken allowing the object, with inner soap film intact, to fall freely. The unbalanced surface tension force from the inner soap film causes the object to buckle dynamically; this motion is captured by a high speed camera. Credit: arXiv:1812.11009 [cond-mat.soft]

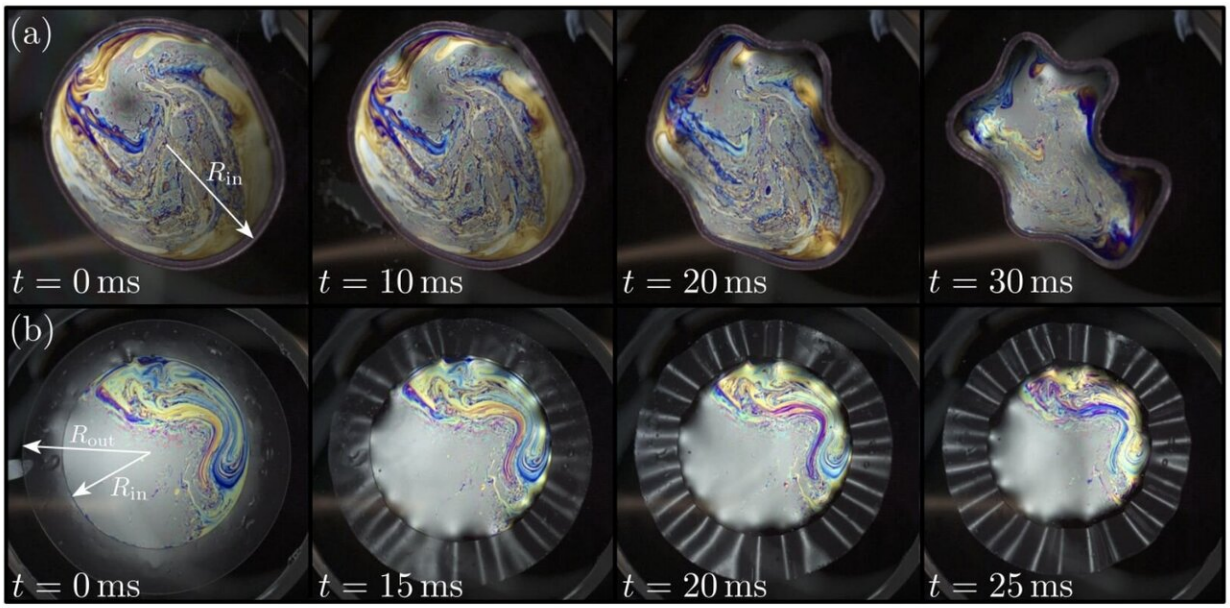
A team of researchers from the University of Oxford, MIT and the University of Limerick has found that it is possible to predict the stability of a collapsing ring by counting its kinks. In their paper published in the journal *Physical Review Letters*, the group describes experiments they conducted that involved placing an elastic ring over a soap film and recording what happens when the ring collapses.

One of the interesting things about the field of physics is its scope. Researchers in the field study the stars looking to explain how we got here; others study the quantum world, seeking to better understand how reality as we know it exists—and then there are less exotic applications, such as studying how and why things buckle the way they do. Why does a bridge suddenly buckle and fall down? Or why do car windshields buckle under the weight of snow, and exactly how much snow is needed? Physicists study such buckling to better understand how materials work under varying conditions.

In this new effort, the researchers wondered about the factors involved when an elastic ring placed over a soap film collapses. Prior research has shown that such a ring will collapse in different ways depending on different factors. The researchers wondered if those factors might be predictable. To find out, they conducted multiple experiments with elastic rings and soap films.

All of the experiments involved the same basic setup. A soap film was applied to a quantity of water. A ring was then placed on the soap film. Once the ring settled into place, the researchers broke the surface tension by poking the soap film with a pin outside of the ring. With the surface tension released, the ring collapsed and sank into the water below. The action was captured with a high-speed camera. The only factor that changed between experiments was the thickness and width of the rings.

The researchers found that when the ring walls were wide and thin, the ring would buckle inward—but when the walls were thick, the ring would buckle both upward and downward. They then created a model to predict the type of ring buckling that would occur based on the ring properties. Testing showed that the model could accurately predict which sort of buckling would occur, based on the type of ring used.



Experimental snap-shots from the dynamic buckling of an elastic (a) ring (h = 1 mm = $R_{out} - R_{in}$, R_{in} = 23.5 mm, E = 42 kPa) and (b) annulus (h = 110 µm, R_{in} = 25 mm, R_{out} = 34 mm, E = 200 kPa) under the action of an unbalanced surface tension T_{in}. Credit: arXiv:1812.11009 [cond-mat.soft]

More information: Finn Box et al. Dynamic Buckling of an Elastic Ring in a Soap Film, *Physical Review Letters* (2020). DOI: 10.1103/PhysRevLett.124.198003 . On *Arxiv*: arxiv.org/abs/1812.11009