# Collapse dynamics of catenoid-shaped liquid crystal film

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The collaps dynamics of liquid films is a fascinating topic that has attracted physicists at least since Rayleigh's work in 1912. Catenoid-shaped films can be formed between two solid support rings, stable catenoids require that the distance between the support rings does not exceeded the critical distance $D = 0.66274R$ (ring radius $R$). Above this critical value, there exists no stable solution for a film with minimal surface. The film collapses in a self-similar process. This process can be divided into several phases: necking, pinching, breaking and relaxing. In the final equilibrium state, planar films remain, spanned across each ring.

Experiments with catenoid-shaped soap films were performed by Steen and coworkers [2], theoretical considerations published by the same group have compared model predictions of the film dynamics during break-up with experimental data. Numerical simulations predict the different film shapes and the appearance of a satellite bubble throughout the collapse with great accuracy. The simulations cover situations where air inertia poses the limiting contribution to the dynamics.

We have performed similar experiments with free standing smectic films (4'-octyl-biphenyl-4-carbonitrile in the smectic A phase). The choice of this material allows to monitor exactly the film thickness changes during the dynamic collapse. High speed camera images are recorded and evaluated to study the acceleration processes and layer thickening during the collaps in few milliseconds. The film thickness is determined using an interference technique suggested earlier [3].

An additional advantage over soap films is the option to perform these experiments under low pressure, where the films enter another dynamic regime in which the thickness of the smectic membranes is the essential parameter limiting the speed of the collapse. Two different collapse scenarios are found, depending upon the ratio of the characteristic times for air and film motion. In one situation (fast collapse), a satellite bubble is formed, while in the second situation, the collapse ends in an (unstable) string structure connecting the two planar films.

[1] Lord Rayleigh, Sci. Papers 3, 441 (1902)

[2] S. A. Cryer and P. H. Steen, *J. Coll. Interf. Sci.* **154**, 276-288 (1902) N. D. Robinson and P. H. Steen, *J. Coll. Interf. Sci.* **241**, 448-458 (2001) Y.-J. Chen and P. H. Steen, *J. Fluid Mech.* **341**, 245-267 (1997)

[3] R. Stannarius, C. Cramer and H. Schring, *Mol. Cryst. Liq. Cryst.* **350**, 297-305 (2000)