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Wrinkling patterns on floating elastic films[1]

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A polymer sheet floating on the surface of a fluid is an ideal arena for studying elastic instabilities in thin sheets. In our experiments we use polystyrene sheets whose typical lateral size, $L \sim 3$ cm, and whose thickness, t ranges from 30 to 300 nm, yielding aspect ratios L/t of up to 10^6. In their unperturbed state, they lie on the surface of a pool of water, stretched flat by surface tension. We can then generate a rich variety of wrinkling patterns by perturbing the surface locally with capillary forces,[2] or with controlled displacements at one or more points on the surface. I will review our understanding of the length scales that characterise these localised patterns. A simple experimental setting in which a multiplicity of these length scales come into play is a situation analogous to an Euler buckling experiment performed on the surface of a fluid. We push two sides of a rectangular sheet towards each other, creating a global pattern of parallel wrinkles whose wavelength is given by a balance between gravitational potential energy of the fluid and bending energy of the sheet. These wrinkles develop a cascade of fine structure at higher wavenumbers close to the uncompressed edges of the sheet. The length scale over which this cascade occurs is the capillary length, whereas the wavenumber at the edge of the sheet reflects a balance between bending energy and surface tension. We discuss the evidence that this is a fundamentally new type of elastic cascade, which proceeds to higher wavenumbers by smooth evolution of the wrinkles, rather than by discrete, sharply localised branching. Work done in collaboration with J. Huang, E. Cerda, B. Davidovitch, W.H. de Jeu, T.P. Russell, C. D. Santangelo

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[2]J. Huang et al., Science 317, 650 (2007).