

Surface displacements in a cracking colloidal film

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We observed the drying and cracking of polystyrene dispersions, with particle diameters of 100-400 nm, in water. Films were cast on glass plates, and dried by either blowing nitrogen gas over them, or by leaving them in still air. As water evaporates, the films dry from their edges inward, leaving a slowly shrinking liquid area, and a water-saturated film of rigidly adhered particles. Fluid flows through the saturated region, balancing surface evaporation. This flow is driven by pressure gradients, and was observed directly by introducing dye into the drying film. As the film dries, it cracks. We monitored the surface deformation caused by the cracks, and show that the film profile in the vicinity of a crack can be reduced to a single scalable shape. These surface displacements around the growing crack are equal to those predicted assuming a pressure equal to the capillary pressure acts on the crack faces of an elastic body. If the film thickness is changed, for example by tilting the drying suspension such that the film slowly thickens, we demonstrate a period doubling instability where each second crack slows down, but continues to grow in an oscillatory, or wavy, way.