Geometrical Frustration and Correlated Capillary Instability among Concentric Toroids

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We present the first study on the simultaneous capillary instability among concentric viscous toroids. An array of concentric polystyrene (PS) toroids were lithographically fabricated with a constant radial spacing between neighboring toroids. The toroids were confined in a poly (methyl methacrylate) (PMMA) matrix. PS and PMMA were used because of their immiscibility and well-characterized physical properties. The glass transition temperature (T_g) of the pattern are well above room temperature. We found that the radial contraction mode of toroids (Pairam & Fernández-Nieves, PRL 2009) was inhibited due to substrate confinement and high viscosity of the medium. We identified three regimes of correlation depending on the degree of substrate confinement. When the degree of confinement was negligible and the toroids were spaced relatively far apart, the breakup behavior among toroids was non-correlated. By decreasing the relative spacing between toroids, the breakup became correlated. When the toroids were strongly confined, the breakup behavior of the toroids became in-phase correlated in the radial direction. In this case, geometric frustration due to the toroidal curvature was observed, which led to an intriguing branching behavior in the correlated instability and closely resembles a Cayley tree with fractal coordination number of 3.