Stability and breakup of confined threads

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Microfluidic devices are often used to generate drops, but confined morphologies with at least one dimension much longer than the wall spacing also exist. An example of this are long threads, either generated by jetting, or coalescence of drops. We use a three-dimensional periodic boundary-integral method to investigate the stability of such threads. Our algorithm incorporates Green's function who exactly satisfy the no-slip condition at the walls. The periodic version makes use of the Hele-Shaw form formulation, that the wall-corrected Green's functions take in the far field. We primarily focus on the stability of threads versus small amplitude disturbances. At large wall separations, we obtain an excellent match with Tomotika's theory. With increasing the confinement ratio, the growth speed reduces, but much more in the direction perpendicular to the walls. Also the wavelength with the fastest growth speed changes slightly. We find that all threads will break up in the confinement, as long as the undeformed drop fits between the plates (confinement ratio < 1), although the breakup time increases significantly. One other aspect we show is the response of threads laying close to each other. Depending on the distance between the threads, waves on neighboring threads form in an in- or out-of-phase pattern. The crossover distance in unconfined situations is in agreement with experimental data and analytical results. We find that the confinement promotes out-of-phase behavior. Finally, we show the influence of shear. If the shear flow can convect distortions before they can grow, shear flow acts to stabilize the thread. Our results match quite well with a simple scaling argument for the critical capillary number, above which the threads are stable.