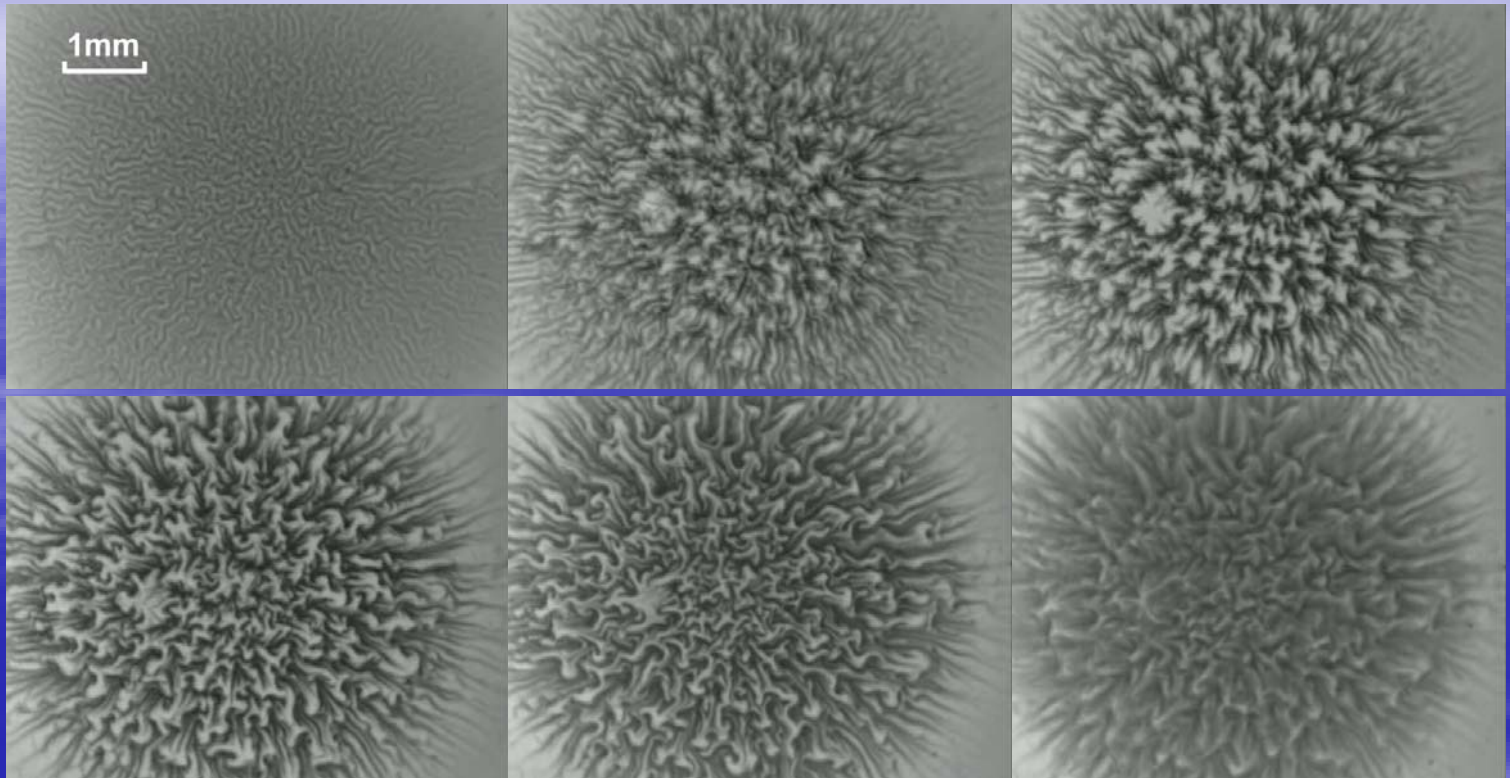


A Ferrofluid Droplet: Blooming and Fading

Submitted by

Ching-Yao Chen, National Chiao Tung University, Taiwan, R.O.C.

W.-K. Tsai, National Yunlin University of Science & Technology, Taiwan, R.O.C.



Ferrofluids are synthetic fluids that conveniently combine the fluidity of liquids and the magnetic properties of solids. One of the most remarkable properties of such fluids is the possibility of manipulating their flow with an external magnetic field. When a ferrofluid is subjected to a sufficiently strong vertical magnetic field, an array of visually striking peaks is formed on its free surface. This effect is known as the normal-field instability. However, if the sample is trapped between two narrowly spaced glass plates and a vertical field is applied, highly branched, effectively two-dimensional structures are formed, characterizing the so-called labyrinthine instability. Recent experiments have performed an ingenious experiment in which peak and labyrinthine patterns coexist and share a coupled dynamic evolution [1]. This has been done by immersing a ferrofluid drop in a *miscible* nonmagnetic fluid. Under such miscible circumstances a peak first grows rapidly, and then gradually decays, to ultimately reimmerse into the surrounding nonmagnetic layer. This unique scenario implies in the simultaneous emergence of peculiar labyrinthine structures within the thin nonmagnetic layer. On other hand, a remarkable morphological revolution after the removal of field is also discovered under the interplays between different components of magnetic forces.

An initially circular ferrofluid droplet of diameter $d=2.1\text{mm}$ is placed on the bottom of a flat cavity. The cavity is filled with the nonmagnetic miscible fluid, so that the ferrofluid droplet is immersed in a thin layer of such a fluid. The magnetic fluid we use is a commercially available ferrofluid (APG836) produced by the Ferrotec Corporation. The surrounding nonmagnetic liquid is a particular type of mineral oil. A magnetic field is provided by a coil powered by power supplier. The power source is turned on instantly to generate a field strength and kept constant for a certain period of time to trigger an initial instability, and then removed to observe the diffusing interface. The time evolution of the diffusing interface after the removal of field are shown in the figures at (from left to right and top to bottom) at $t=0\text{s}$, 1s , 2.5s , 4.5s , 10.5s and 16.5s . While typical labyrinthine instability is retained right before the removal of the field at $t=0\text{s}$ [1], absence of the vertical lifting force immediately causes collapses of the heavier ferrofluids once the field is removed. The collapses of ferrofluids result in local aggregations. These local aggregations of ferrofluids lead to an amazing interfacial topology, that mimics a blooming flower as shown at $t=1\text{s}$, and 2.5s . Nevertheless, the aggregations would eventually be weakened because of diffusion, and the floristic interface starts to fade gradually as shown at $t=4.5\text{s}$, 10.5s and 16.5s . This research is supported by the National Science Council of the Republic of China through the grant NSC 96-2221-E-009-244-MY3.

[1] C.-Y. Chen, W.-K. Tsai, J. A. Miranda, *Phys. Rev., E* **77**, 056306, 2008.