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Running Magnetic Spouts and Hedgehogs FREE

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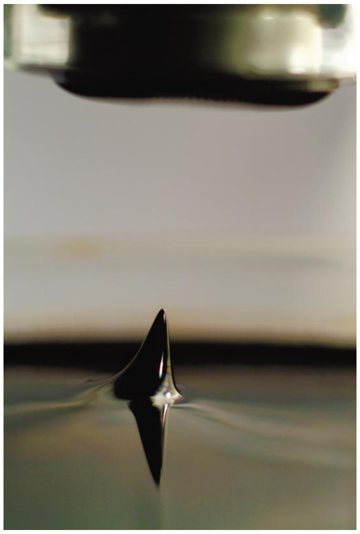

FIG. 1.

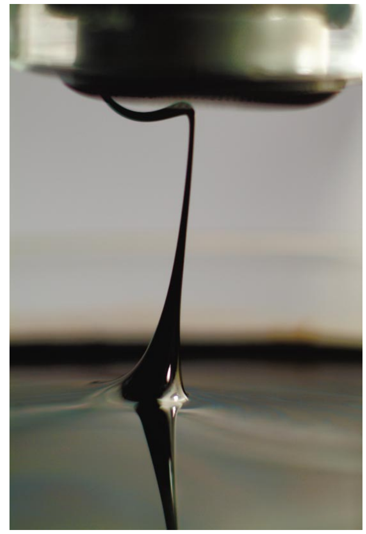

FIG. 2.

FIG. 3.

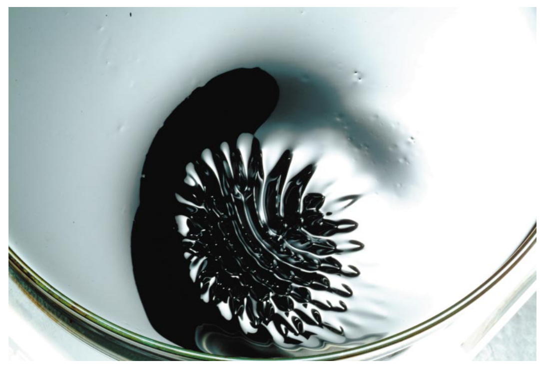

FIG. 4.

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A permanent magnet is slowly lowered towards the surface of a ferrofluid reservoir. The magnetic liquid is pulled up by the field gradient and forms a cone (Fig. 1, similar to Taylor cones in electric fields).[1] Below a critical separation, the cone becomes unstable and a sharp jet of ferrofluid jumps to the magnet (Fig. 2). This transition is reminiscent of the spout formation observed in selective withdrawals experiment.[2] The cone shape and the jetting transition are modified by a relative motion between the liquid and the magnet: the cone loses its axial symmetry, as seen in Fig. 1, and the cone height decreases and eventually vanishes. The jetting transition is then observed at a larger value of the field gradient. As the Reynolds number, based on the cone size and the translation speed, remains smaller than 10, we interpret the attenuation of the cone as a consequence of viscous dissipation within the ferrofluid.

When a permanent magnet is approached from underneath the vessel containing the ferrofluid, an array of peaks appears where the magnetic field exceeds a critical value (Fig. 3). This is the classical normal field instability (Rosensweig's instability). If the magnet is moved parallel to the surface, the pattern of peaks evolves into curved ridges similar to capillary waves generated by a moving object (Fig. 4). In addition, the peak amplitude decreases and eventually vanishes at high velocities. These observations can be interpreted from the dispersion relation in a ferrofluid layer.[3]

[1]G. I. Taylor, ''Disintegration of water droplets in an electric field,'' Proc. R. Soc. London, Ser. A **280**, 383 (1964).
[2]I. Cohen and S. Nagel, ''Scaling at the selective withdrawal transition through a tube suspended above the fluid surface,'' Phys. Rev. Lett. **88**, 074501 (2002).
[3]B. Abou, G. Néron de Surgy, and J. E. Wesfreid, ''Dispersion relation in a ferrofluid layer of any thickness and viscosity in a normal magnetic field; Asymptotic regimes,'' J. Phys. II **7**, 1159 (1997).