

FIG. 1. The Faraday experiment: snapshots from a vertically vibrated fluid. (a) At the lowest resonant frequency, a parametric instability eventually forces the liquid surface into a jet. (b) At higher frequencies, there is a chaotic ballet of surface waves and jets. (c) When shaking sand instead of glycerin, a forest of thin jets emerges.

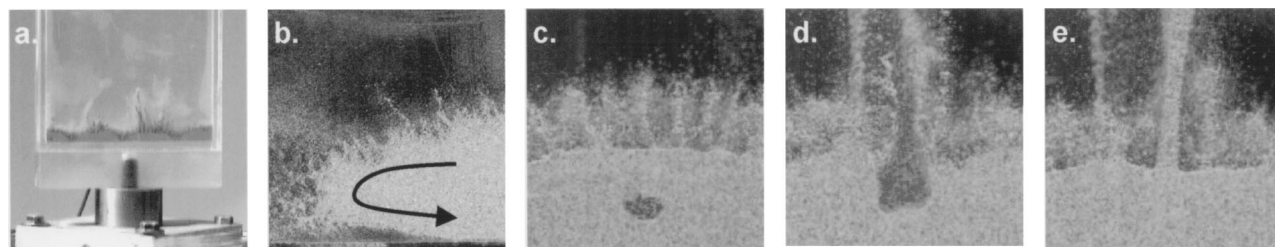


FIG. 2. The two-dimensional setup reveals the formation of jets in vibrated sand: The sand is seen to organize in ripples (a) below which air is entrained by the convective motion of the grains (b). An air bubble forms at the bottom and slowly rises (c) to the surface where it creates a void (d). The void collapses and focuses into a jet (e).

Faraday, Jets, and Sand

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The well-known Faraday experiment, in which a fluid is shaken vertically with a fixed amplitude and frequency, exhibits surprisingly rich behavior. At the lowest resonant frequency, a parametric instability forces the glycerin surface into a jet.¹

Recordings with a high-speed camera reveal the process of jet formation: The falling mass of a surface wave creates a void in the liquid, which collapses from bottom to top and focuses into a strong, upward jet [Fig. 1(a)]. Sometimes the void collapses in the middle, and an air bubble is entrained. In this case the upward jet is weaker and a downward jet is seen to pinch all the way through the bubble.

At higher shaking frequencies, we observe a chaotic ballet of surface waves and jets, which are again formed by the collapse of voids created at the fluid surface [Fig. 1(b)].

How does granular matter behave under the same condi-

tions? A 6 mm layer of fine sand with an average grain size of 40 μm is poured into the cylindrical setup and the experiment is repeated: Surprisingly, also in this case we see thin jets, shaped as sandy worms. They emerge from an airy cloud of grains, like protuberances from the corona of the sun [Fig. 1(c)].

To reveal the mechanism of jet formation in the granular bed, sand is shaken in a thin, rectangular box. The sand is seen to accumulate in ripples [Fig. 2(a)], below each of which air is entrained by the convective motion of the grains [Fig. 2(b)]. Air bubbles form at the bottom and slowly rise through the sand [Fig. 2(c)]. Every time a bubble reaches the surface, it creates a void [Fig. 2(d)], which thereupon collapses and focuses into a jet [Fig. 2(e)].

These experiments show that the formation of voids in liquid and in sand evolves along very different paths. Their collapse at the surface, however, is similar and in both cases leads to jet formation.²

¹B.W. Zeff, B. Kleber, J. Fineberg, and D.P. Lathrop, *Nature (London)* **403**, 401 (2000).

²See <http://www.tn.utwente.nl/pof/gallery.htm> for the full video.