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Competitive Clustering in a Granular Gas

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Citation: Physics of Fluids **15**, S8 (2003); doi: 10.1063/1.4739212
View online: http://dx.doi.org/10.1063/1.4739212
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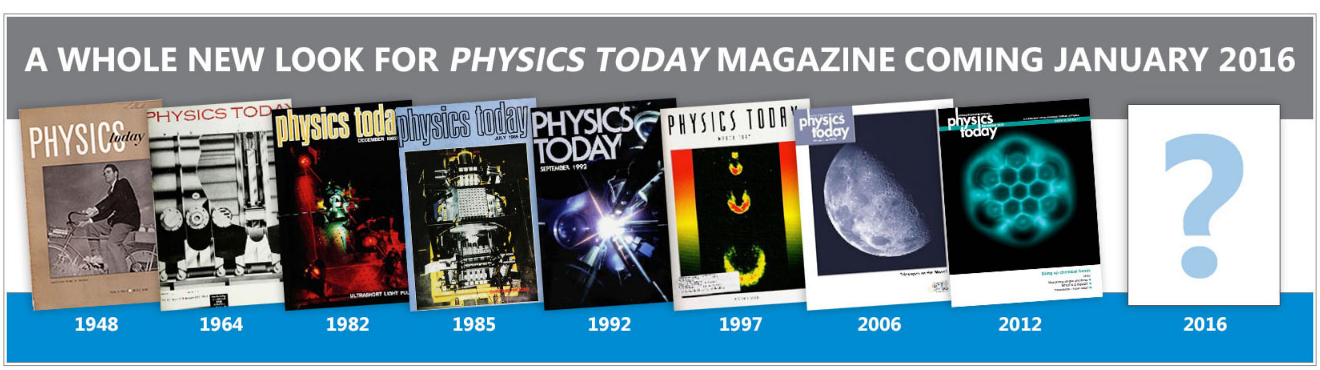

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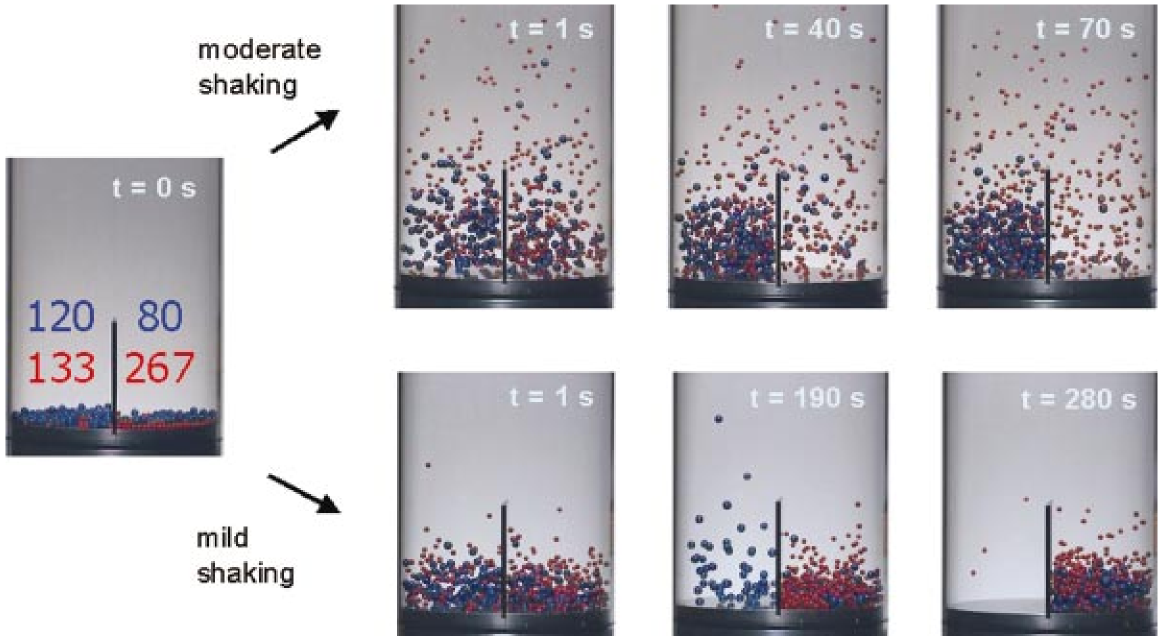

FIG. 1. Upper row: A bidisperse mixture of glass beads at moderate shaking strength (frequency $f=60$ Hz, amplitude $a=1$ mm). The beads cluster into the left compartment, in roughly one minute. The blue beads have twice as large a diameter as the red ones, i.e., in the given initial situation the left compartment contains 55% of the total particle mass. Lower row: At mild shaking ($f=35$ Hz, $a=1$ mm) the clustering goes in the opposite direction: Starting from the same initial condition, the beads now end up in the right compartment. This time it takes five minutes before the clustering is complete.

Competitive Clustering in a Granular Gas

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A mixture of large and small beads, in a compartmentalized container, is shaken vertically to form a bidisperse granular gas. At vigorous shaking the beads spread out as in any ordinary gas, but when the shaking strength is reduced below a critical level the beads cluster together, due to the fact that in every collision some of their kinetic energy is dissipated. We find that by tuning the shaking strength this clustering can be *directed*: One can let either the large or the small beads win.[1]

At moderate shaking the beads cluster into the left compartment (Fig. 1, upper row). This is just as expected, since here the initial total particle mass—and hence the dissipation rate—is larger.

Reducing the shaking even further, the beads surprisingly cluster into the other compartment (Fig. 1, lower row). The series of events is as follows: At first, the large beads stay close to the bottom. On top of them, the smaller beads jump higher than they would on the plain floor, just like tennis balls on top of a basketball. This effect is stronger in the left box (which has more large beads) than in the right box, and thus the small beads go preferentially into the latter. Once the small ones have left, the large beads become more mobile too and follow one by one.

The second clustering process (lower row) takes much longer than the first (upper row). The observed time scales are in good agreement with the predictions from a flux model describing the particle flow between the compartments.[2]

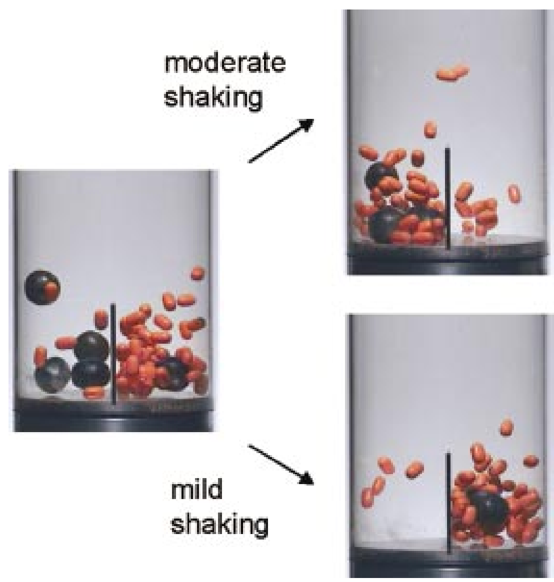

FIG. 2. Competitive clustering for candy: at moderate shaking ($f=75$ Hz, $a=1.25$ mm) and at mild shaking ($f=60$ Hz, $a=1.25$ mm).

The same competitive clustering behavior is found for mixtures of particles with nonspherical shapes and different material properties. Figure 2 shows that the effect is robust enough to work even for candy.

[1]See http://www.tn.utwente.nl/pof/gallery.htm for a video of the competitive clustering effect.

[2]R. Mikkelsen, D. van der Meer, K. van der Weele, and D. Lohse, Phys. Rev. Lett. **89**, 214301 (2002).

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