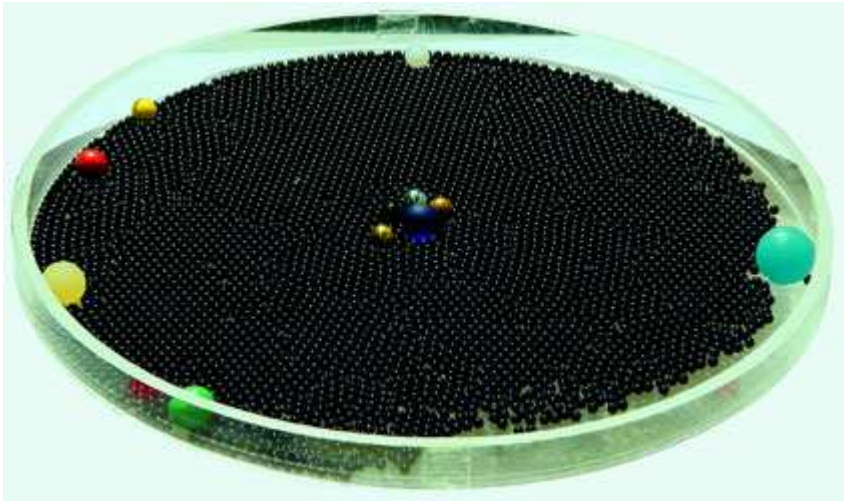
8 July 2005

Simplifying a Nutty Problem

Physicists have long struggled to fully explain the "Brazil-nut effect"--the fact that shaking a can of mixed nuts or other granular materials drives the larger objects to the top and the smaller ones to the bottom. Now researchers have discovered that marbles swirling in a pan sort themselves out in much the same way. Because the marble model only involves horizontal motion, it may provide scientists with a simpler system for deciphering the Brazil-nut effect.



Panning for insight. Swirling marbles separate by size and density. The simple side-winding experiment could help explain the complicated physics of granular materials.

CREDIT: C. Kruelle

The Brazil nut effect is useful for separating the wheat from the chaff, but it can also be a major nuisance, when mixing sand and gravel for concrete, for example. Physicists and engineers have a rough understanding of why the big grains end up on top. When shaken, the grains in a can circulate, rising in the center of the can and descending along the wall. The larger grains cannot squeeze into the thin descending streams, so they end up on top. But this crude theory is not the whole story. It doesn't explain, for example, why shaking the can harder sends the larger grains to the bottom if they are less dense than the smaller grains. And researchers cannot explain how the interaction of individual grains creates these patterns.

Now, a simpler experiment with swirling marbles could provide the insights that theorists need. Physicists Tobias Schnautz and Christof Kruelle of the University of Bayreuth in Germany, along with colleagues from Bayreuth and Complutense University of Madrid, Spain, have found that marbles swirling in a pan also separate according to size and density. The researchers placed hundreds of glass spheres measuring 6 millimeters in diameter in a 30-centimeter-wide circular pan. They then introduced a single larger "intruder" sphere made of steel, bronze, glass, polypropylene, polyurethane, or wood. The team swirled the pan in much the same way that a gold

miner might swirl a pan of water and pebbles, and the intruder jiggled its way to the edge if it was less dense than glass. If it was denser than glass, however, the intruder migrated to the more-crowded center, the team reports online 7 July in *Physical Review Letters*. The new experiment takes gravity out of the picture and has no preferred direction of shaking, Kruelle says, so it should be easier to analyze theoretically.

"It's a really clean experiment," says Joseph McCarthy, a chemical engineer at the University of Pittsburgh in Pennsylvania, "a real nice one to sit down and look at analytically." Arshad Kudrolli, a physicist at Clark University in Worcester, Massachusetts, agrees: "I can already see the questions that should be asked next."

--ADRIAN CHO

Related sites
The paper
A very brief introduction to granular materials
A do-it-yourself Brazil-nut effect experiment

PAGE TOP Previous Story *Science*NOW Home