Researchers observe phase transition in artificially created flock

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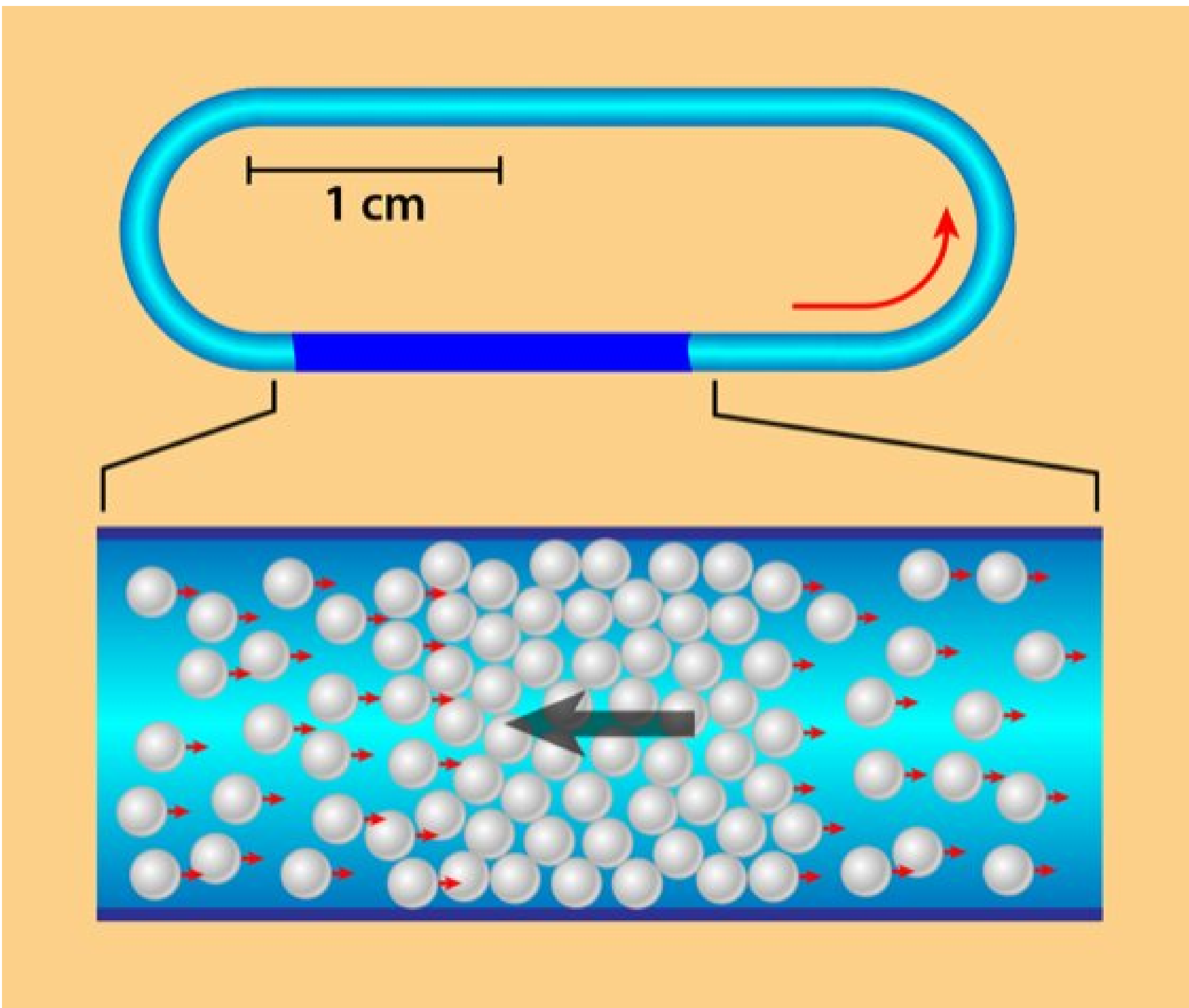

(Top) Sketch of the setup used by Bartolo and colleagues [1]. Millions of microbeads, which roll upon the application of an electric field, explore a centimeter-sized racetrack-shaped enclosure. (Bottom) The flock of particles with aligned velocities (red arrows) can be arrested by the formation of large solid jams at high particle density (the sketch only represents a few of the millions of particles that make up the jam). While the particles do not move within the jam, the latter propagates like a compact wave in the opposite direction to the flock (black arrow). Credit: APS/Alan Stonebraker

A team of researchers affiliated with several institutions in France has observed a phase transition in an artificially created flock. In their paper published in the journal *Physical Review Letters*, the group describes how they created their artificial flock and the events that led to a phase transition.

Scientists trying to understand crowd behavior generally create computer models meant to mimic human behavior under crowded conditions—but such simulations are limited by the parameters that are used to create them. Most in the field agree on the need to recreate crowd or flocking behavior physically in a lab. In this new effort, the researchers have built on prior work with an artificial crowd, and have found that under certain conditions it underwent a phase transition similar to water freezing to an ice state.

Working on a prior effort, some of the team members created an artificial crowd consisting of millions of beads suspended in a liquid between two plates of glass. The plates were joined in a way that allowed the beads to move around the outer edges of an oval—similar to cars on a partially three-dimensional race track. The beads were forced to move in one direction by applying an electric field—the Quincke effect spun the beads, which pushed them through the liquid in the same direction. Also, due to a dipole effect, the beads did not adhere to one another—instead, they moved around the track, seemingly of their own accord. The prior team showed that increasing density of the beads could set off a Vicsek-like transition in which randomly moving particles exhibit flock-like behaviors. In this new effort, the researchers used the same setup with the beads to create a flock and then watched what would happen as density was increased.

The researchers report that at a given point, the entire flock ceased moving, stopping as if frozen in place—very similar, they claim, to water freezing in a creek. They describe the change as a type of phase transition. Further study showed that the beads did not all stop at once—first, small groups bunched up, though they did not stick together. The bunching forced the others that encountered the bunched group to slow and then stop until the whole group had stopped. The researchers also found that once the whole group had stopped, they began slowly propagating in the opposite direction of their previous flow—as beads at the head of the massed group broke away and traveled around the racetrack until they met the other end of the crowd, where they were stopped, making the back end of the crowd grow.

More information: Delphine Geyer et al. Freezing a Flock: Motility-Induced Phase Separation in Polar Active Liquids, *Physical Review X* (2019). DOI: 10.1103/PhysRevX.9.031043 , arxiv.org/abs/1903.01134