Researchers use wave theories to explain bird flock size properties

June 4 2015, by Bob Yirka

Credit: Andrea Cavagna/CNR/Physics

(Phys.org)—An international team of researchers studying starling flock sizes in Rome has found that flocks of different sizes behave differently due to wave properties similar to fluids. In their paper published in *Physical Review Letters*, the researchers describe how they created 3D models based on the starlings and what was revealed by doing so.

The starlings flying around the skies over Rome have become the stuff of legend—thanks to tourism and movies—flocks of thousands or even tens of thousands of the birds form undulating patterns that at times appear to be a single organism moving in unpredictable wave patterns. Prior research has found that the birds alter the distance between themselves and others around them based on distance awareness—the result is a flock that moves in ways similar to sound waves. In this new effort, the researchers wanted to better understand flying direction in the flock—what causes it to come about and in what ways does it occur? To find out, they created a 3D model using datasets from real starling flocks, allowing for creating flocks of any size. Suspecting that directional flying might be related to flock size, the researches created different sized flocks that fell into three main categories: large, intermediate and small.

In looking at their model simulations, the researchers noted that those flocks intermediate in size tended to be too small for the spread of density waves, yet were too large for directional changes to spread throughout the flock, which they noted, likely accounts for the absence of such flocks in the real world. Flocks that number in the tens of thousands, the team notes, can continue to exist despite subsets of birds tending to fly in their own direction for a moment or two—resulting in what they team calls soft edges. Smaller flocks on the other hard are far less flexible—they maintain a consistent shape when traveling, because, the researchers suggest, information is able to travel to all the members relatively quickly.

The researchers conclude by suggesting that flight direction in the flocks also works much like a wave, though it is much more muted than distance based flight.

More information: Silent Flocks: Constraints on Signal Propagation Across Biological Groups, *Phys. Rev. Lett.* 114, 218101 – Published 27 May 2015. dx.doi.org/10.1103/PhysRevLett.114.218101

ABSTRACT

Experiments find coherent information transfer through biological groups on length and time scales distinctly below those on which asymptotically correct hydrodynamic theories apply. We present here a

new continuum theory of collective motion coupling the velocity and density fields of Toner and Tu to the inertial spin field recently introduced to describe information propagation in natural flocks of birds. The long-wavelength limit of the new equations reproduces the Toner-Tu theory, while at shorter wavelengths (or, equivalently, smaller damping), spin fluctuations dominate over density fluctuations, and second-sound propagation of the kind observed in real flocks emerges. We study the dispersion relation of the new theory and find that when the speed of second sound is large, a gap in momentum space sharply separates first- from second-sound modes. This gap implies the existence of silent flocks, namely, of medium-sized systems across which information cannot propagate in a linear and underdamped way, either under the form of orientational fluctuations or under that of density fluctuations, making it hard for the group to achieve coordination.