Flocking and coherence emergence on active particle suspensions.

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The emergence of collective motion is a ubiquitous self-organization phenomenon, which is interesting in several fields, from the biological perspective to the technological one, and observable at all scales. We can find from macro-scales, for example animals moving en masse to even molecular scale, where we can find novel results from experimental groups[1], they observed motional patterns associated with polar interactions using actin filaments and more recently another group have reported coordinated motion of hundreds of thousands of subcellular structures known as microtubules, which spontaneously self-organize into a lattice-like structure of vortices[2]. The non-living world has systems where collective motion appears also. From molecules to metallic rods, or even robots[3]. Just in the middle of these two extremal scales we mentioned above, we found the unicellar living organisms, such bacteria and algae, which propel themselves through a medium via cyclic strokes involving the motion of cilia and flagella. Hence, this micro-organisms can be classified by its characteristic propulsion, in pullers, pushers, movers and shakers[4]. Using this terminology we have fully characterized the collective motion since flocking to coherence in the orientation of swimm that emerge for this kind of micro-organism suspensions. Using a simple model in which the effect of the internal metabolism of the micro-organism can be described through the effective fluid flow the particle generates on its surface[5], and adding a Lenard-Jones (LJ) interaction between the swimmers as a model of the communication between the micro-organisms.

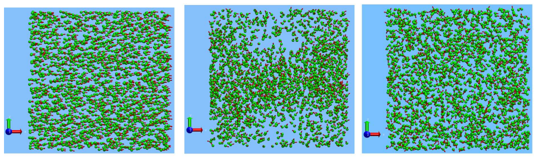

FIG. 1. Snapshots of a simulation with $\beta = 0$ (movers), $\beta = 0.5$ (pullers) and $\beta = -0.5$ (pushers) respectively at $t = 6 \cdot 10^5$. The snapshots have been done using the VMD software[6] with the Normal Mode Wizard (NMWiz) plugin[7].

The mechanism of how collective motion is created can be remarkably varied, so the search for possible universal features becomes a paramount issue. As it can be the stresslet parameter β, in which different values produce different collective phenomena as we depicted in Fig. 1. Where we can see three states of the active particle suspension: a completly coherent fluid, a fluid in a flocking state and an homogeneous and isotropic fluid.

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