Collective motion in squirmer suspensions

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Collective motion in out-of-equilibrium systems composed of a large number of interacting individuals can be seen as a self-assembly phenomenon, which gives rise to intriguing emergent patterns. Due to their kinetic origin, the spontaneous structures that these system give rise to, are far more complex than equilibrium self-assembly in traditional metals, ceramics and polymers, with many levels of functionality, hierarchical organization, and compartmentalization [1]. Non-equilibrium materials must actively consume energy and remain out of equilibrium to support their structural complexity and functional diversity [2, 3]. In Biology flocking birds, fish schools, and insect swarms constitute examples of collective motion that plays a role in a range of problems, such as spreading of diseases [4]. In particular, micro-swimmer suspensions at low Reynolds number, such as bacterial colonies [5], exhibit fascinating collective behavior, including the possibility of non-equilibrium phase transitions between disordered and ordered states, novel long-range correlations, and pattern formation on mesoscopic scales [6]. 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, making use of the squirmer model [7], and adding a Lennard-Jones (LJ) interaction between the swimmers as a model of the communication between the micro-organisms, we have fully characterized the clusters and the collective coherent orientation of the swimmers movement which emerge for some cases. We analyze the transition of the spontaneously formed structures as a function of the relative strength of the LJ interactions and hydrodynamic interactions.

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