Collective Motion of Self-Propelled Objects: From Molecule to Colloid

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Swarming behavior such as flocking, schooling, and clustering of self-propelled objects has been attracting interests from scientists in many fields ranging from mathematical physics to biology. Recent progress in this field has been made by close collaboration between theoretical modeling and experimental observation. In the presentation, I will explain some new results on non-trivial dynamics and self-organizing behavior of self-propelled particles. One extreme of experimental approaches for studying swarming behavior in a controlled manner is to use molecular motor and microtubule in motility assay. I will present some new phases observed in dense microtubule suspension of the motility assay. In this system, interaction between motile elements (microtubule) is governed by collisions, but not by hydrodynamic interaction. Other extreme is to study artificial self-propelled particles under non-equilibrium condition by fabricating micron or nano sized objects. We realized self-propelled motion under laser irradiation or under uniform electric field by fabricating Janus particles with their half hemisphere covered with gold. Asymmetric surface flow around the particle enables a self-propulsive ballistic motion for the particle. We succeeded to control interaction between colloidal particles with changing salt condition and frequency of electric filed. Changing the interaction between particles from repulsive to attractive, resulted in formation of chains which swim, oscillate, and rotate under steady uniform electric fields. Mechanism of these nontrivial behavior and hydrodynamic interaction affecting to collective behavior will be discussed. Since this experimental system is controllable, it will be useful for understanding collective dynamics in a suspension of microorganisms.