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Collective motion and density fluctuations in swimming bacteria

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The emergence of collective motion such as in fish schools, mammal herds, and insect swarms is a ubiquitous self-organization phenomenon. Such collective behavior plays an important role in a range of problems, such as spreading of deceases in animal or fish groups. Current models have provided a qualitative understanding of collective motion, but progress in quantitative modeling in hindered by the lack of experimental data. Here we examine a model microscopic system, where we are able to measure simultaneously the positions, velocities, and orientations of up to a thousand bacteria in a colony. The motile bacteria form closely-packed dynamic clusters within which they move cooperatively. The number of bacteria in a cluster exhibits a power-law distribution truncated by an exponential tail, and the probability of finding large clusters grows markedly as bacterial density increases. Mobile clusters cause anomalous fluctuations in bacterial density as found in mathematical theories and numerical models. Our results demonstrate that bacteria are an excellent system to study general phenomena of collective motion.