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Collective motion and density fluctuations in bacterial colonies

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Univ. of Texas at Austin — The emergence of collective motion such as in fish schools and swarming bacteria is a ubiquitous self-organization phenomenon. Such collective behavior plays an important role in a range of phenomenon, such as formation and migration of animal or fish groups. To understand the collective motion, tracking of large numbers of individuals is needed, but such measurements have been lacking. Here we examine a 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 exhibit anomalous fluctuations in bacterial density: the standard deviation (ΔN) grows with the mean (N) of the number of bacteria as $\Delta N \sim N^{3/4}$ rather than $\Delta N \sim N^{1/2}$, as in thermal equilibrium systems.

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