Collective motion and density fluctuations in bacterial colonies
HEPENG ZHANG, AVRAHAM BE’ER, E.-L. FLORIN, HARRY L. SWINNEY,
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 for-
mation 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 simul-
taneously 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 distri-
bution 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 ($\Delta N$) 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.

Hepeng Zhang
Univ. of Texas at Austin

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