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The effects of self-induced noise on the onset of collective behavior in suspensions of swimming bacteria[1]

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Collective dynamics of self-locomoting micro-organisms, such as bacteria and algae have attracted enormous attention, with a large number of experimental and theoretical works published in the last few years. A plethora of nontrivial properties have been predicted and consequently studied, including dynamic instabilities, anomalous density fluctuations, nontrivial stress-strain relations, rectification of chaotic motion, and viscosity reduction. Here we investigate the viscosity of a suspension of swimming bacteria analytically and numerically. We propose a simple model that takes into account excluded volume constraints and allows for efficient computation for a large number of bacteria. Our calculations show that long-range hydrodynamic interactions, intrinsic to self-locomoting objects in a viscous fluid, result in a dramatic reduction of the effective viscosity. In agreement with experiments on suspensions of *Bacillus subtilis*, we show that the viscosity reduction is related to the onset of large-scale collective motion due to interactions between the swimmers. The simulations reveal that the viscosity reduction occurs only for relatively low concentrations of swimmers: further increases of the concentration yield an increase of the viscosity. We derive an explicit asymptotic formula for the effective viscosity in terms of known physical parameters and show that hydrodynamic interactions are manifested as self-induced noise in the absence of any explicit stochasticity in the system. We also explain the increase in the viscosity for pullers by analysis of the deviations from the mean field approximation

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