Quorum Sensing and Nonlocal Hydrodynamics of Swimming Bacteria

Sisir Roy[1], Rodolfo Llinás[2]
[1] Physics and Applied Mathematics Unit, Indian Statistical Institute, Calcutta-700035, INDIA
sisir.sisirroy@gmail.com
[2] Department of Neuroscience and Physiology, New York University School of Medicine, NY, USA
llinar01@med.nyu.edu

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Water fluidity is modified, in a non trivial manner, by the presence of bacteria, above a threshold number density. At such threshold conditions suspensions of swimming bacteria impose a coordinated water movement on a length scale of the order of $(10 - 100)$m with bacterial size of the order of 3m. This observation leads to fundamental questions relating to the mechanism of cell-cell communication among bacteria, presently known as quorum sensing. Hydrodynamic model of "swimming" bacteria or bacterial colonies seems to be one of the most comprehensive alternate model in defining possible quorum sensing mechanism. Here the densely packed bacteria may be viewed as a"bacterial fluid" or "living fluid" similar to that of dense granular systems. Lega and Passot initially assumed a two-phase hydrodynamic equations taken the bacteria and water as two interpenetrating and interacting continuum. However, by considering the relatively high bacterial density, given the fact that no water motion is observed (under isothermal conditions and in the sense of displacement sheer viscosity, while rotational bulk viscosity may be present) in absence of the bacteria, we assume the dynamics of the suspended bacteria is governed by bacterial dynamics. Under these conditions bacteria and water appear to move as a single fluid at hydrodynamic scale. We propose that "bacterial fluid" is consistently described by weakly non-local hydrodynamics where kinematic viscosity is generated due to self- induced noise. This viscosity leads to form a metastable state of the actively moving bacteria. This meta-stable state is necessary for the simultaneous activation of the bacteria to support quorum, given the existence of non-local nature of stresses mediated by autoinducers. The stability of noisy Burger equation for this metastable situation will be also studied in this approach.