Pattern Formation and Moving Structures in Bacterial Colonies

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Bacterial colonies of *Escherichia coli* [1, 2] and *Salmonella typhimurium* [7] show complex patterns of high density cell aggregates when exposed to certain nutrients. Decisive for this pattern formation is the production of a potent chemoattractor by the bacteria as a reaction to the nutrient. The observed bacterial patterns range from temporary spots formed in liquid medium to "sunflower like" spot arrangements of striking complexity in a semi-solid medium.

Motivated by these observations we suggest a simple model for the description of bacterial colonies based on the concept of Active Brownian motion [4, 3, 6, 5]. Our model represents an interesting alternative to the usually employed "pure" reaction-diffusion equations as it allows us to study the macroscopic pattern formation of the colony, the mesoscopic dynamics of bacterial ensembles (swarming), as well as the microscopic dynamics of single cells.

Here we will present qualitative and quantitative numerical results of our model and compare them with the experimentally observed bacterial dynamics and the analytical results of a continious description.

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[1] E. O. Budrene and H. C. Berg. Complex patterns formed by motile cells of *escherichia coli*. *Nature*, 349:630–633, 1991.

[2] E. O. Budrene and H. C. Berg. Dynamics of formation of symmetrical patterns by chemotactic bacteria. *Nature*, 376:49–53, 1995.

[3] W. Ebeling, F. Schweitzer, and B. Tilch. Active Brownian particles with energy depots modelling animal mobility. *BioSystems*, 49:17–29, 1999.

[4] U. Erdmann. Structure formation by Active Brownian particles with nonlinear friction. *Interjournal of Complex Systems* Article, 114, 1997.

[5] U. Erdmann, W. Ebeling, and A. S. Mikhailov. Noise induced transition from translational to rotational motion of swarms. *Phys. Rev. E*, 71(5):051904, 2005.

[6] U. Erdmann, W. Ebeling, L. Schimansky-Geier, and F. Schweitzer. Brownian particles far from equilibrium. *Eur. Phys. J. B*, 15(1):105–113, 2000.

[7] D. E. Woodward, R. Tyson, M. R. Myerscough, J. D. Murray, E. O. Budrene, and H. C. Berg. Spatio-temporal patterns generated by *salmonella typhimurium*. *Biophys. J.*, 68:2181–2189, 1995.