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INFLUENCE OF THE RANDOM DISTURBANCES ON THE CHEMOTACTIC BACTERIAL COLONY FORMATIONS

Takayuki Tanabe and Masaaki Ishikawa

Graduate School of Science and Engineering
Yamaguchi University
2-16-1 Tokiwadai, Ube 755-8611, Japan
ishi@yamaguchi-u.ac.jp

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Abstract. *Self-organization phenomena are often observed in various fields of engineering including chemical and biological engineering. The self-organization can generate complex spatio-temporal patterns. The analysis of the spatio-temporal patterns created by the self-organization is one of major nonlinear problems in engineering. For example, the analysis of the spatio-temporal patterns in phase transitions of polymeric materials is essential to development of new materials. In this paper, we analyze chemotactic bacterial colony patterns in the semi-solid media as the patterns created by the self-organization. Focusing on bacterial species Escherichia coli (E. coli) among the chemotactic bacteria, we study the influence of the disturbances such as impurities in the semi-solid media on the colony formation by numerical simulations.*
Keywords: Reaction diffusion equation, Chemotactic bacteria, Bacterial colony formations, Numerical simulations, Random noise

1. **Introduction.** Some bacteria form complicate geometric spatio-temporal colonies by the self-organization[1]-[11]. For example, bacterial species *E. coli* create four kinds of colony patterns in the semi-solid agar [10], swarm rings, radial stripes and spots, sunflower-like arrays of spots, and chevron as shown in Figure 1. With increasing concentration of a stimulant substrate(succinate), *E. coli* create bacterial colonies (a) to (d) in Figure 1. The white regions in Figure 1 denote the high-density aggregates of *E. coli*. Bacteria species *E. coli* and Salmonella typhimurium (*S. typhimurium*) move in the direction of increasing of concentration of chemoattractant, asparate. This property of bacteria is called chemotaxis [6]. Because of chemotaxis, they form high-density aggregates: bacterial colonies. Taking into account the fact that there exist fluctuations more or less in the natural world, we propose the stochastic three components reaction diffusion equations as the model of the chemotactic bacterial colony formation. The three components are a bacteria density, concentrations of chemical attractant and stimulant respectively.

As a main culture medium of bacteria, there are the liquid and the semi-solid media [6],[7],[11]. The chemotactic bacteria such as *E. coli* and *S. typhimurium* form various bacterial colonies depending on the culture medium. In the liquid medium, both bacteria create comparatively similar colonies like continuous concentric rings or concentric rings of spots, whereas they form different colony patterns in the semi-solid medium. The basic mechanism to create the colony patterns in the semi-solid medium is different from each other. From the initial inoculum at the center of the region, *S. typhimurium* first form a low density lawn and then create continuous concentric rings or spot-like rings on the lawn, which expand outwards from the initial inoculum. On the other hand, *E. coli* first form the so-called swarm ring, continuous high density ring of bacteria, and then they