Numerical Experiments on Global Flow Structure during Chemical Wave Propagation in the Belousov-Zhabotinsky Reaction System

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Abstract

The Belousov-Zhabotinsky reaction system self-organizes spatio-temporal patterns during its chemical wave propagation. Sakurai et al. found that the system self-organizes the global flow structure which travels on a petri-dish in the shallow layer of depth [1]. The wave length of the flow structure is larger than that of the chemical wave train and the traveling speed of the flow structure is much higher than that of the chemical waves. In addition, the propagation direction of the flow structure alternates at high frequency. Another type of flow structure was also reported for a single chemical wave [2]; there exists not local but global flow structure in front of the single chemical wave.

Several researchers have tried to understand the global flow structures during chemical wave propagation by utilizing the mathematical models of the chemical reactions coupled with the Navier-Stokes equations [3]. They utilized the buoyancy driven and/or the surface tension driven models for connecting the chemical reaction with the fluid flow. However, those models connecting the chemical reaction with fluid flow provided only partial understanding of flow structure; previous results are quite far from full understanding of the mechanism organizing the global flow structure. We suppose that any additional model or mechanism on the solution surface is necessary to understand the global flow structure.

In this poster presentation, we first review previous results on laboratory experiments on fluid flow observed during chemical wave propagation and also on numerical experiments. Then, we present a model imitating the global flow structure observed during chemical wave propagation; the model assumes the existence of elastic property on the solution surface. Finally, we discuss the validity of the model by comparing the results of the numerical experiments and those of the previous laboratory experiments with respect to the frequency of direction changes and the wave length of the flow structure.

References

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