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

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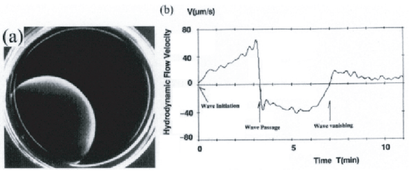
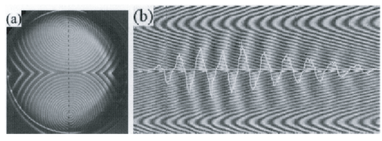
Abstract

The Belousov-Zhabotinsky reaction system self-organizes spatio-temporal patterns during its chemical wave propagation. It is well known that the system self-organizes flow structures on a petri-dish in the shallow layer of depth [1-4]. Several researchers have tried to understand the flow structures during chemical wave propagation by utilizing the mathematical models of the chemical reactions coupled with the Navier-Stokes equations [4-6]. They utilized the buoyancy driven and/or the surface tension driven models for connecting the chemical reaction with the fluid flow. However, the models provided partial understanding of the flow structures. We suppose that any additional model or mechanism on the solution surface is necessary to understand the flow structures. In this poster presentation, we first review previous studies. Then, we present a model that assumes the existence of elastic property on the solution surface. Finally, we present the results of the numerical experiments.

Previous Experimental Results



Single Chemical Wave Propagation [3]



Chemical Wave Train Propagation [1]

Previous Models

	Model Equations	Motive Force	Domain
Wilke [5]	Navier-Stokes Eqs. + Oregonator Model	Gravity Effect	2-Dimension (X-Z)
Diewald et al. [6]	Navier-Stokes Eqs. + Oregoantor Model	Marangoni Effect	2-Dimension (X-Z)

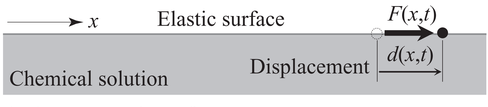
These previous models cannot explain the flow structures observed in the above experimental results.

Proposed Model and Numerical Results

$$\frac{\partial u}{\partial t} = D_u \nabla^2 u + \frac{1}{\varepsilon}\left[u(1-u) - f v \frac{u-q}{u+q}\right] - V_s \frac{\partial u}{\partial x}$$

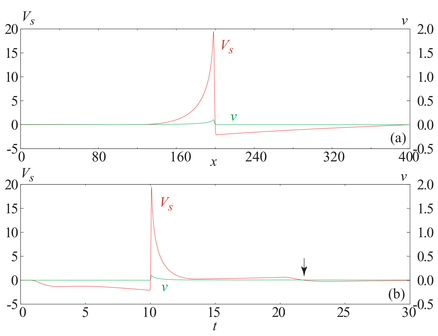
$$\frac{\partial v}{\partial t} = D_v \nabla^2 v + (u - v) - V_s \frac{\partial v}{\partial x}$$

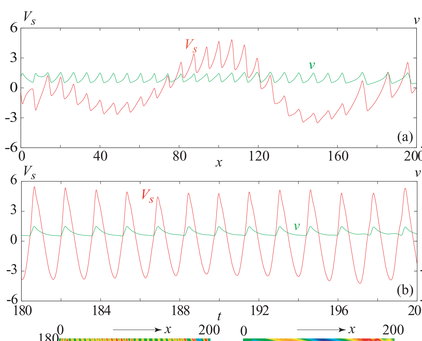
$$\frac{\partial^2 d}{\partial t^2} + a \frac{\partial d}{\partial t} = D_d \nabla^2 d + F(x,t)$$

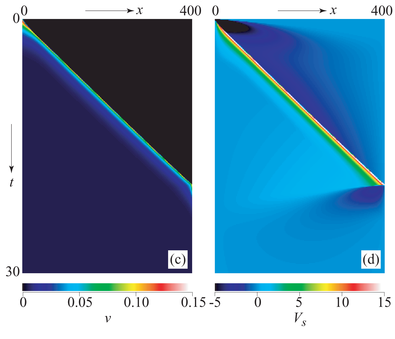


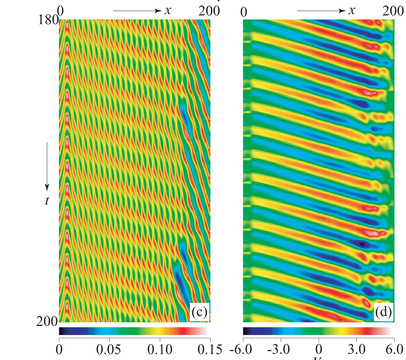
(u,v): concentrations of chemical species

$$F(x,t) = b\frac{\partial v}{\partial x}, V_s = \frac{\partial d}{\partial t}$$









References

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[6] Diewald et al., Phys. Rev. Lett. 77, p.4466 (1996)