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Bifurcation phenomena in spatially extended kinase-receptor interaction model

We consider a reaction-diffusion model of mutual interaction of membrane receptors with kinases proposed in [1]. It is assumed that membrane receptors and cytosolic kinases activate each other, which establishes the positive feedback. The kinases and the receptors are dephosphorylated by uniformly distributed phosphatases. The existence of positive feedback leads to bifurcation at which the positive stable solution appears.

In this study we consider, unlike the authors in [1], the case of nonuniformly distributed membrane receptors. We apply the Steklov eigenproblem theory [2] to analyze the linearized model and find the analytic form of solutions. This approach allows us to determine the critical value of phospahatase activity at which cell activation is possible as a function of kinase diffusion coeffcient and anisotropy of receptor distribution using only algebraic methods.

We showed that cell sensitivity grows with decreasing kinase diffusion and increasing polarity of receptor distribution. Moreover, these two effects are cooperating. The solutions to the original nonlinear system close to the bifurcation point can be approximated by the solution to the linearized one. Moreover this approximation can be improved by using the method of successive approximations.

References

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