Spatiotemporal chaos and quasipatterns in coupled reaction-diffusion systems

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In coupled reaction-diffusion systems, modes with two different length scales can interact to produce a wide variety of spatiotemporal patterns. Three-wave interactions between these modes can explain the occurrence of spatially complex steady patterns and time-varying states including spatiotemporal chaos. The interactions can take the form of two short waves with different orientations interacting with one long wave, or vice verse. We investigate the role of such three-wave interactions in a coupled Brusselator system. As well as finding simple steady patterns when the waves reinforce each other, we can also find spatially complex but steady patterns, including quasipatterns. When the waves compete with each other, time varying states such as spatiotemporal chaos are also possible. The signs of the quadratic coefficients in three-wave interaction equations distinguish between these two cases. By manipulating parameters of the chemical model, the formation of these various states can be encouraged, as we confirm through extensive numerical simulation. Our arguments allow us to predict when spatiotemporal chaos might be found: standard nonlinear methods fail in this case. The arguments are quite general and apply to a wide class of pattern-forming systems, including the Faraday wave experiment. This talk with be based on work that appeared recently in reference https://doi.org/10.1016/j.physd.2020.132475 with co-authors Jennifer Castelino, Daniel Ratliff, Priya Subramanian and Chad Topaz.