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An Asymptotic Analysis of Spike Self-Replication and Spike Nucleation of Reaction-Diffusion Patterns on Growing 1-D Domains

Pattern formation on growing domains is one of the key issues in developmental biology, where domain growth has been shown to generate robust patterns under Turing instability. In this work, we investigate the mechanisms responsible for generating new spikes on a growing domain within the semi-strong interaction regime, focusing on three classical reaction-diffusion models: the Schnakenberg, Brusselator, and Gierer-Meinhardt (GM) systems. Our analysis identifies two distinct mechanisms of spike generation as the domain length increases. The first mechanism is spike self-replication, in which individual spikes split into two, effectively doubling the number of spikes. The second mechanism is spike nucleation, where new spikes emerge from a quiescent background via a saddle-node bifurcation of spike equilibria. Critical stability thresholds for these processes are derived, and global bifurcation diagrams are computed using the bifurcation software pde2path. These results yield a phase diagram in parameter space, outlining the distinct dynamical behaviors that can occur.