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Symmetry and Bifurcations in First-order Hyperbolic PDEs with Nonlocal Terms Modelling Animal Aggregation

Pattern formation in self-organised biological aggregation is a phenomenon that has been studied intensively over the past twenty years. I will present a class of models for animal aggregation in the form of two first-order hyperbolic partial differential equations on a one-dimensional domain with periodic boundary conditions, describing the motion of left and right moving individuals with nonlinear, nonlocal social interaction terms for attraction, repulsion and alignment giving the turning rates of individuals. This class of models has been introduced in the Ph.D thesis of R. Eftimie. In this talk, I will show that the equations are O(2)-equivariant where the group O(2) is generated by space-translations and a reflection which interchanges left-moving individuals with right-moving individuals across the middle of the interval. I will discuss steady-states and their symmetry with a focus on homogeneous O(2) symmetric states and the existence of codimension two steady-state/steady-state, steady-state/Hopf and Hopf/Hopf bifurcation points. I will present how using existing symmetry-breaking bifurcation theory and new theoretical results, one can study the neighborhood of those bifurcation points and classify the patterns obtained. This is joint work with R. Eftimie (U. Dundee, Scotland).