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Biological Aggregation Driven by Social/Environmental Factors: A Nonlocal Model and Its Degenerate Cahn-Hilliard Approximation

Biological aggregations such as insect swarms and fish schools may arise from a combination of social interactions and environmental cues. Nonlocal continuum equations are often used to model aggregations, which manifest as localized solutions. While popular in the literature, the nonlocal models pose significant analytical and computational challenges. Beginning with the nonlocal aggregation model of [Topaz, Bertozzi & Lewis, Bull. Math. Bio., 2006], we derive the minimal well-posed long-wave approximation, which is a degenerate Cahn-Hilliard equation. Using analysis and computation, we study energy minimizers and show that they retain many salient features of those of the nonlocal model. Furthermore, using the Cahn-Hilliard model as a testbed, we investigate how an external potential modeling food sources can suppress peak population density, which is essential for controlling locust outbreaks. Random potentials tend to increase peak density, whereas periodic potentials can suppress it.