Applied Mathematics Seminar

UCC
University College Cork, Ireland
Coláiste na hOllscoile Corcaigh

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Rate-induced tipping in reaction-diffusion problems: The rise and fall of geographically shifting ecosystems

We introduce and analyse mathematical models that describe the spatial distributions of migratory species when subject to a geographically-shifting habitat. These models are underpinned by reaction-diffusion equations that are heterogeneous in space and nonautonomous in time. To address this problem (as well as a wider class of problems), we propose a methodology that combines a compactification technique together with Lin's method for connecting heteroclinic orbits implemented with numerical continuation. This allows for the transformation of a travelling-pulse problem into a heteroclinic orbit problem in the compactified system. Using our methodology, we identify and study two classes of tipping points in reaction-diffusion systems. Bifurcation-induced tipping causes the current state to become unstable when an environmental parameter goes through a critical level underpinned by a bifurcation (i.e. topological change) of the autonomous system. Rate-induced tipping, the focus of this study, occurs when the slow components of the system change faster than some critical rate; this is underpinned by critical speeds of the moving habitat. Finally, we identify parameter boundaries for tipping points and determine how these boundaries depend on the size of the habitat, the speed of climate shifts, and dispersal rates of the migrating species.

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