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Rate-induced tipping in nonautonomous dynamical systems with bounded noise

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Tipping points describe bifurcations where the output of a dynamical system changes disproportionately compared to the change in the parameter. A classification of different mechanism of tipping in dynamical systems has been proposed in literature and a new behaviour has been identified: the so-called rate-induced tipping, R-tipping or rate-induced bifurcation. This work aims at providing a mathematical framework for rate-induced tipping in one dimensional nonautonomous dynamical systems in the presence of bounded noise and to give a necessary condition for such behaviour to occur.

It is given an autonomous dynamical system depending on a parameter. The system is generally not undergoing any classical bifurcation under changes in the parameter. We consider the parameter changing in time at a positive rate so that the system is now nonautonomous but asymptotically autonomous. Moreover, consider a bounded time-dependent perturbation so that the system can be regarded as a nonautonomous set-valued (or general) dynamical system. A rate-induced tipping describes a destabilisation of such system due to a rapid change in the parameter, i.e. the existence of a critical rate. A precise definition of rate-induced tipping as a discontinuity in the limiting behaviour of a local pullback attractor is proposed. Under appropriate assumptions, an attractor-repeller collision is shown to be a necessary condition for such tipping to occur.