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Non-autonomous stability in non-linear delayed systems

Delayed non-linear systems have a widespread use across the engineering, physical and biological sciences, displaying a wide variety of complex dynamics. Non-autonomous perturbations, such as noise, greatly impact the dynamics of such systems and further alter their stability. I will here present an approach to handle that problem using center manifold theory formulated for delay equations, where an explicit time-dependence is taken into account. Using the characteristic time scale separation emerging in the vicinity of instabilities, this approach makes possible to capture the effect of forcing on the stability of a delayed non-linear system in the vicinity of a bifurcation, and serves as new strategy to highlight novel non-linear phenomena in the harmonically driven and/or stochastic regimes. Using this method, we propose to first expose the effect of additive random fluctuations on the stability of a particular scalar delayed non-linear system near a pitchfork bifurcation and demonstrate how noise might be used to prevent the system from entering bistable domains. We extend this result to the delay-induced Hopf bifurcation by showing how noise suppresses ongoing oscillatory dynamics by shifting the instability threshold in parameter space, as revealed by the dynamics of the ensemble average solution.