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The Eigenvalue Spectrum of Distributed Delay Differential Equations with Large Mean Delay

This talk studies the eigenvalue spectrum of linear delay differential equations with a uniformly distributed delay kernel. We carry out asymptotic analysis in the limit of large mean delay to show that the spectrum splits into (i) a strong critical spectrum referring to a finite set of isolated, pure imaginary eigenvalues that are unaffected by delay, (ii) an asymptotic strong spectrum consisting of a finite set of eigenvalues with limits that are determined by non-delayed terms in the model, and (iii) a pseudo-continuous spectrum consisting of infinitely many eigenvalues that limit on the imaginary axis, with real parts that scale linearly with the delay. This behaviour is similar to the fixed delay case, but the distributed delay introduces additional spectral features, including a countably infinite number of horizontal asymptotes in the pseudo-continuous spectrum at frequencies inversely proportional to the width of the distribution. We validate our theoretical results through numerical studies of several examples and compare our findings with fixed-delay results from the literature. Finally, we apply the results to study the stability and bifurcations of a Wilson-Cowan model with a delayed self-coupling, large mean delay, and homeostatic plasticity. This is joint work with Isam Al-Darabsah and Bootan Rahman