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Delays, Oscillations and Hopf Bifurcations in Drug Delivery Systems

Drug therapies are sometimes designed to reproduce the physiological fluctuations in normal biological agents, such as hormones, which entails the need for a periodic, yet sustained administration. The generation of oscillatory variations in concentrations is thus desirable in this context. We present such a system containing explicit time delays, in which the oscillations are generated by the delayed response of the permeability of a membrane at the boundary of a reaction chamber. We completely analyse the stability of the equilibrium, and present conditions under which Hopf bifurcations are present. We also provide further conditions for multiple mode instabilities to occur, by the occurrence of double Hopf bifurcations, and present evidence of highly nonsinusoidal oscillations.