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Dynamics of localized structures in DDEs with large delay

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Temporally localized structures arise in various types of applications and are often modelled by DDE systems with large delay. We develop a theory for such states, which appear as periodic solutions with a period close to the large delay of the system. Using the limit of infinite delay, they can be treated as homoclinic solutions of an equation with an advanced argument. Using the Morris–Lecar model with time-delayed feedback as a paradigmatic example, we demonstrate how classical homoclinic bifurcation theory can be used to study the emergence, stability, and bifurcations of such localized states. In particular, we show how a homoclinic orbit flip of a single-pulse solution leads to the destabilization of equidistant multi-pulse solutions and to the emergence of stable pulse packages. It turns out that this transition is induced by a heteroclinic orbit flip in the system without feedback, which is related to the excitability properties of the Morris–Lecar model.