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ON A NEURON MODEL WITH DYNAMICAL THRESHOLD

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ABSTRACT

We study the dynamics of a class of two-dimensional hybrid non-autonomous neuron models known as the *Meng–Huguet–Rinzel neuron model* [1, 2]. The model combines continuous sub-threshold evolution with a spike-triggered reset mechanism and features a dynamical firing threshold. Its continuous dynamics consist of a linear voltage equation coupled to a threshold variable whose evolution depends nonlinearly on the membrane potential. We consider periodically driven systems, with external input given by either pulse forcing or a rectified sinusoidal current.

Our main goal is to characterize periodic responses and to understand how the reset mechanism changes the long-term dynamics. We establish existence and uniqueness results for periodic solutions and show that, when resets are absent, the periodically forced system admits a unique globally attracting periodic orbit. In the hybrid setting, we prove that there can be at most one reset-free periodic orbit that remains entirely in the subthreshold regime. At the same time, numerical simulations reveal a richer dynamical picture, including coexistence between such a reset-free periodic response and periodically spiking attractors. These results highlight the role of the dynamical threshold and reset mechanism in generating transitions between subthreshold oscillations and repetitive firing under time-dependent stimulation. This is joint work with Juan Belmonte-Beitia and Justyna Signerska-Rynkowska.

REFERENCES

- [1] X. Meng, G. Huguet, and J. Rinzel: *Type III excitability, slope sensitivity and coincidence detection*, Discrete Contin. Dyn. Syst. **32** (2012), 2729–2757.
- [2] A. Granados and G. Huguet: *Gluing and grazing bifurcations in periodically forced 2-dimensional integrate-and-fire models*, Commun. Nonlinear Sci. Numer. **70** (2019), 48–73.