Bump Attractors and Waves in Networks of Integrate-and-Fire Neurons

Bump attractors are localised patterns observed in in vivo experiments of neurobiological networks. They are important for the brain's navigational system and specific memory tasks. A bump attractor is characterised by a core in which neurons fire frequently, while those away from the core do not fire. We uncover a relationship between bump attractors and travelling waves in a classical network of excitable, leaky integrate-and-fire neurons. This relationship bears strong similarities to the one between complex spatiotemporal patterns and waves at the onset of pipe turbulence. We define and study analytical properties of the voltage mapping, an operator transforming a solution's firing set into its spatiotemporal profile. This operator allows us to construct localised travelling waves with an arbitrary number of spikes at the core, and to study their linear stability. A homogeneous "laminar" state exists in the network, and it is linearly stable for all values of the principal control parameter. We show that one can construct waves with a seemingly arbitrary number of spikes at the core; the higher the number of spikes, the slower the wave, and the more its profile resembles a stationary bump. As in the fluid-dynamical analogy, such waves coexist with the homogeneous state, are unstable, and the solution branches to which they belong are disconnected from the laminar state. We provide evidence that the dynamics of the bump attractor displays echoes of the unstable waves.

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