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Microstate description of stable chaos in networks of spiking neurons MAXIMILIAN PUELMA TOUZEL, MONTEFORTE MICHAEL, FRED WOLF, Max Planck Institute for Dynamics and Self-organization, Bernstein Center for Computational Neuroscience, Goettingen — Dynamic instabilities have been proposed to explain the decorrelation of stimulus-driven activity observed in sensory areas such as the olfactory bulb, but are sensitive to noise. Simple neuron models coupled through inhibition can nevertheless exhibit a negative maximum Lyapunov exponent, despite displaying irregular and asynchronous (AI) activity and having an exponential instability to finite-sized perturbations above a critical strength that scales with the size, density and activity of the circuit [1]. This stable chaos, a phenomenon first found in coupled-map lattices, produces a large, finite set of locally-attracting, yet mutually-repelling AI spike sequences ideally suited for discrete, high-dimensional coding. We analyze the effects of finite-sized perturbations on the spiking microstate and reveal the mechanism underlying the stable chaos. From this, we can analytically derive the aforementioned scaling relations and estimate the critical value of previously observed transitions to conventional chaos. This work highlights the features of intra-neuron dynamics and inter-neuron coupling that generate this phase space structure, which might serve as an attractor reservoir that downstream networks can use to decode sensory input.

[1] Monteforte, M. & Wolf, F., PRX 2, 1(2012).

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