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Chaos and correlated avalanches in excitatory neural networks with synaptic plasticity

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Irregular firing patterns characterized by power-law distribtion in avalanches size are observed to be fundamental dynamical features of neural networks. Here we show how such dynamical regimes naturally emerge in a disordered mean field model of purely excitatory leaky integrate-and-fire neurons with dynamical synapses modeling short-term plasticity. We compute the phase diagram of the model as a function of the coupling strength and of the synaptic time-scales and we show that it exhibits two transitions, from quasi-synchronous and asynchronous regimes to a nontrivial bursty collective activity. In the homogeneous case without disorder, the bursty behavior is reflected into a doubling-period transition to chaos for a two dimensional discrete map. Numerical simulations confirm that the introduction of disorder preserves the main chaotic features of the dynamics and it gives rise, through a dynamical mechanism, to power-law scaling of activity events.

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