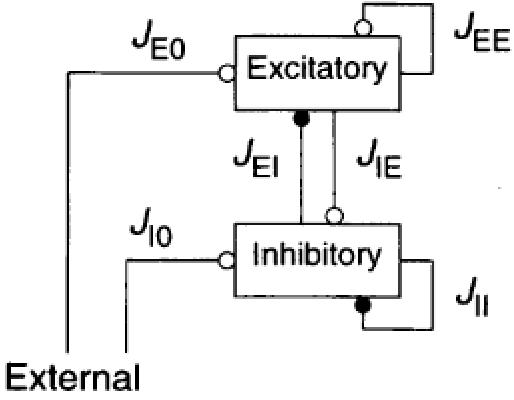
Network Model (1):

E/I Balanced Network

Neuron models	HH neuron model
	LIF neuron model
	Exponential IF model
Synapse models	Exponential/Alpha synapse
	AMPA/GABA/NMDA synapse
Network Models	E/I balance network
	Continuous attractor network
	Working memory model
	Decision making model

E/I balanced network

- Question: Neurons in the cortex of behaving animals show temporally irregular spiking patterns.



$$\tau \frac{du_i^E}{dt} = -u_i^E + \sum_{j=1}^{K_E} J_{EE} r_j^E + \sum_{j=1}^{K_I} J_{EI} r_j^I + I_i^E$$

$$\tau \frac{du_i^I}{dt} = -u_i^I + \sum_{j=1}^{K_I} J_{II} r_j^I + \sum_{j=1}^{K_E} J_{IE} r_j^I + I_i^I$$

- Sparse & random connections
- Neurons fire largely independently to each other.

(Van Vreeswijk C., Sompolinsky H, Science, 1996)

$$\tau \frac{du_i^E}{dt} = -u_i^E + \sum_{j=1}^{K_E} J_{EE} r_j^E + \sum_{j=1}^{K_I} J_{EI} r_j^I + I_i^E$$

$$\tau \frac{du_i^I}{dt} = -u_i^I + \sum_{j=1}^{K_I} J_{II} r_j^I + \sum_{j=1}^{K_E} J_{IE} r_j^I + I_i^I$$

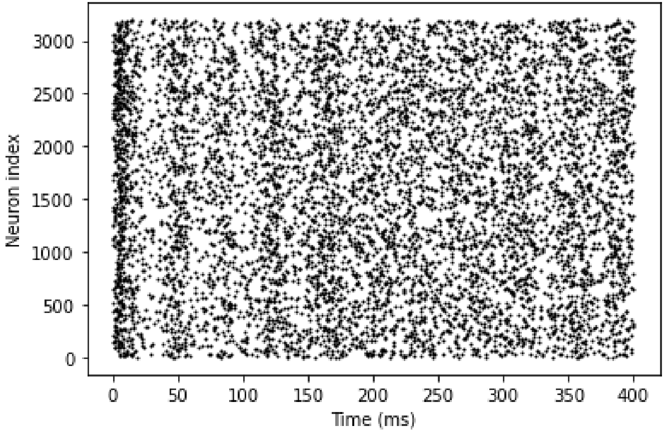
- Suppose each neuron fires irregularly with mean rate μ and variance δ^2

- The mean of recurrent input received by E neuron: $\sim K_E J_{EE} \mu - K_I J_{EI} \mu$
- The variance of recurrent input received by E neuron: $\sim K_E (J_{EE})^2 \delta^2 + K_I (J_{EI})^2 \delta^2$

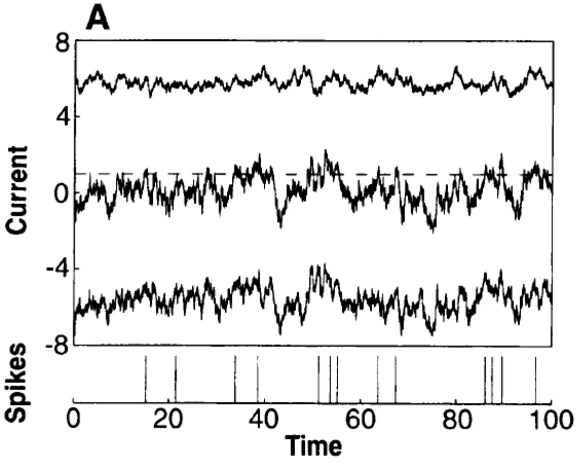
- The balanced condition:
  - $K_E\, J_{EE} - K_I J_{EI} \approx 0$; the mean is close to zero
  - $J_{EE} \sim \frac{1}{\sqrt{K_E}}, J_{EI} \sim \frac{1}{\sqrt{K_I}}$; the variance is order of one

E/I balanced network

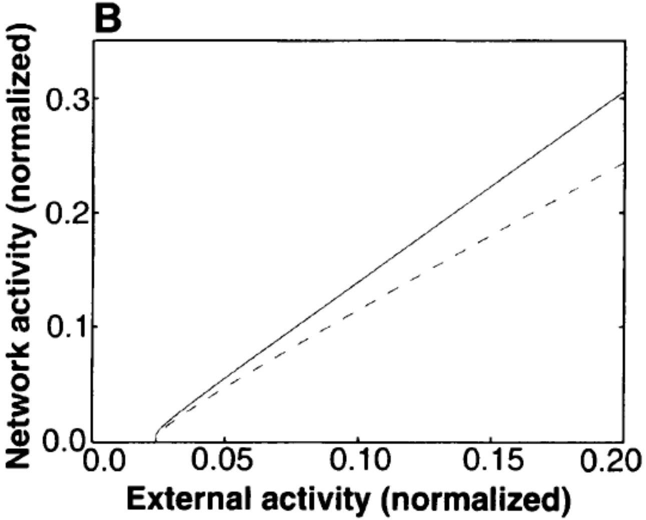
- Irregular firing (chaos) emerge from the network dynamics, without fine tuning parameters



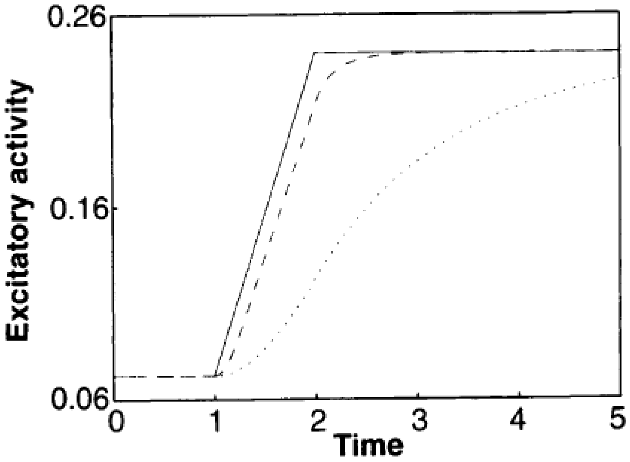
- Neuronal firing is driven by input fluctuations



- External input strength is “linearly” encoded by the mean firing rate of the neural population



- One possible functional advantage of the balanced state is that the balanced network quickly tracks changes in the rate of the external input.



Exercise

1. Implement EI balanced network model