

## Week 5 – part 5 : Stochastic spike firing in integrate-and-fire models



### **Neuronal Dynamics: Computational Neuroscience of Single Neurons**

#### **Week 5 – Variability and Noise: The question of the neural code**

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- ✓ **5.1 Variability of spike trains**
  - experiments
- ✓ **5.2 Sources of Variability?**
  - Is variability equal to noise?
- ✓ **5.3 Three definitions of Rate code**
  - Poisson Model
- ✓ **5.4 Stochastic spike arrival**
  - Membrane potential fluctuations
- 5.5. Stochastic spike firing**
  - subthreshold and superthreshold

## Week 5 – part 5 : Stochastic spike firing in integrate-and-fire models



### ✓ 5.1 Variability of spike trains

- experiments

### ✓ 5.2 Sources of Variability?

- Is variability equal to noise?

### ✓ 5.3 Three definitions of Rate code

- Poisson Model

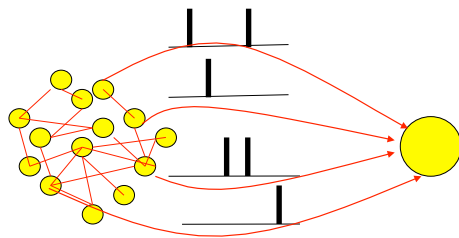
### ✓ 5.4 Stochastic spike arrival

- Membrane potential fluctuations

### 5.5. Stochastic spike firing

- subthreshold and superthreshold

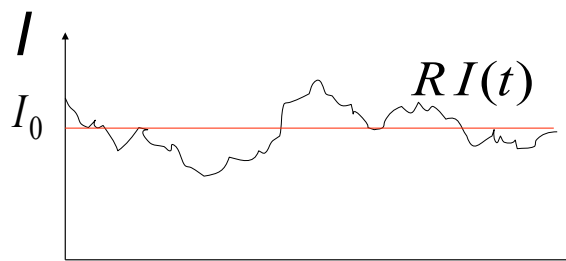
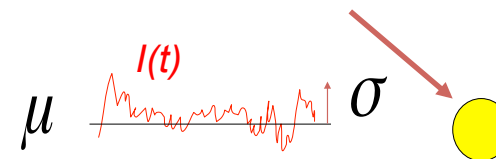
# Neuronal Dynamics – review: Fluctuations of potential



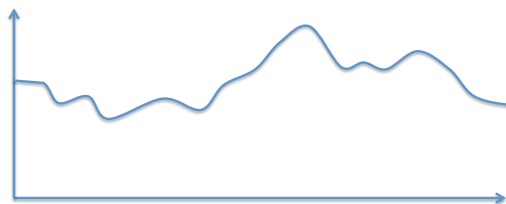
*Passive membrane*

$$\tau \frac{d}{dt} u = -(u - u_{rest}) + RI(t)$$

→ Fluctuating potential

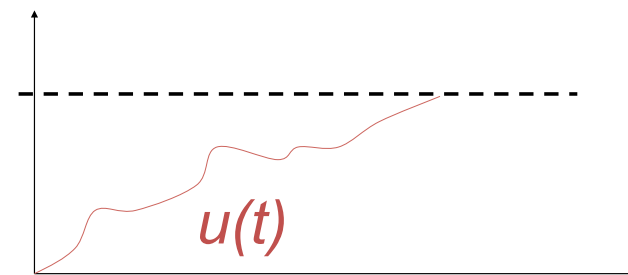
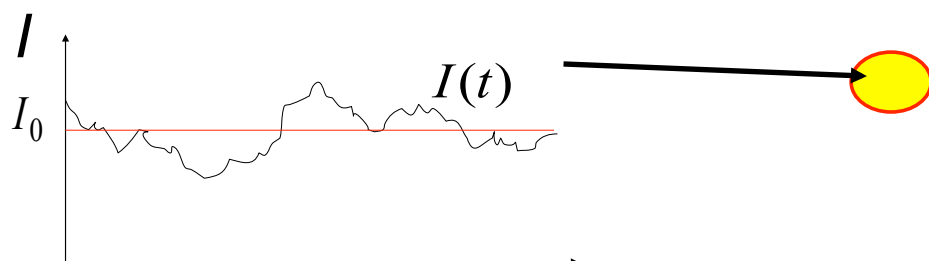


$$I^{syn}(t) = I_0 + I^{fluct}(t)$$



# Neuronal Dynamics – 5.5. Stochastic leaky integrate-and-fire

effective noise current



LIF

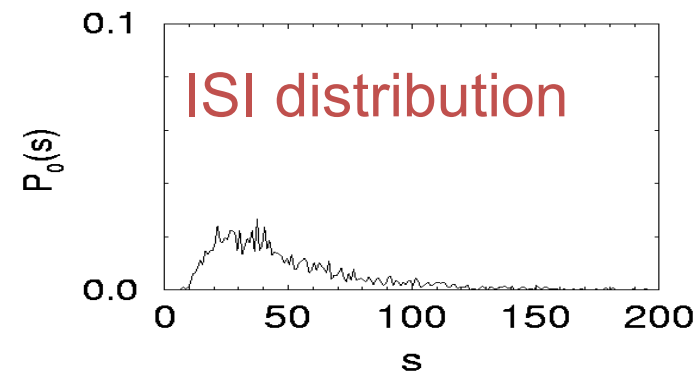
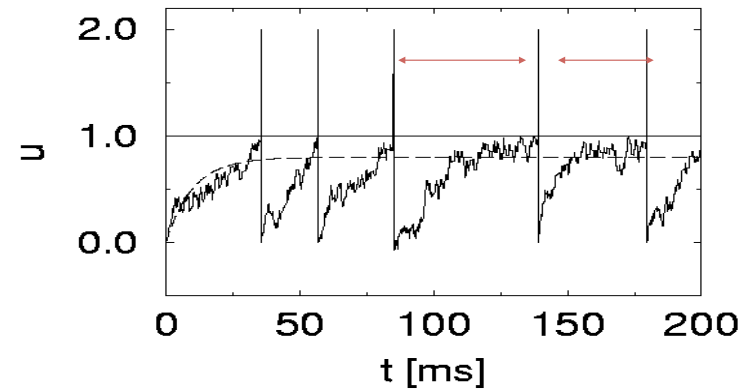
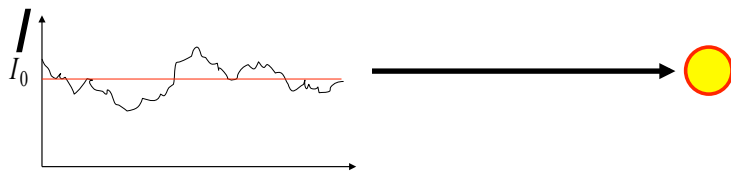
$$\tau \frac{d}{dt} u = -(u - u_{rest}) + RI(t)$$

$$I(t) = [I_0 + I_{noise}]$$

$$\text{IF } u(t) = \vartheta \text{ THEN } u(t + \Delta) = u_r$$

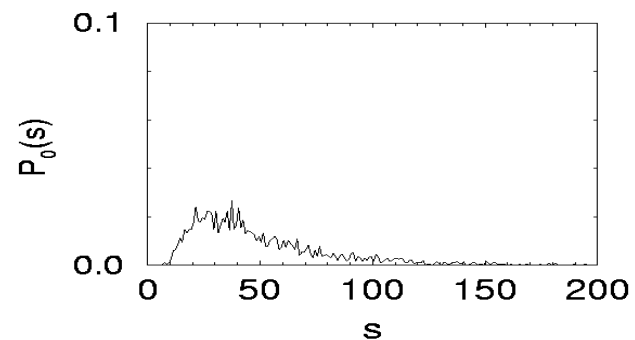
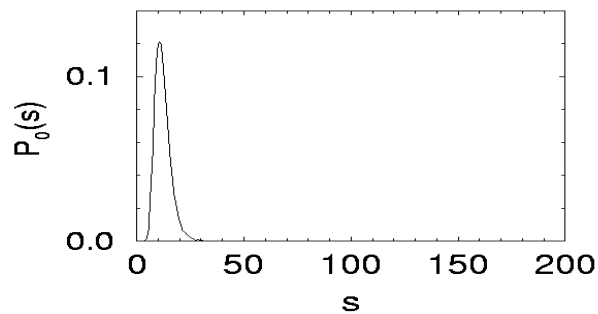
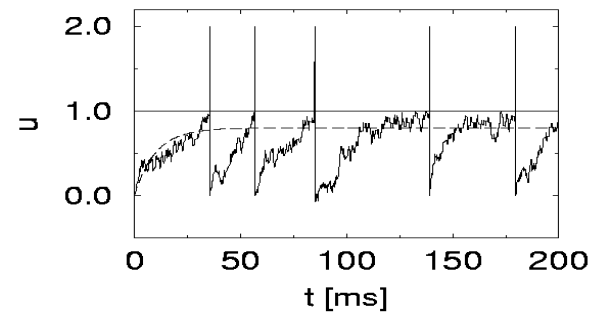
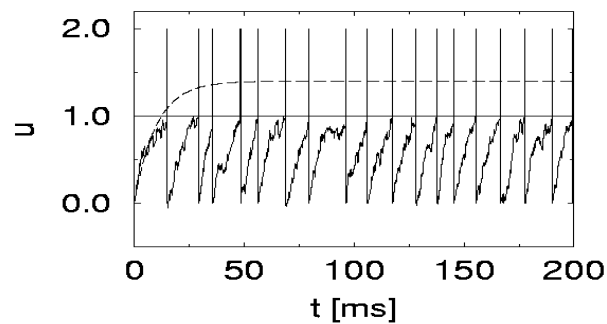
noisy input/  
diffusive noise/  
stochastic spike  
arrival

## stochastic spike arrival in I&F – interspike intervals



## LIF with Diffusive noise (stochastic spike arrival)

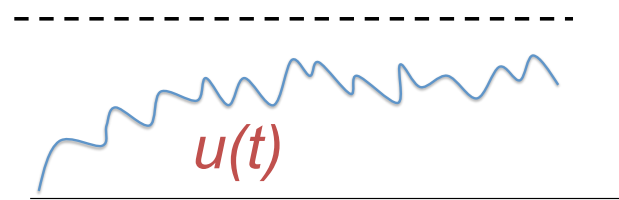
### Superthreshold vs. Subthreshold regime



## Neuronal Dynamics – 5.5. Stochastic leaky integrate-and-fire

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noisy input/ diffusive noise/  
stochastic spike arrival



subthreshold regime:

- firing driven by fluctuations
- broad ISI distribution
- *in vivo* like

## Neuronal Dynamics **week 5**— References and Suggested Reading

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**Reading:** W. Gerstner, W.M. Kistler, R. Naud and L. Paninski,

*Neuronal Dynamics: from single neurons to networks and models of cognition*. Ch. 7,8: Cambridge, 2014

**OR** W. Gerstner and W. M. Kistler, *Spiking Neuron Models*, Chapter 5, Cambridge, 2002

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