Week 1 – part 4: Generalized Integrate-and-Fire Model

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

Neuronal Dynamics:
Computational Neuroscience of Single Neurons

Week 1 – neurons and mathematics:

a first simple neuron model

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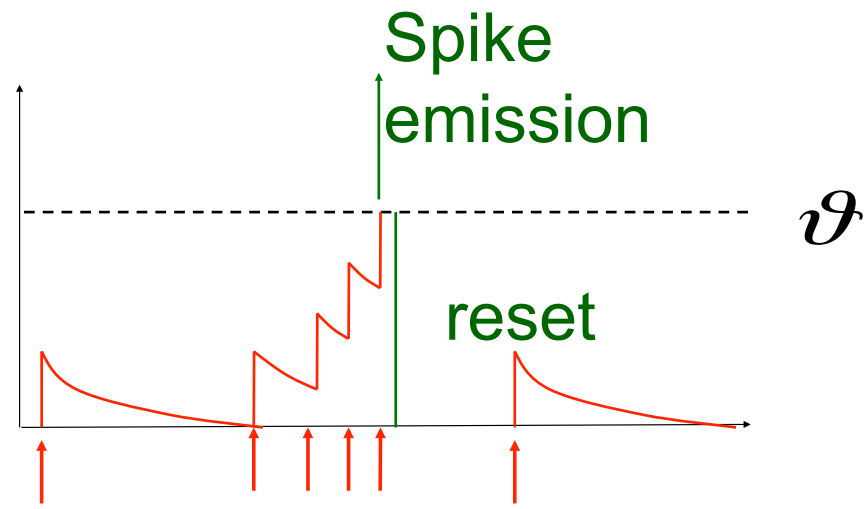
- √ 1.1 **Neurons and Synapses:**
  Overview
- √ 1.2 **The Passive Membrane**
  - Linear circuit
  - Dirac delta-function
- √ 1.3 **Leaky Integrate-and-Fire Model**
- 1.4 **Generalized Integrate-and-Fire Model**
- 1.5. **Quality of Integrate-and-Fire Models**

Neuronal Dynamics – 1.4. Generalized Integrate-and Fire



Integrate-and-fire model

LIF: linear + threshold

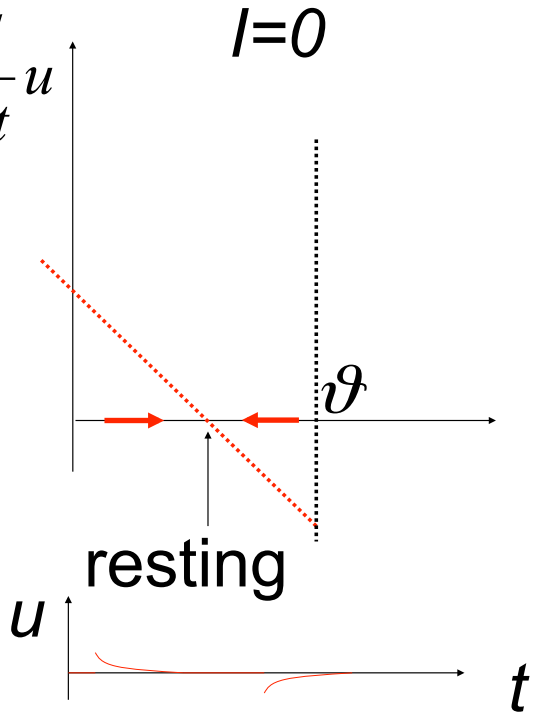
Neuronal Dynamics – 1.4. Leaky Integrate-and Fire revisited

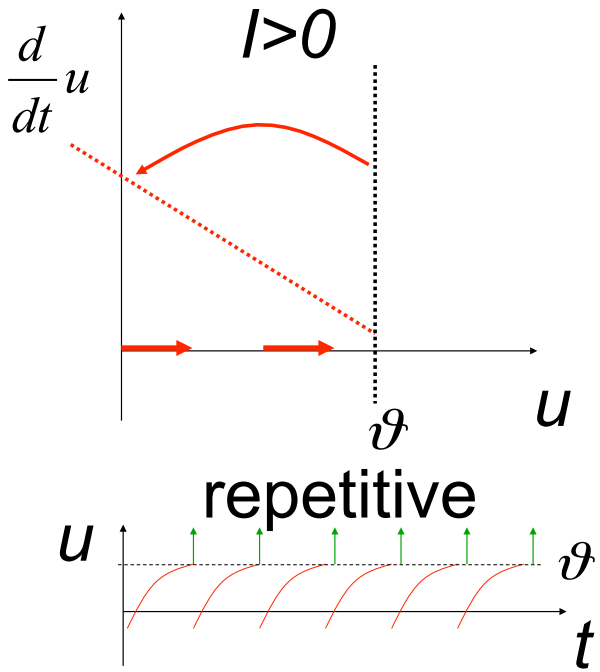
LIF

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

If firing:

$$u \rightarrow u_r$$





Neuronal Dynamics – 1.4. Nonlinear Integrate-and Fire

LIF

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

NLIF

$$\tau \cdot \frac{d}{dt} u = F(u) + RI(t)$$

If firing:

$$u \rightarrow u_{reset}$$

Neuronal Dynamics – 1.4. Nonlinear Integrate-and Fire

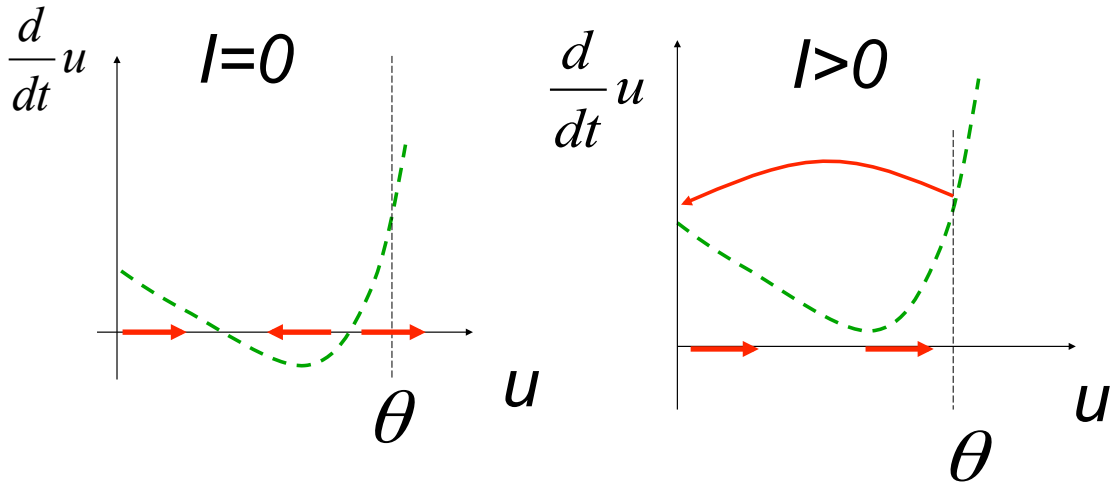
Nonlinear Integrate-and-Fire

NLIF

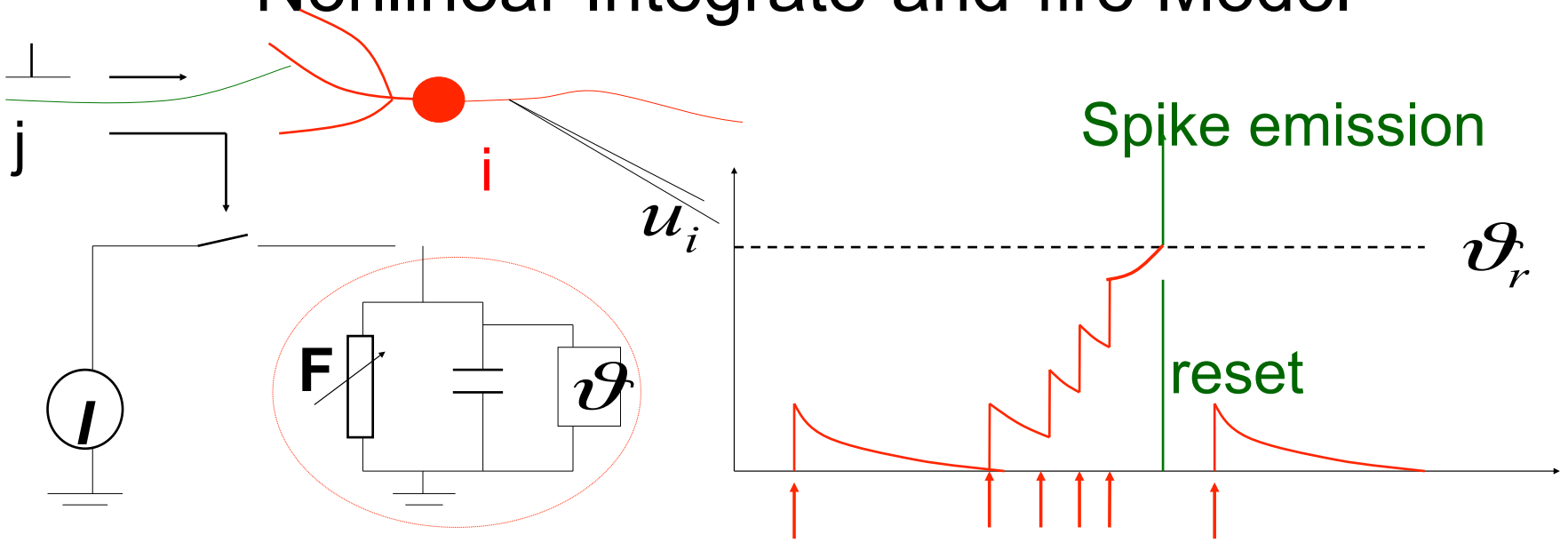
$$\tau \cdot \frac{d}{dt} u = F(u) + RI(t)$$

firing: $u(t) = \theta \Rightarrow$

$$u \rightarrow u_r$$



Nonlinear Integrate-and-fire Model



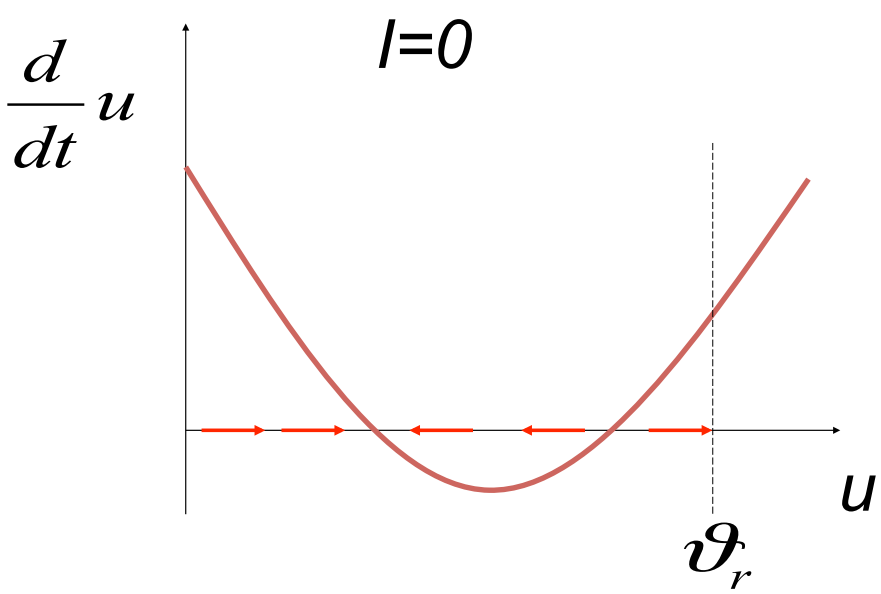
$$\tau \cdot \frac{d}{dt} u = F(u) + RI(t)$$

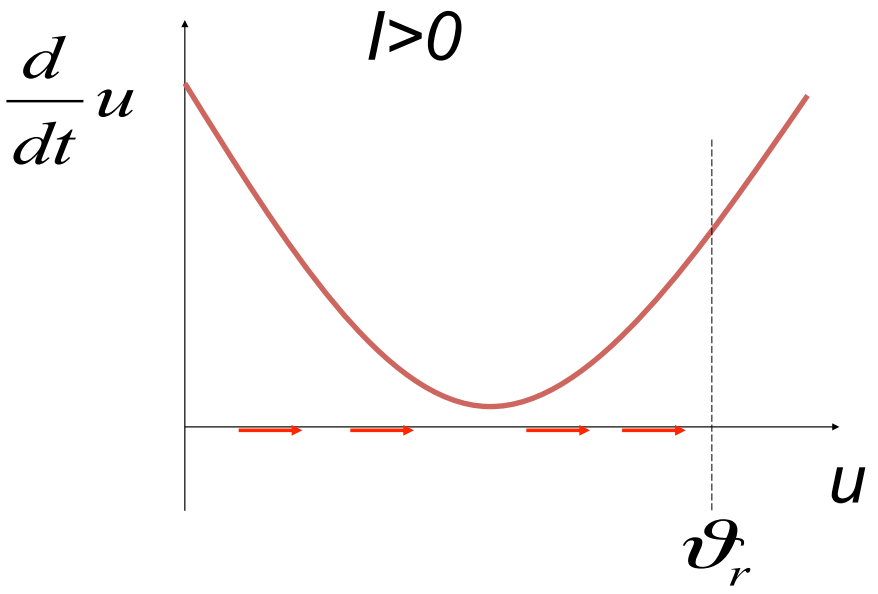
NONlinear

$$u(t) = \vartheta_r \Rightarrow$$

Fire+reset threshold

Nonlinear Integrate-and-fire Model





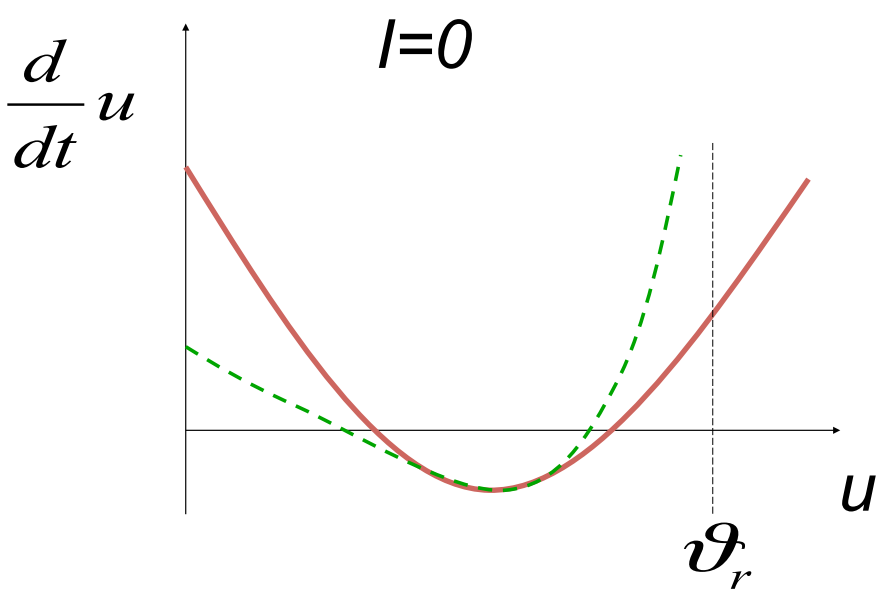
$$\tau \cdot \frac{d}{dt}u = F(u) + RI(t)$$ NONlinear

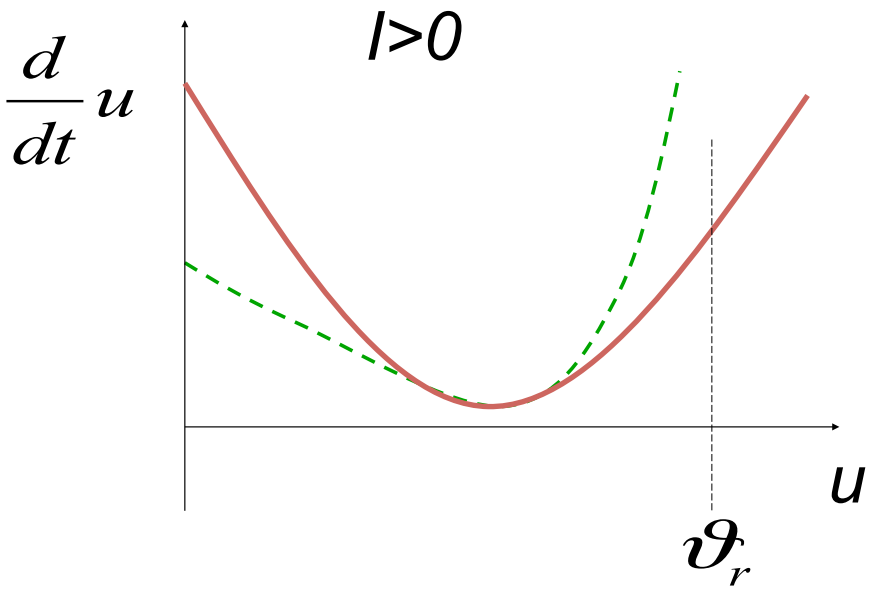
$$u(t) = \vartheta_r \Rightarrow$$ Fire+reset threshold

Quadratic I&F:

$$F(u) = c_2(u - c_1)^2 + c_0$$

Nonlinear Integrate-and-fire Model





$$\tau \cdot \frac{d}{dt}u = F(u) + RI(t)$$

$$u(t) = \vartheta_r \Rightarrow \text{ Fire+reset}$$

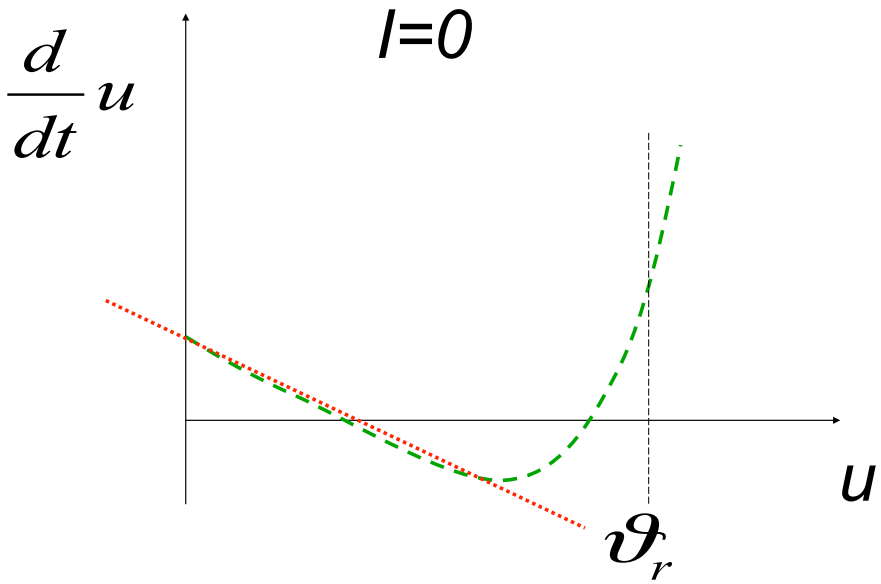
Quadratic I&F:

$$F(u) = c_2 (u - c_1)^2 + c_0$$

exponential I&F:

$$F(u) = -(u - u_{rest}) + c_0 \exp(u - \vartheta)$$

Nonlinear Integrate-and-fire Model



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

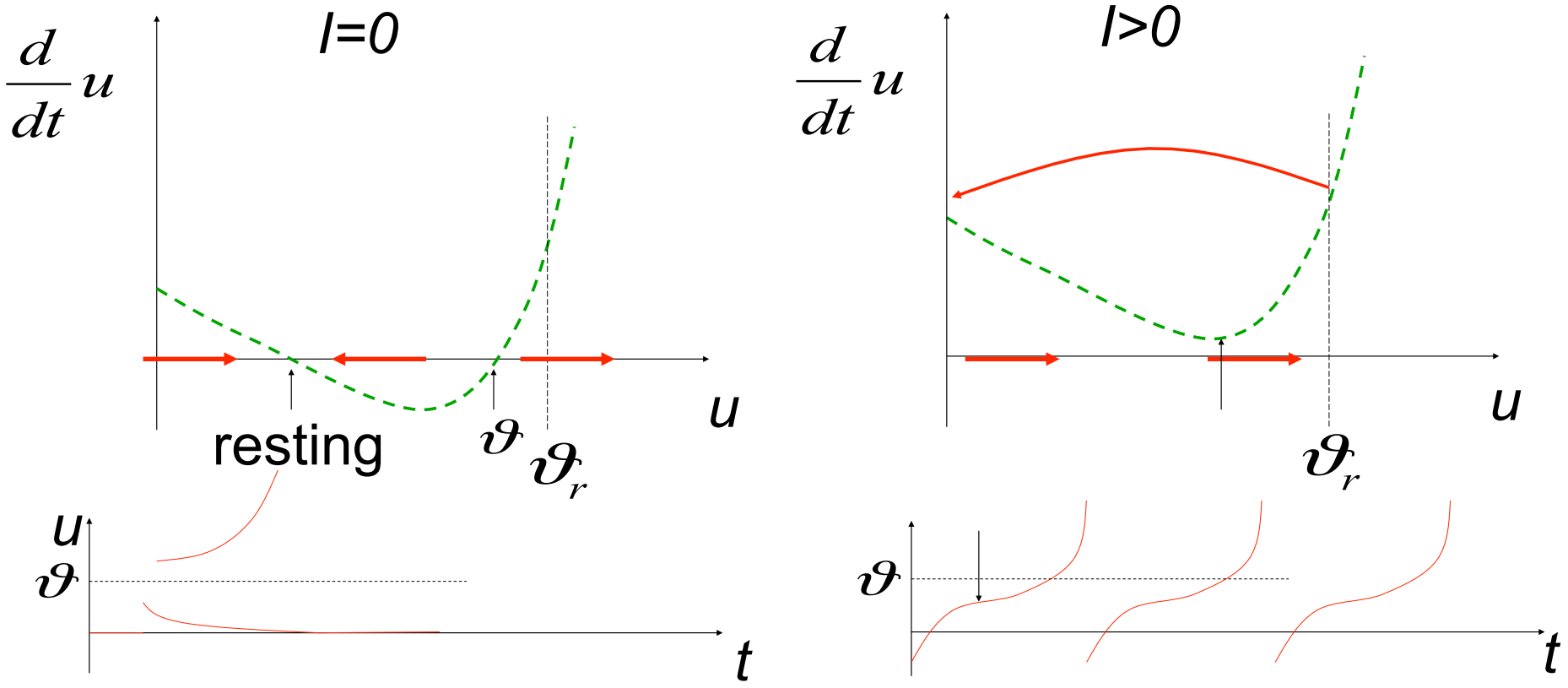
$$u(t) = \vartheta_r \Rightarrow$$ Fire+reset threshold

exponential I&F:

$$F(u) = -(u - u_{rest}) + c_0 \exp(u - \vartheta)$$

Nonlinear Integrate-and-fire Model

Where is the firing threshold?



$$\tau \cdot \frac{d}{dt} u = F(u) + RI(t)$$

Neuronal Dynamics – Homework 1.3

Homework!