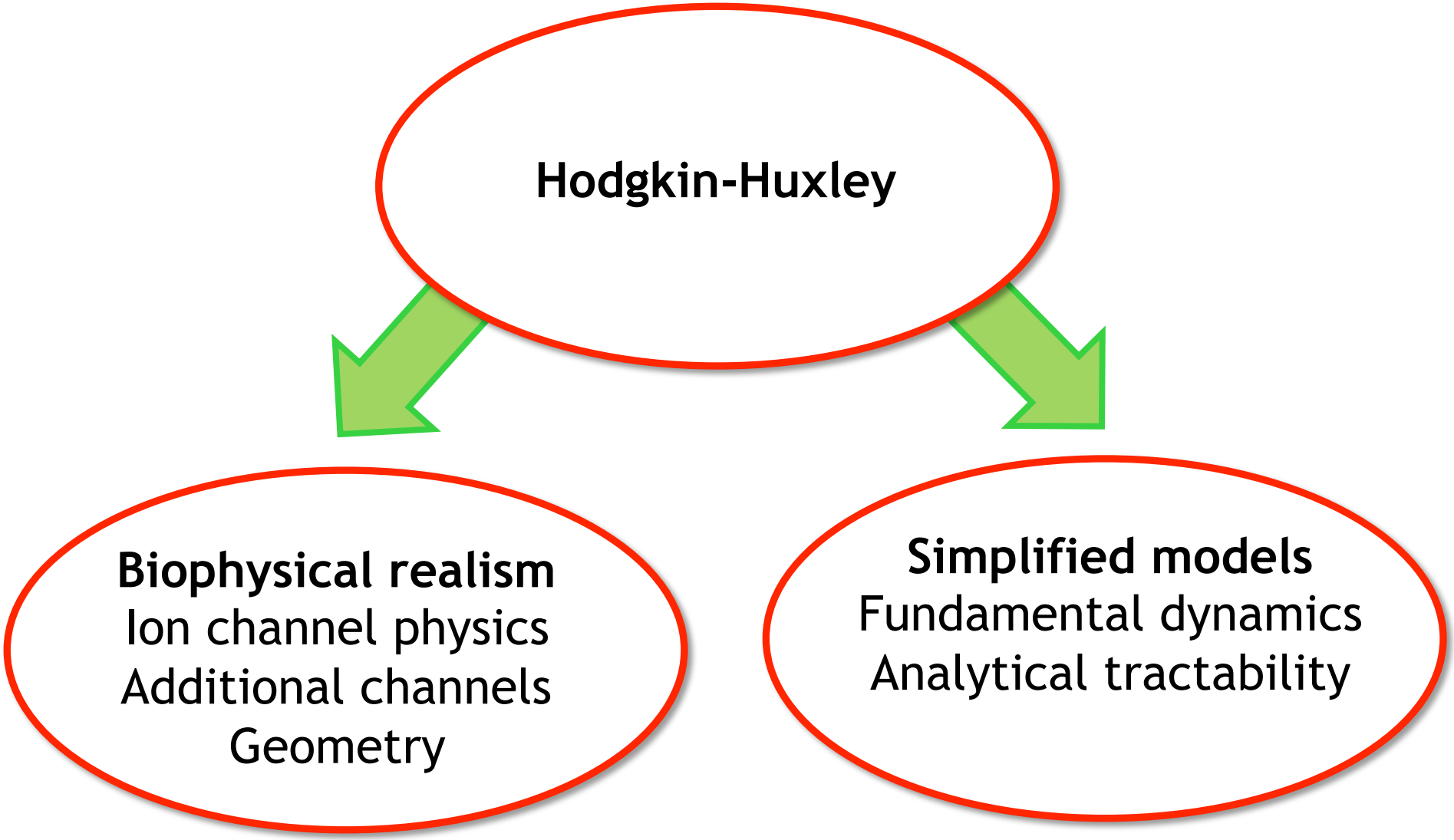
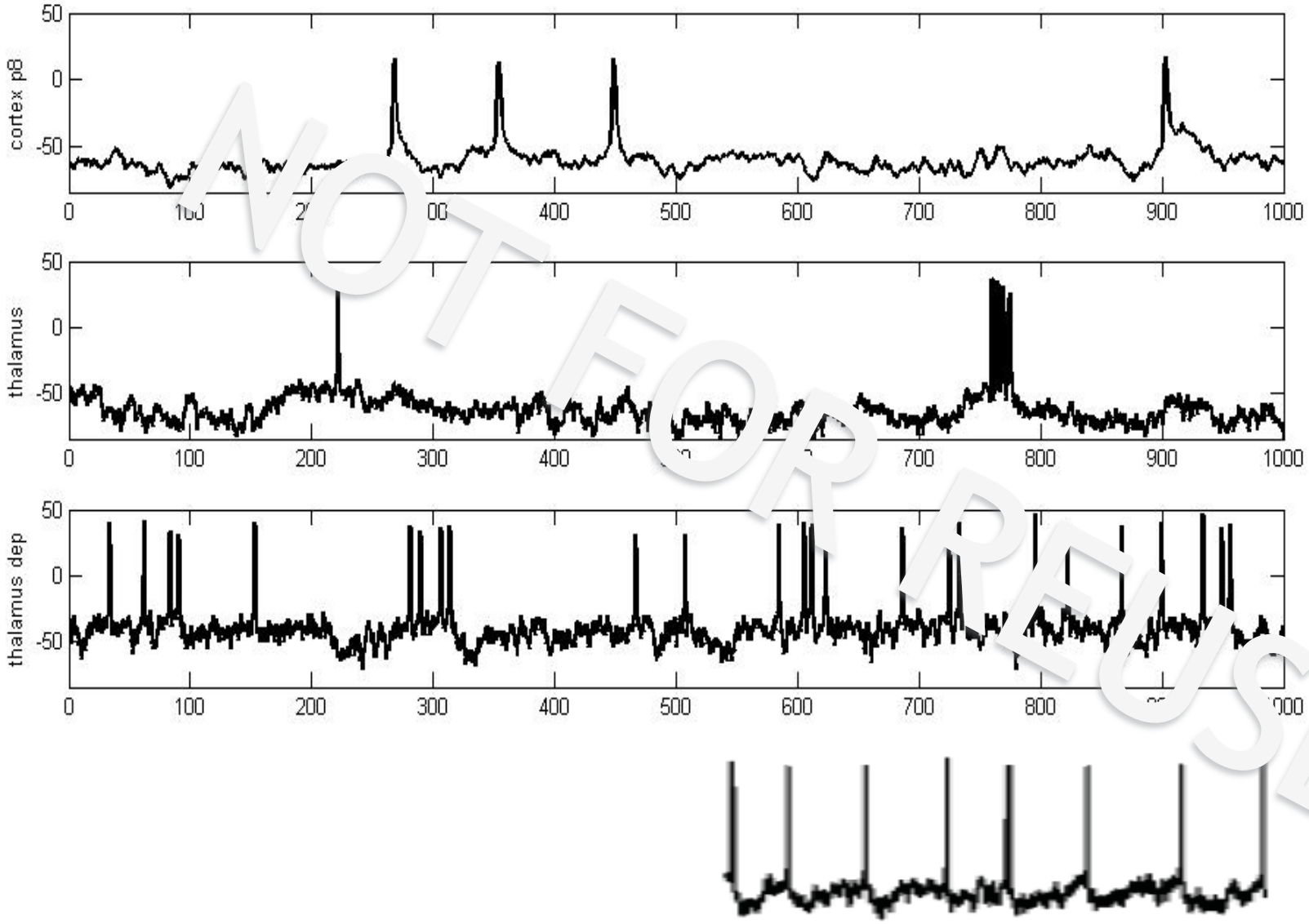
Where to from here?



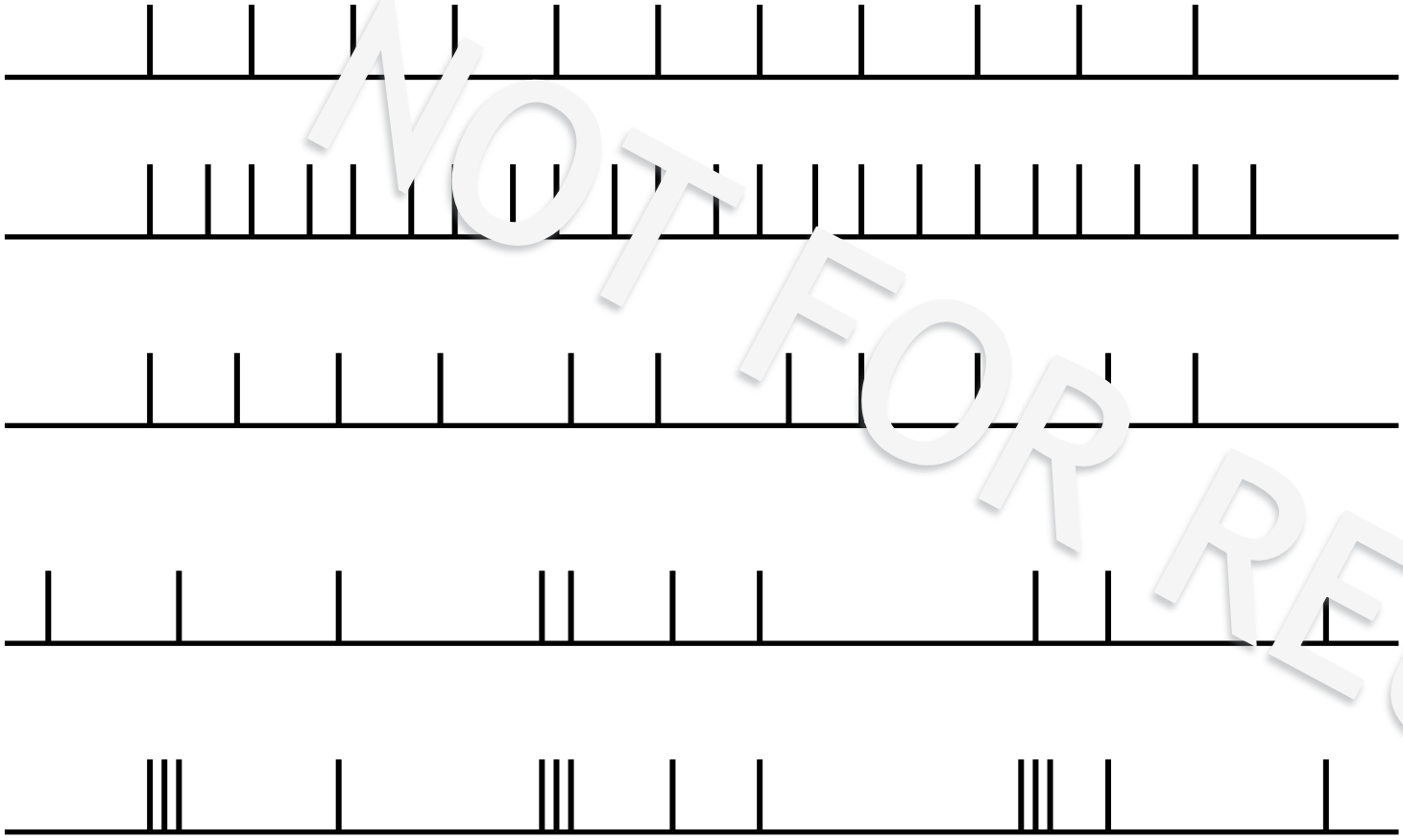
The electric personalities of neurons



NOT FOR RELEASE

Neuron, what are you trying to tell us?

We see that neurons can have a wide range of firing patterns, which come about partly because of the nature of their dynamics, and partly because of the nature of their inputs.



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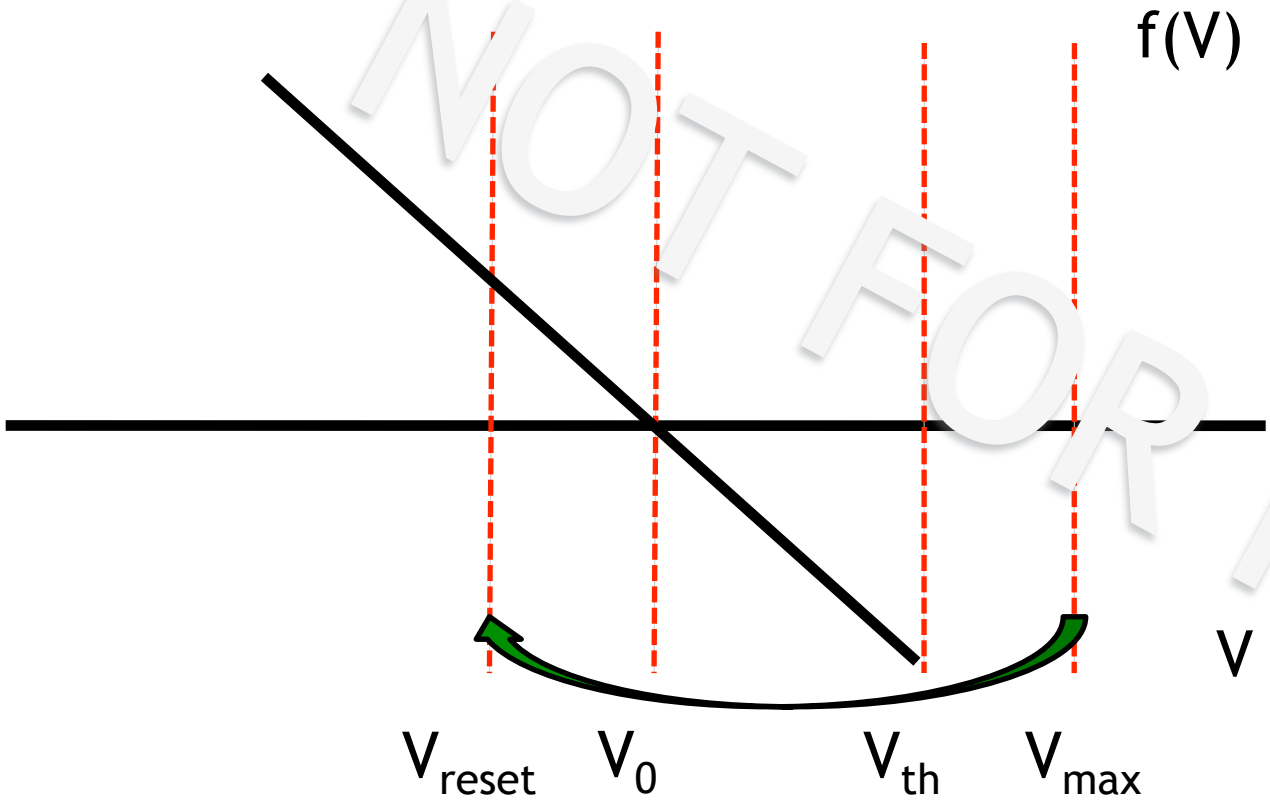
Capturing the basic dynamics of neurons

Capturing the basic dynamics of neurons



$$dV/dt = -(V-V_0) + I(t)$$

NOT FOR REUSE

The integrate-and-fire neuron

Like a passive membrane:

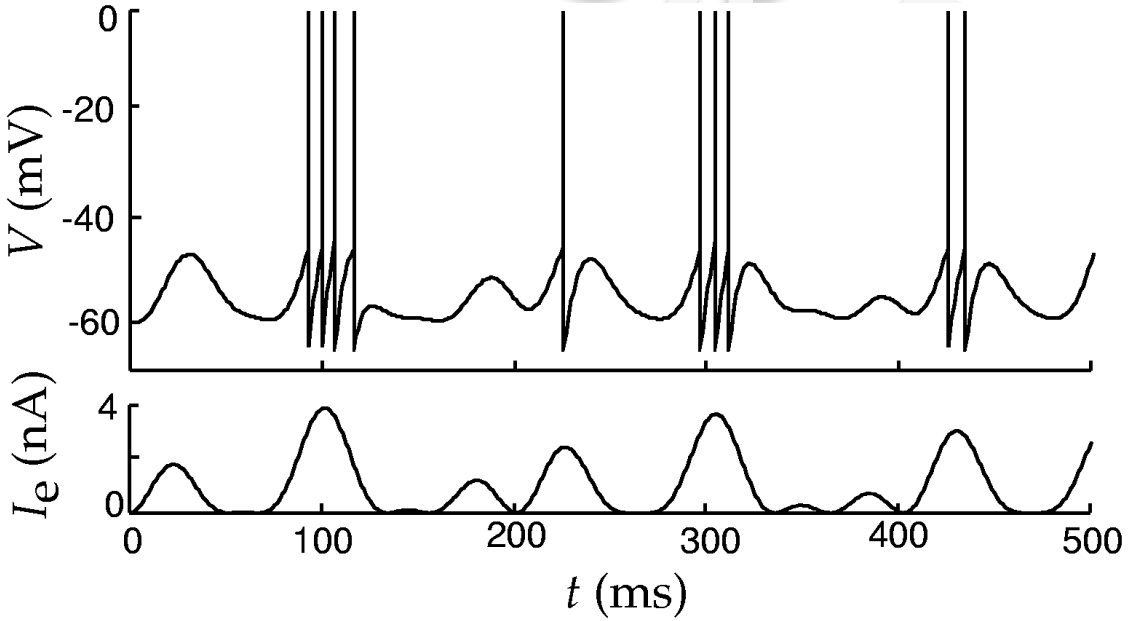
$$C_m \frac{dV}{dt} = -g_L(V - E_i) - I_e$$

but with the additional rule that

when $V \rightarrow V_T$, a spike is fired

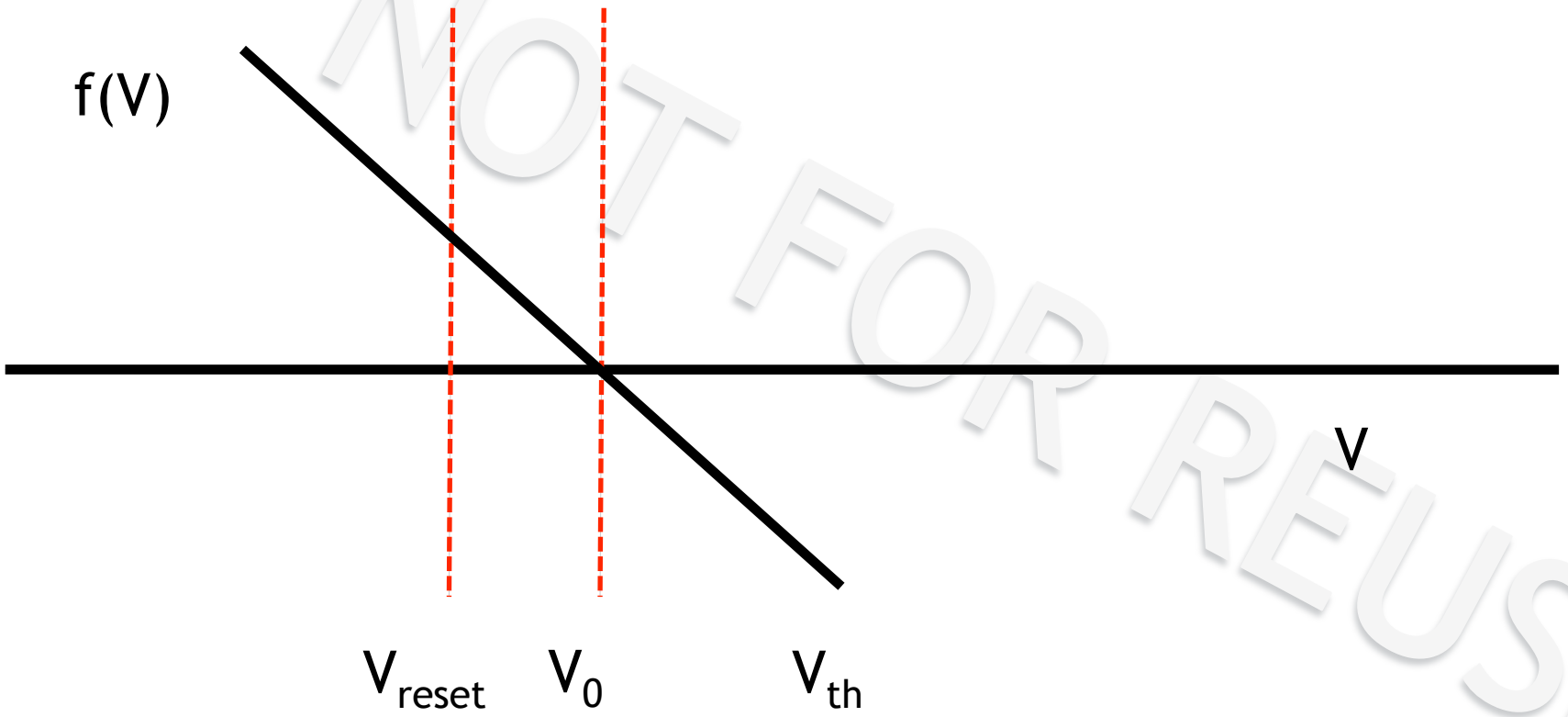
and $V \rightarrow V_{reset}$.

E_L is the resting potential of the "cell".



NOT FOR DISTRIBUTION

How do we make it excitable?

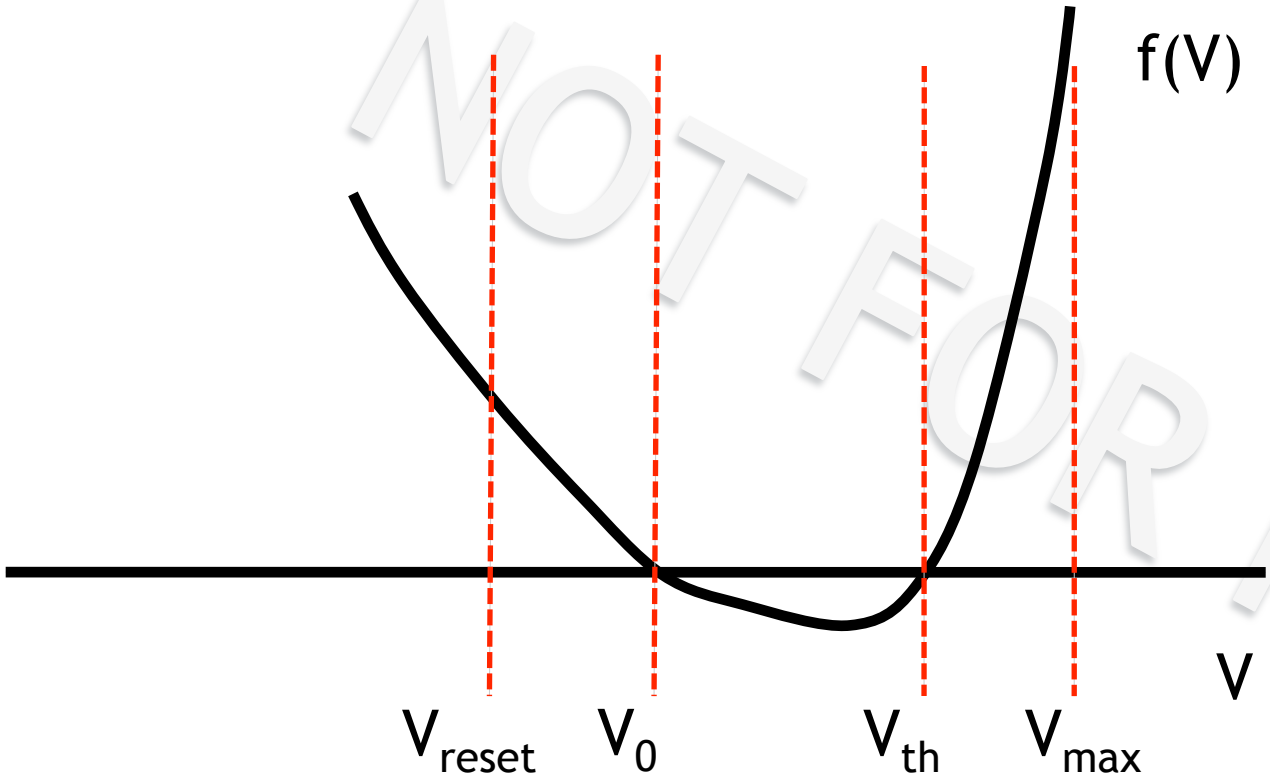


NOT FOR REUSE

这里我们需要借助 “ 外力 ” 让他们firing and resting
我们需要找到一个数学公式内在地刻画，不需要外力

$$dV/dt = -a(V-V_0) + I(t)$$

Capturing the basic dynamics of neurons



quad

$$dV/dt = f(V) + I(t)$$

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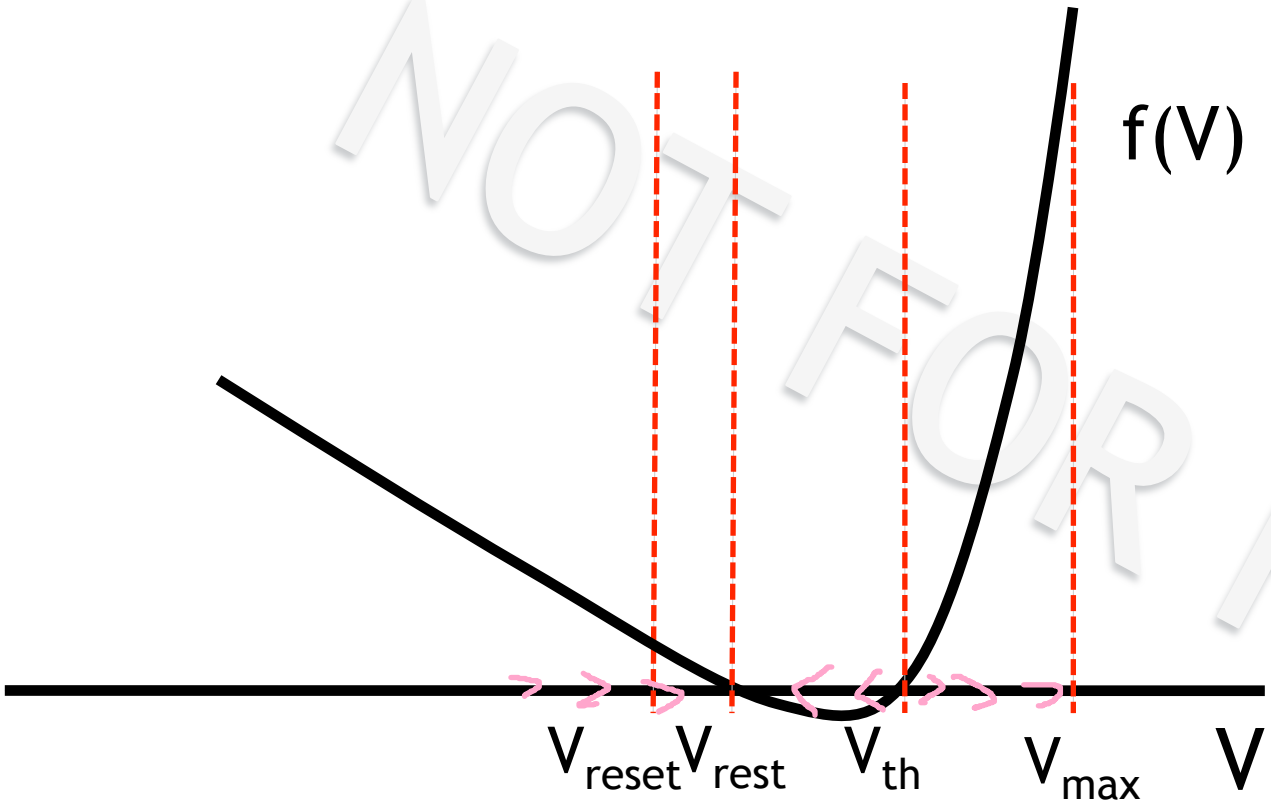
Exponential integrate-and-fire neuron



$$f(V) = -a(V-V_0) + \exp([V-V_{th}]/\Delta)$$

这个是负数的时候，这一项很小，因此对
前一项的影响很小，所以前面还是linear的

Fourcaud-Trocmé, Hansel, van Vreeswijk and Brunel.

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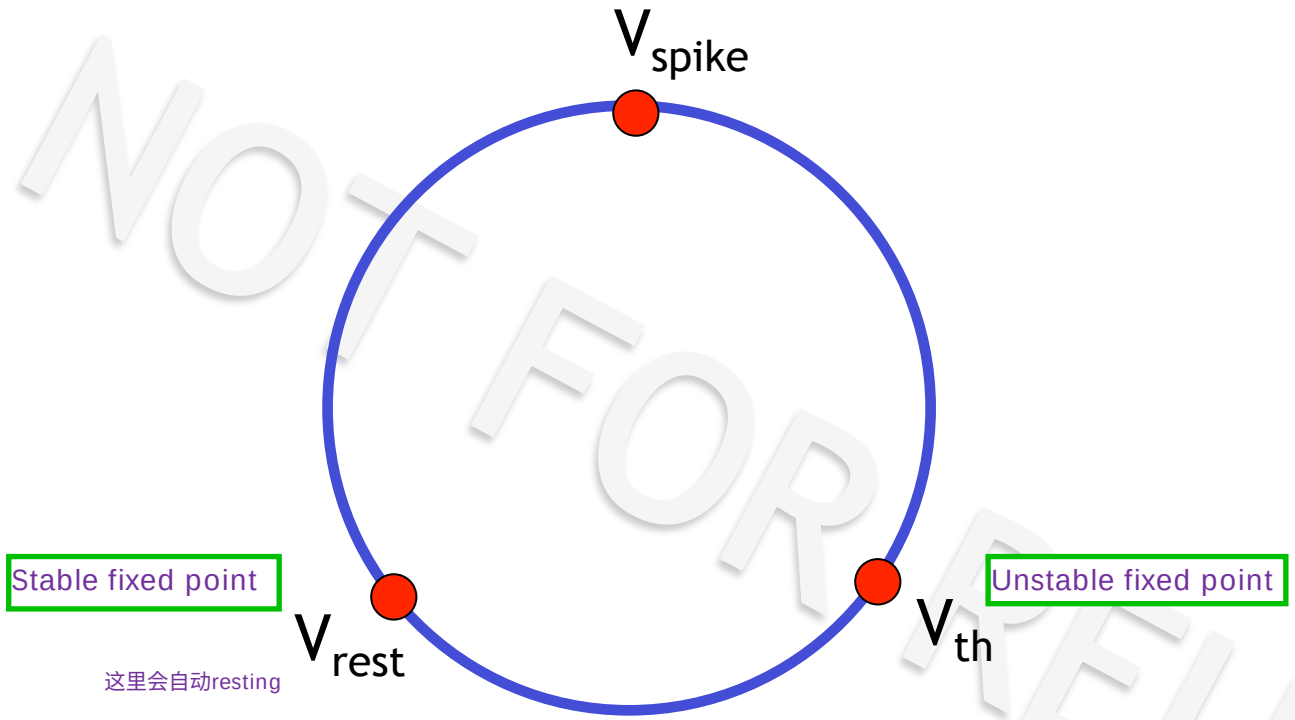
The theta neuron

phase coding



即使没有input，还是能一直firing，它们会一直振荡。因此通常用这样的模型来刻画周期性地firing的神经元。

$$d\theta/dt = 1 - \cos\theta + (1+\cos\theta)\, I(t)$$

Ermentrout and Kopell

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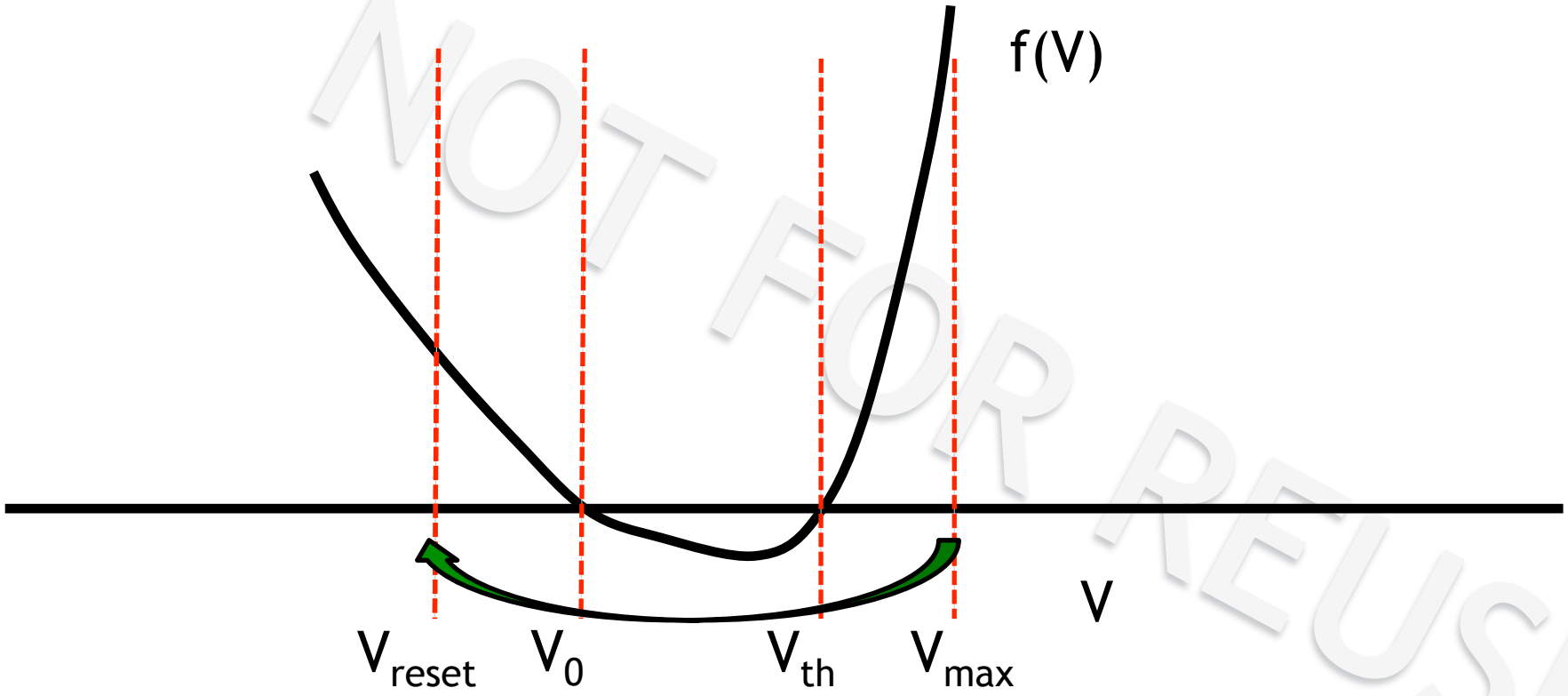
Capturing the basic dynamics of neurons



$$dV/dt = f(V) + I(t)$$

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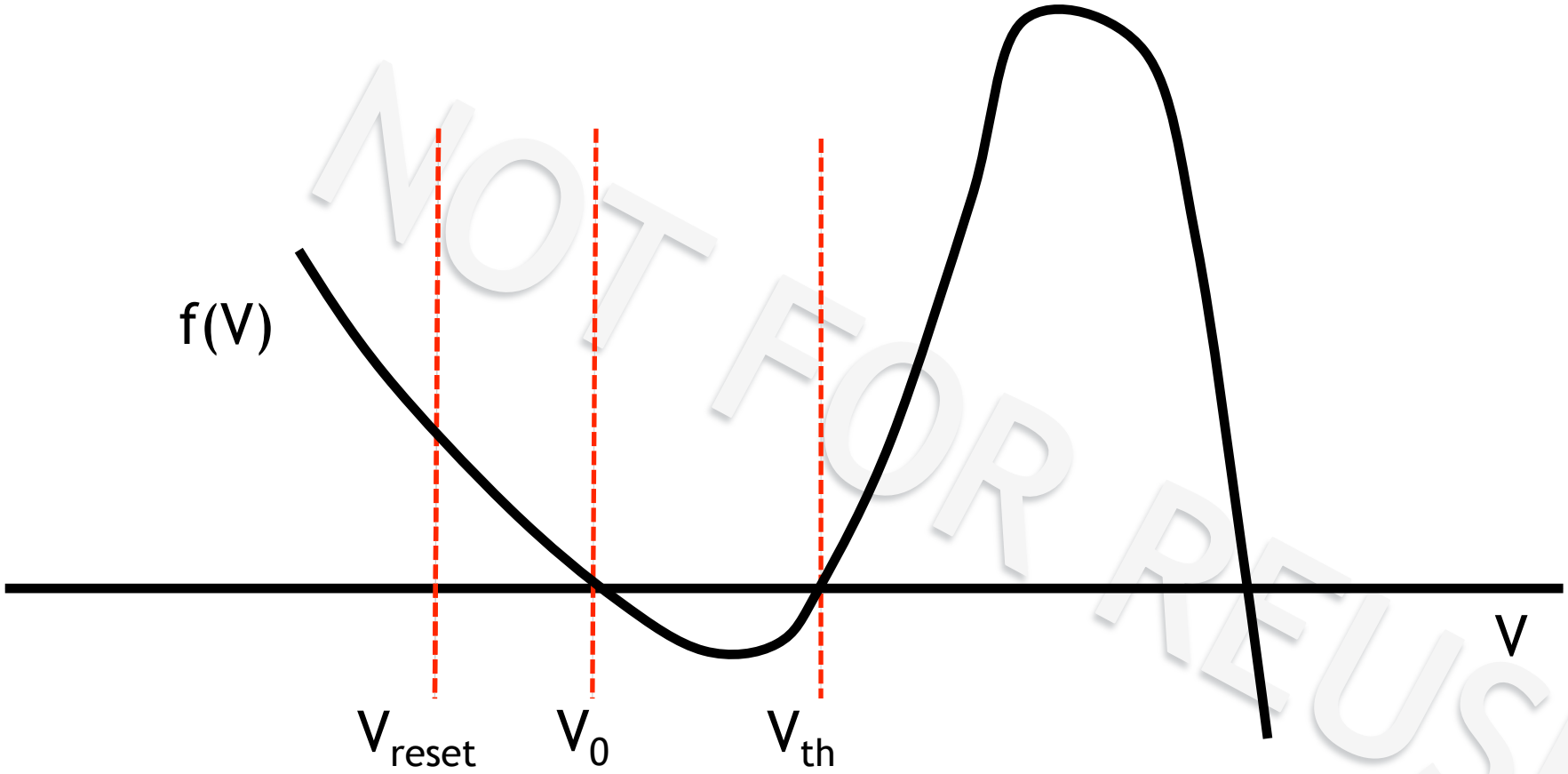
Capturing the basic dynamics of neurons



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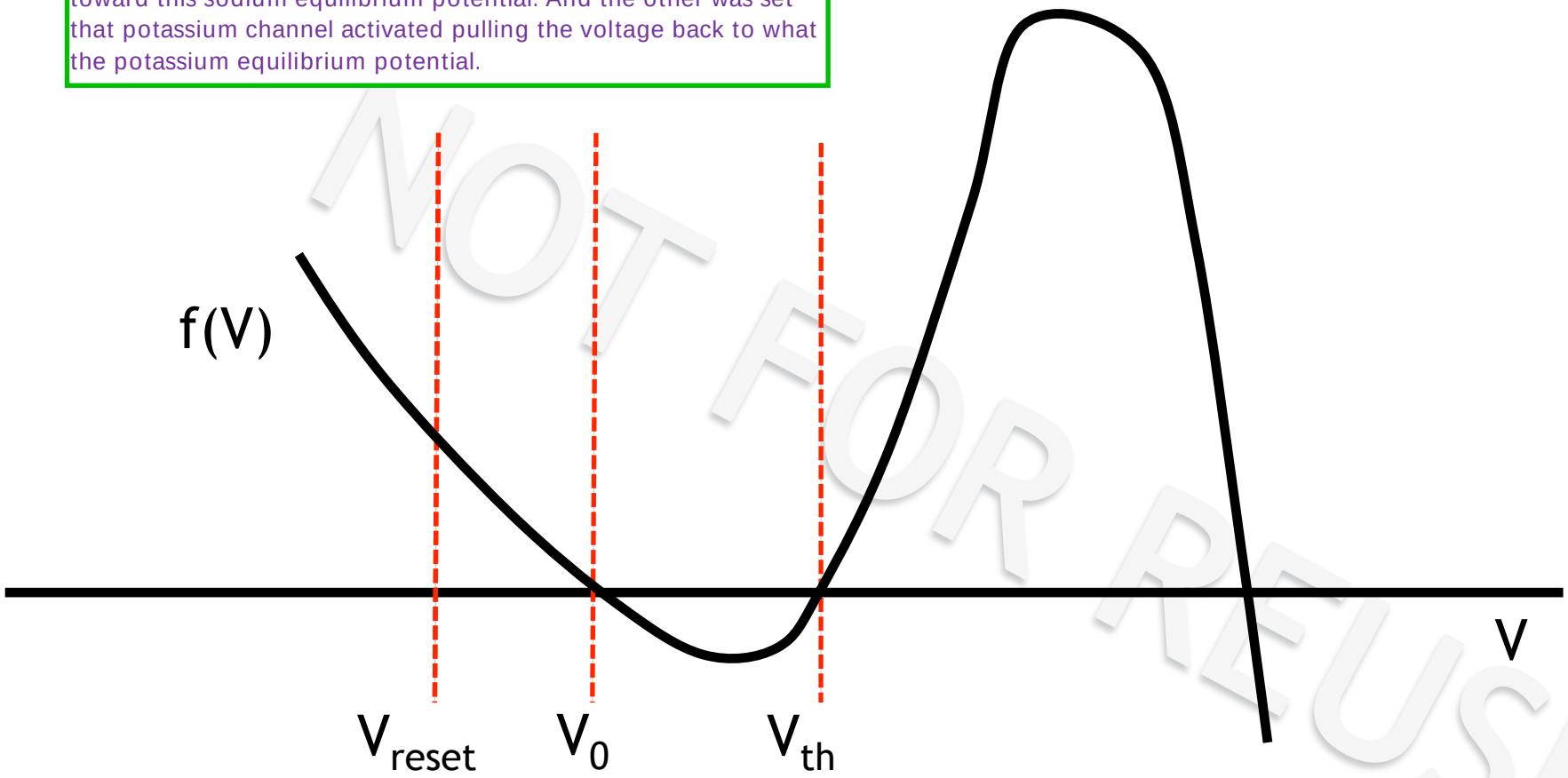
防止到infinity
但是他回不来，是一个bistable system

Capturing the basic dynamics of neurons

回忆：用两个方程，One was that the sodium, switching of the drive toward this sodium equilibrium potential. And the other was set that potassium channel activated pulling the voltage back to what the potassium equilibrium potential.



NOT FOR REUSE

G(u)是抑制项，u变大，G(u)就是一个很大的负数。

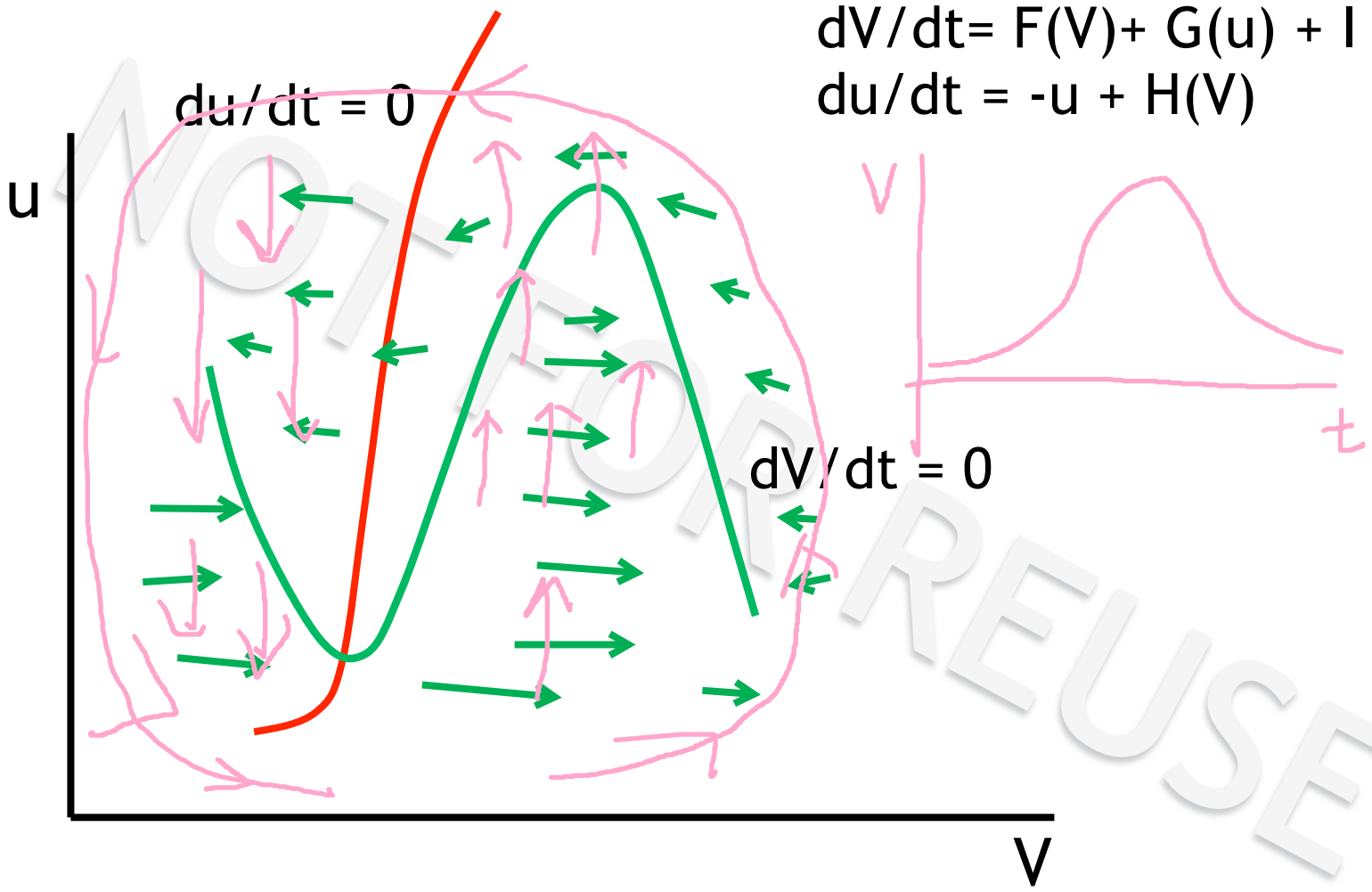
$$dV/dt = f(V) + I(t) \rightarrow$$

$$dV/dt = F(V) + G(u) + I(t)$$

$$du/dt = -u + H(V)$$

V变大，u也变大

Two-dimensional models



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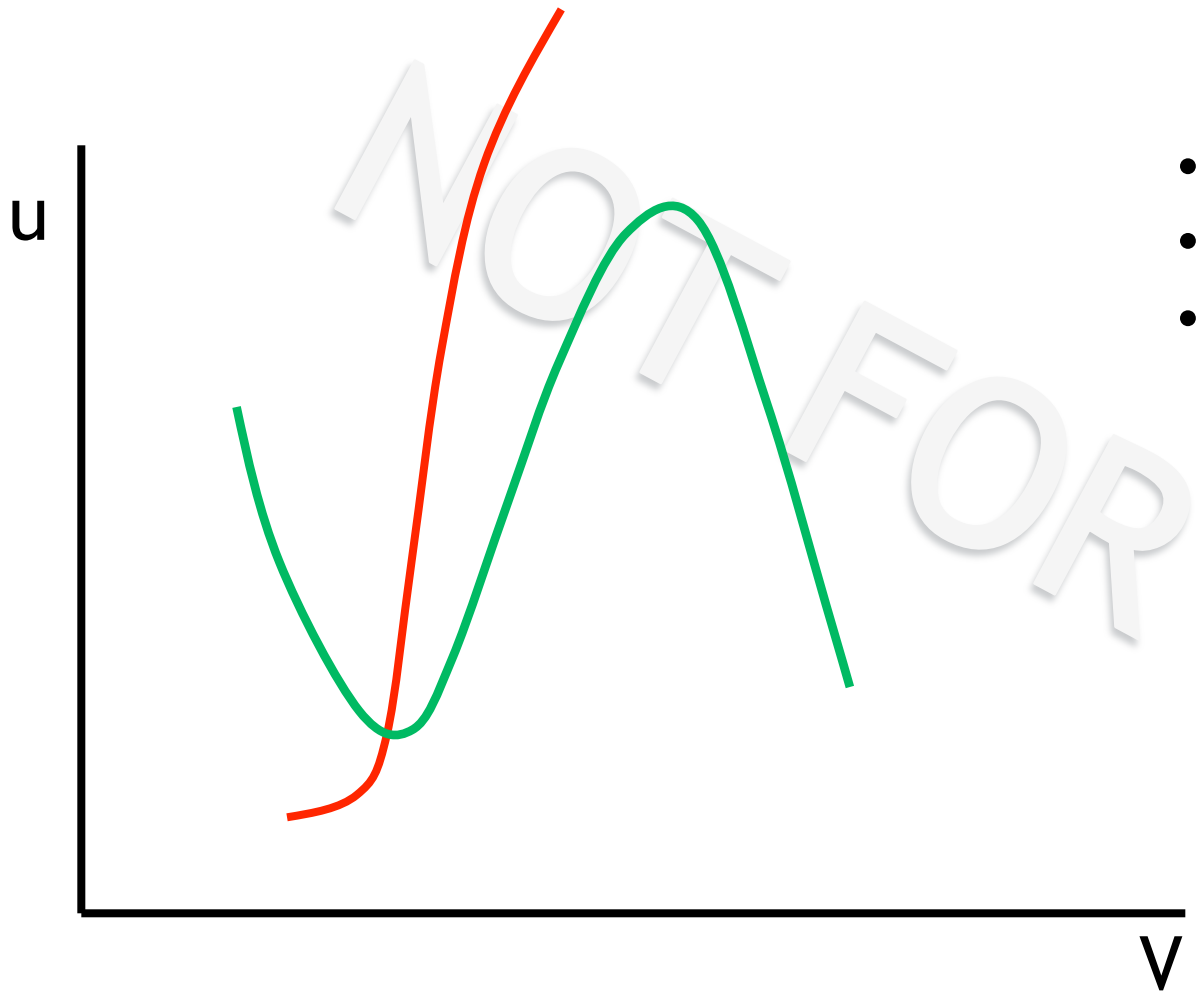
On-line resources about phase plane analysis



- Wulfram Gerstner
- Bard Ermentrout
- Scholarpedia

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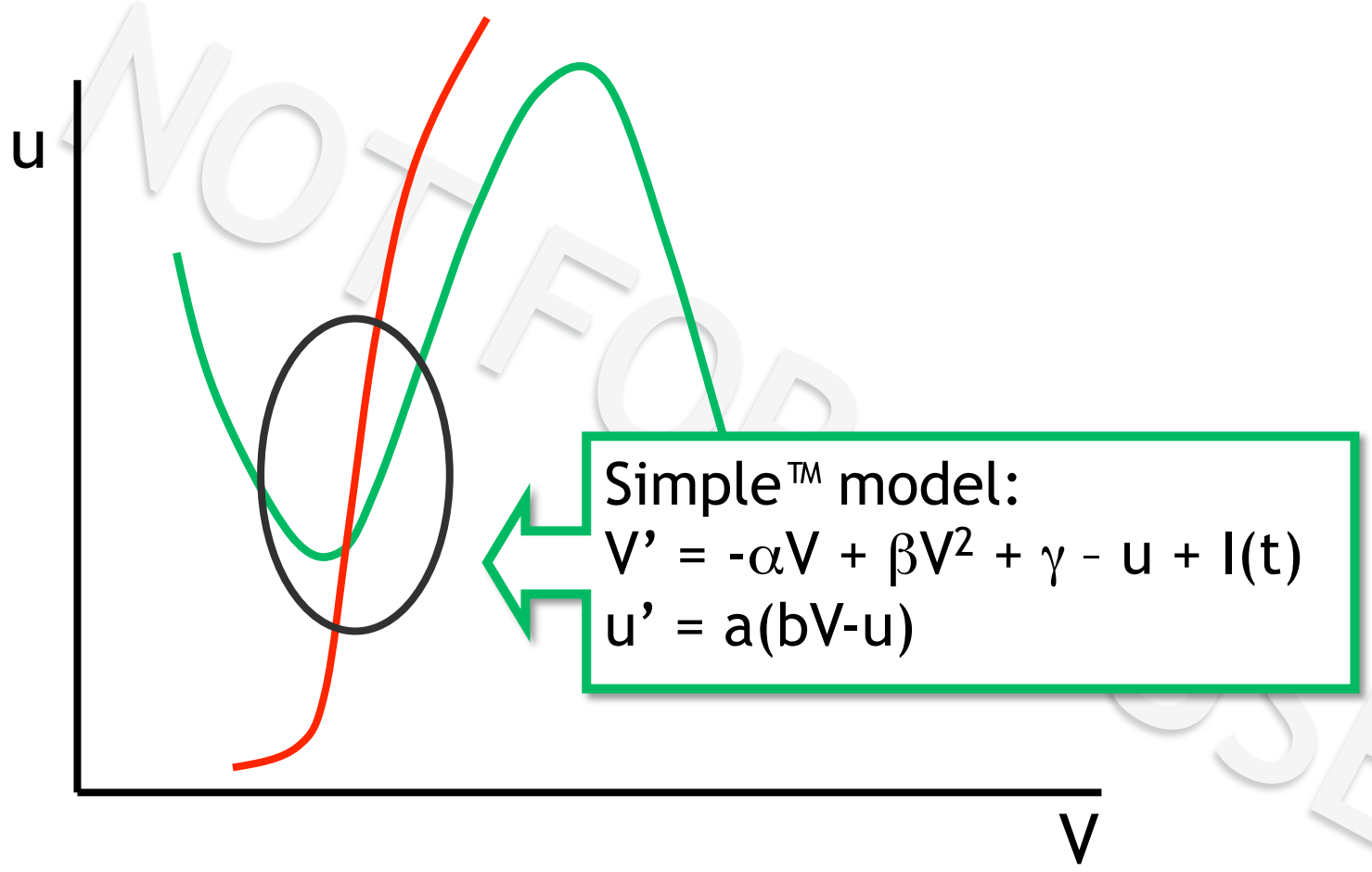
Two-dimensional models

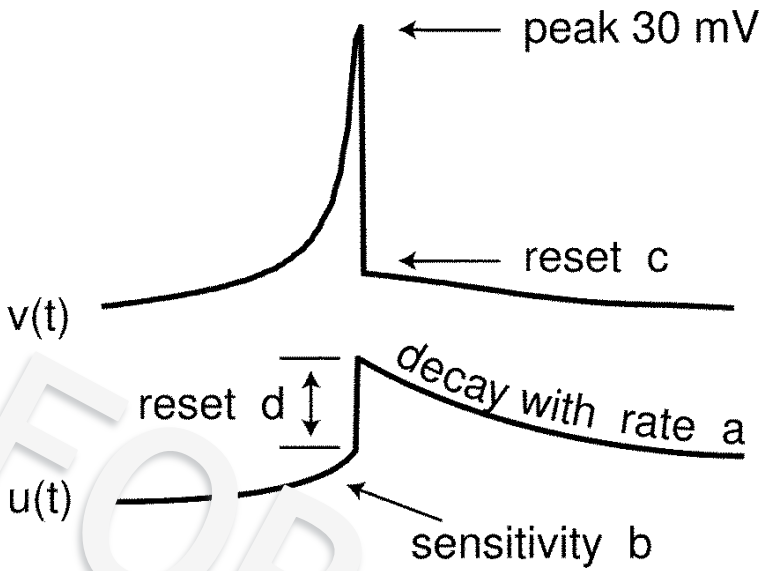


NOT FOR USE

The simple model

$$v' = 0.04v^2 + 5v + 140 - u + I$$
$$u' = a(bv - u)$$

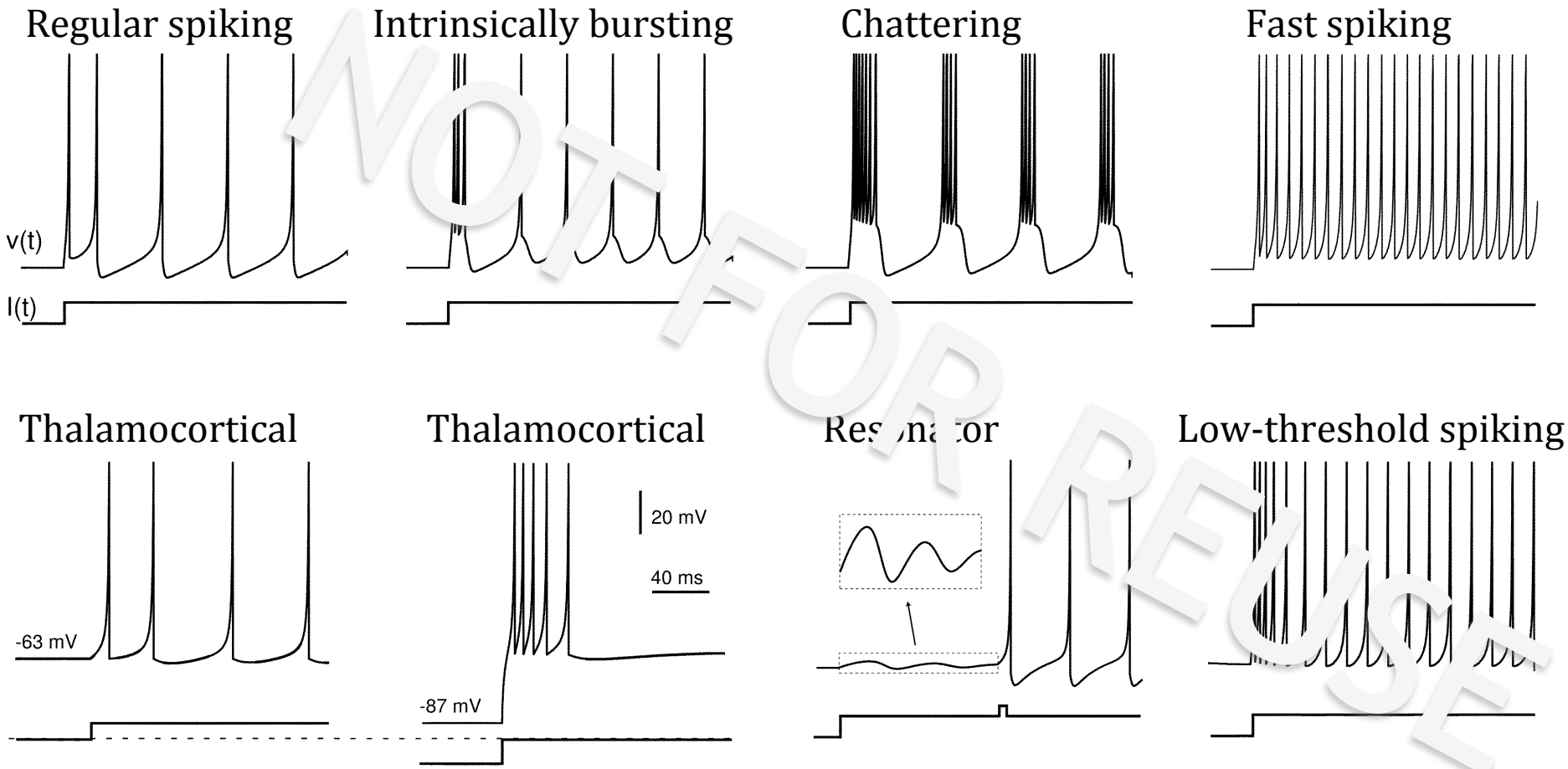
if $v = 30$ mV,
then $v \leftarrow c$, $u \leftarrow u + d$



NOT FOR REUSE

The simple model

用4个参数做出来的模型



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Where to from here?