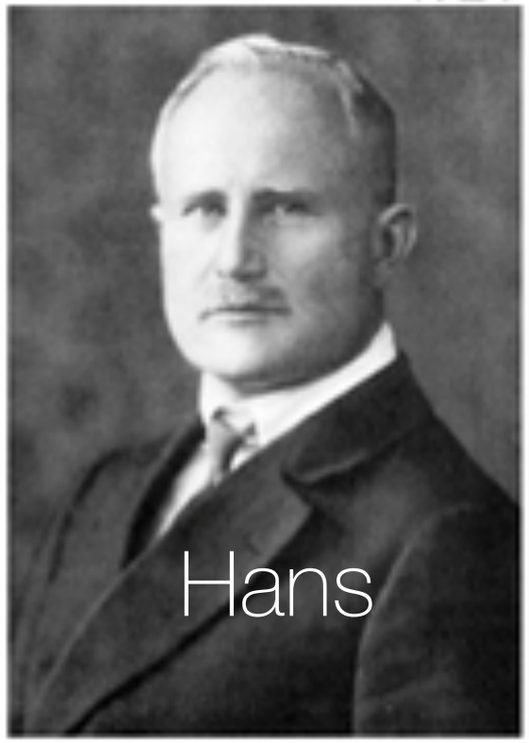
Build your own brainwaves.

Erik Peterson

robotpuggle.com

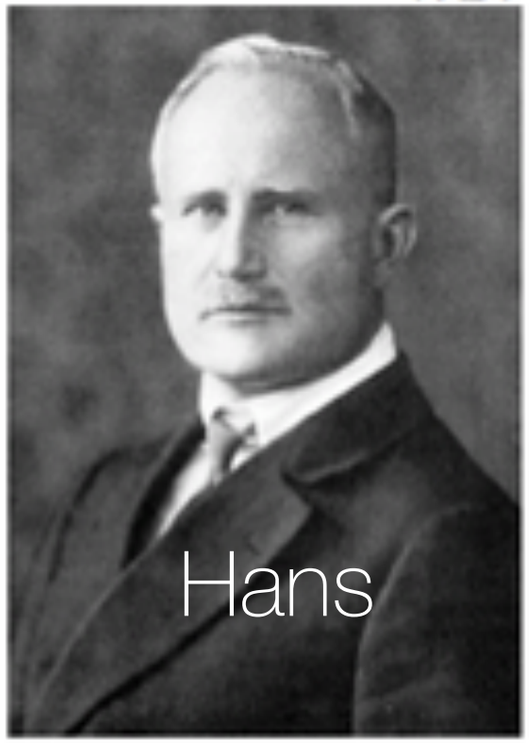
1924



Hans

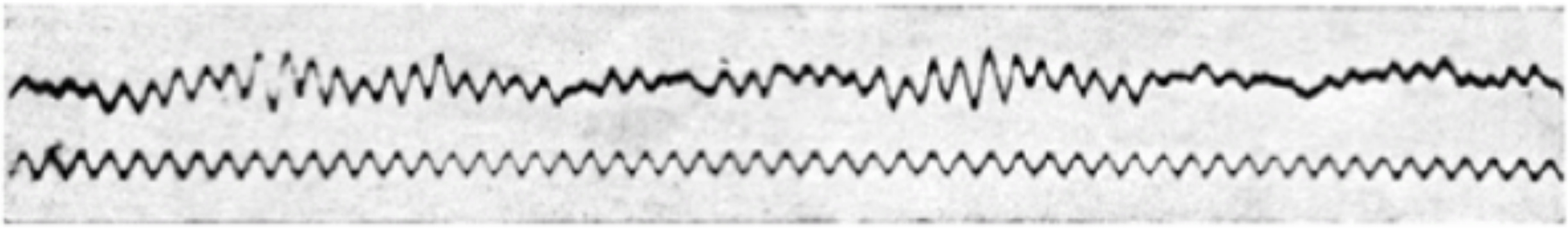
His son

1924

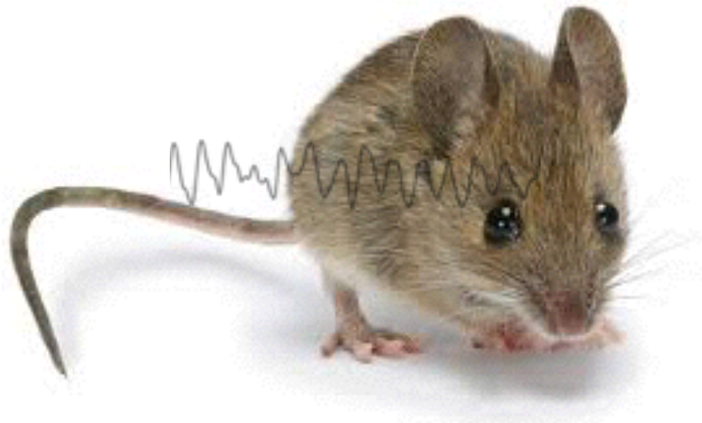


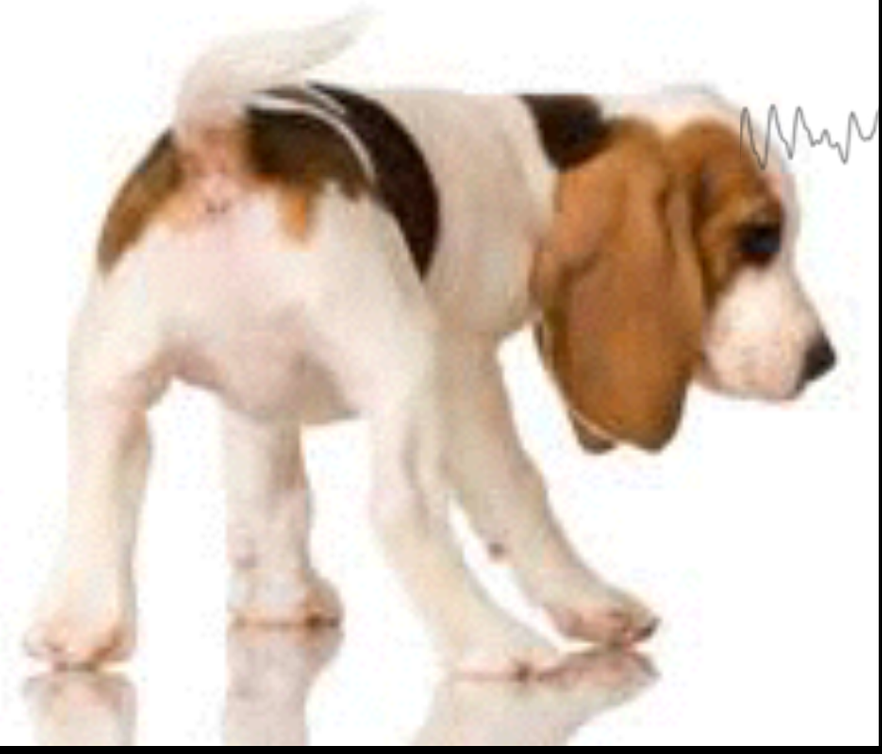
Hans

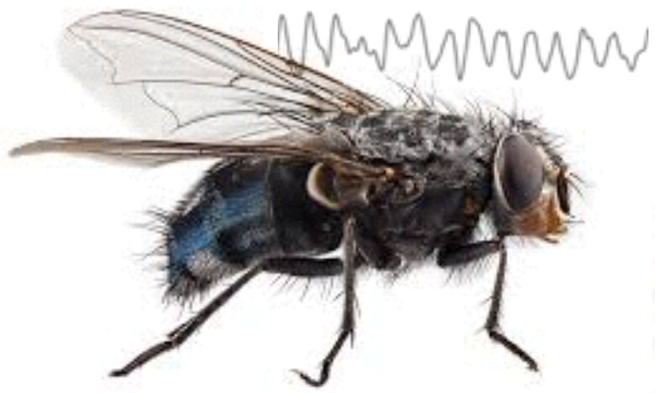
His son

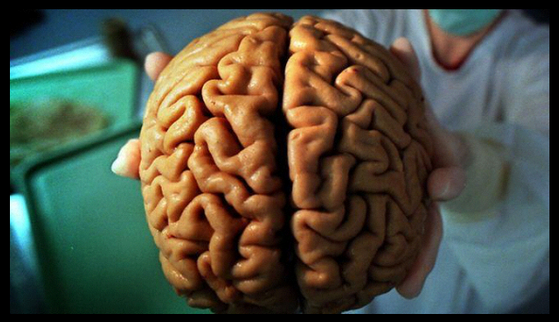


PATRICK SWAYZE
KEANU REEVES









(neuron)

~86 billion neurons

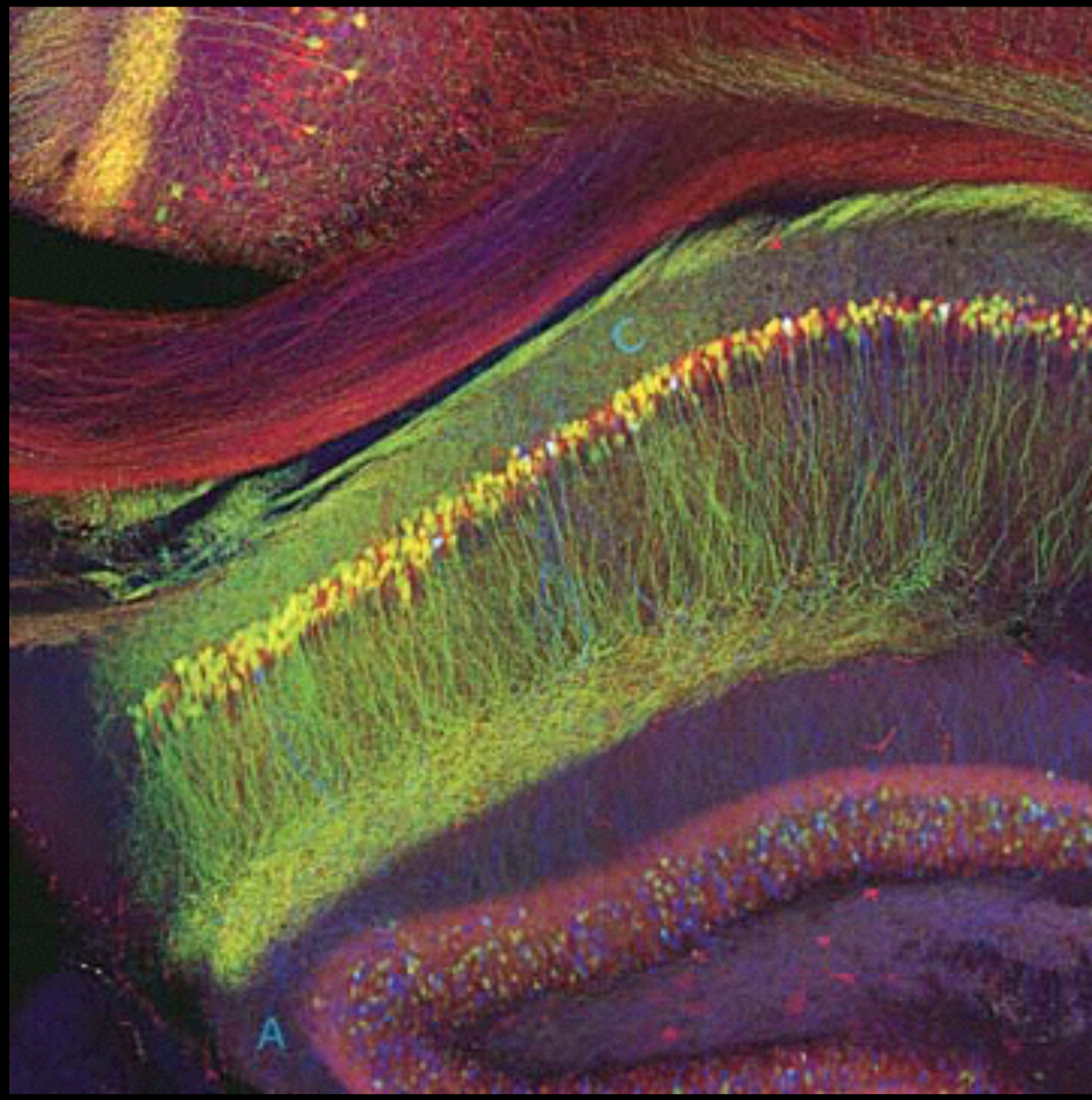
> 100 types

Trillions of connections

~86 billion neurons

> 100 types

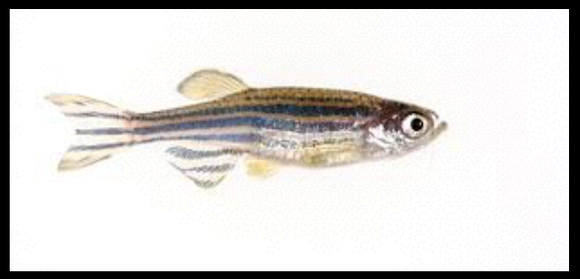
Trillions of connections

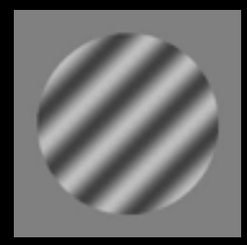


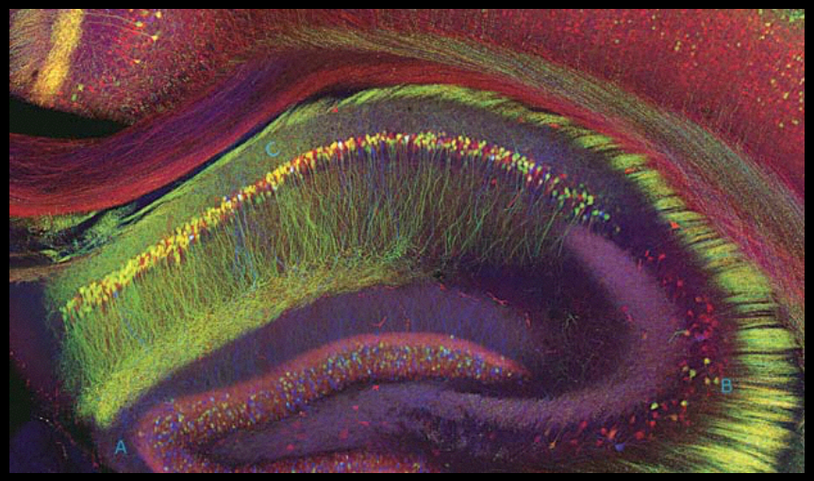
dorsal view
386.698 s

dF/F
1
0

100 µm







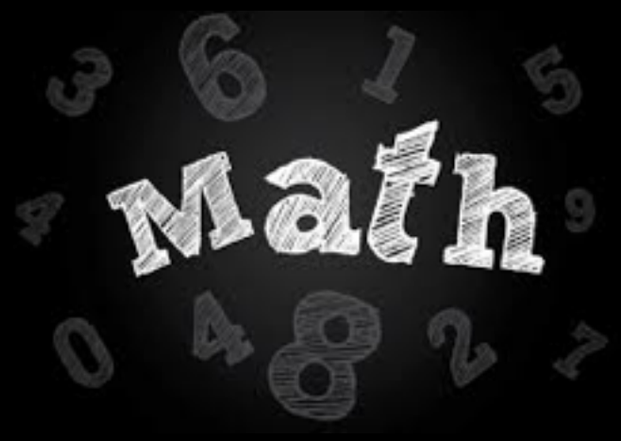
BUILD YOUR OWN BRAINWAVES?

Math

Implementation

"Dynamical systems are fun!"

–Me


Math

$\{ + - * \}$

{ + - * }

&

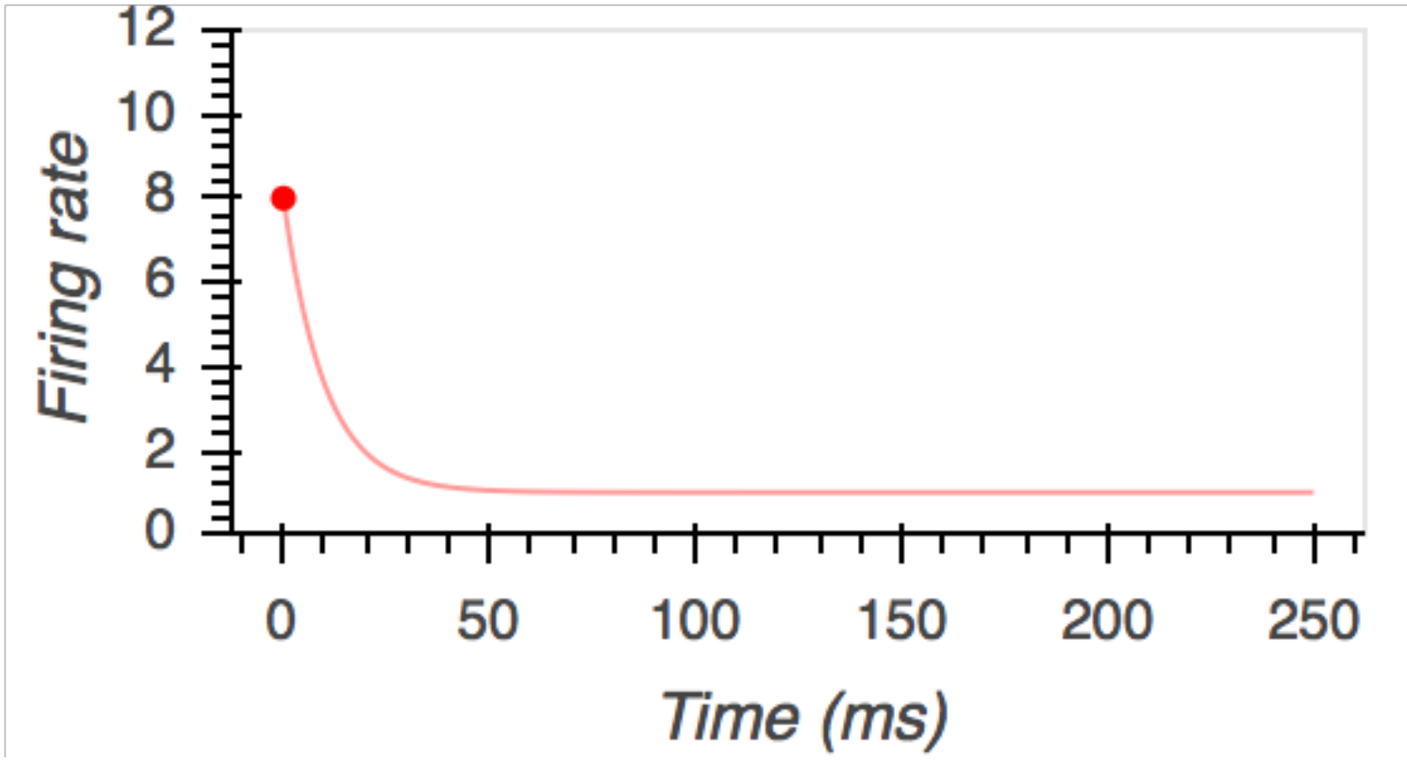
E(x)

Our 1st function.

(A differential equation)

E

E



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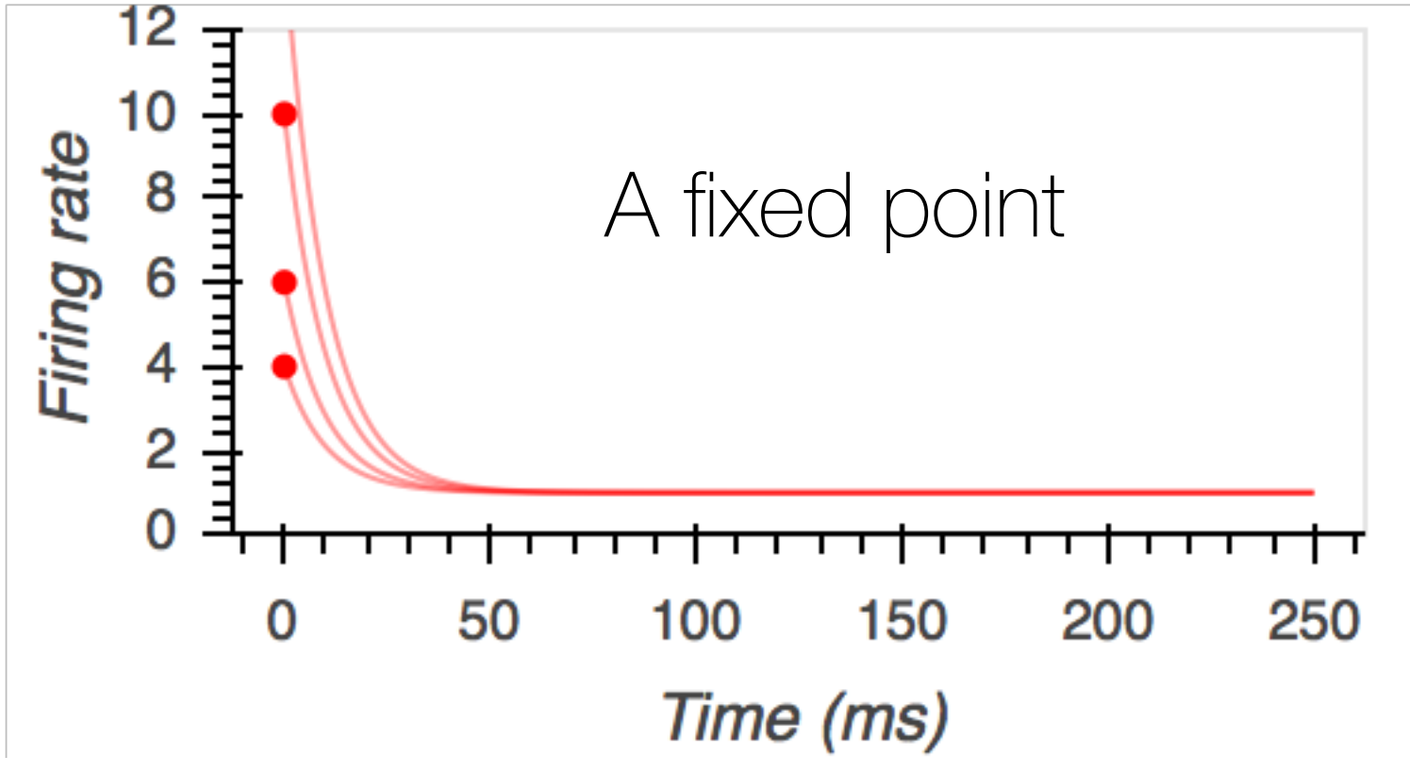
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Firing rate
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10
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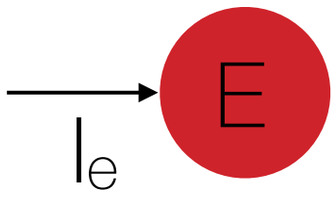
250
Time (ms)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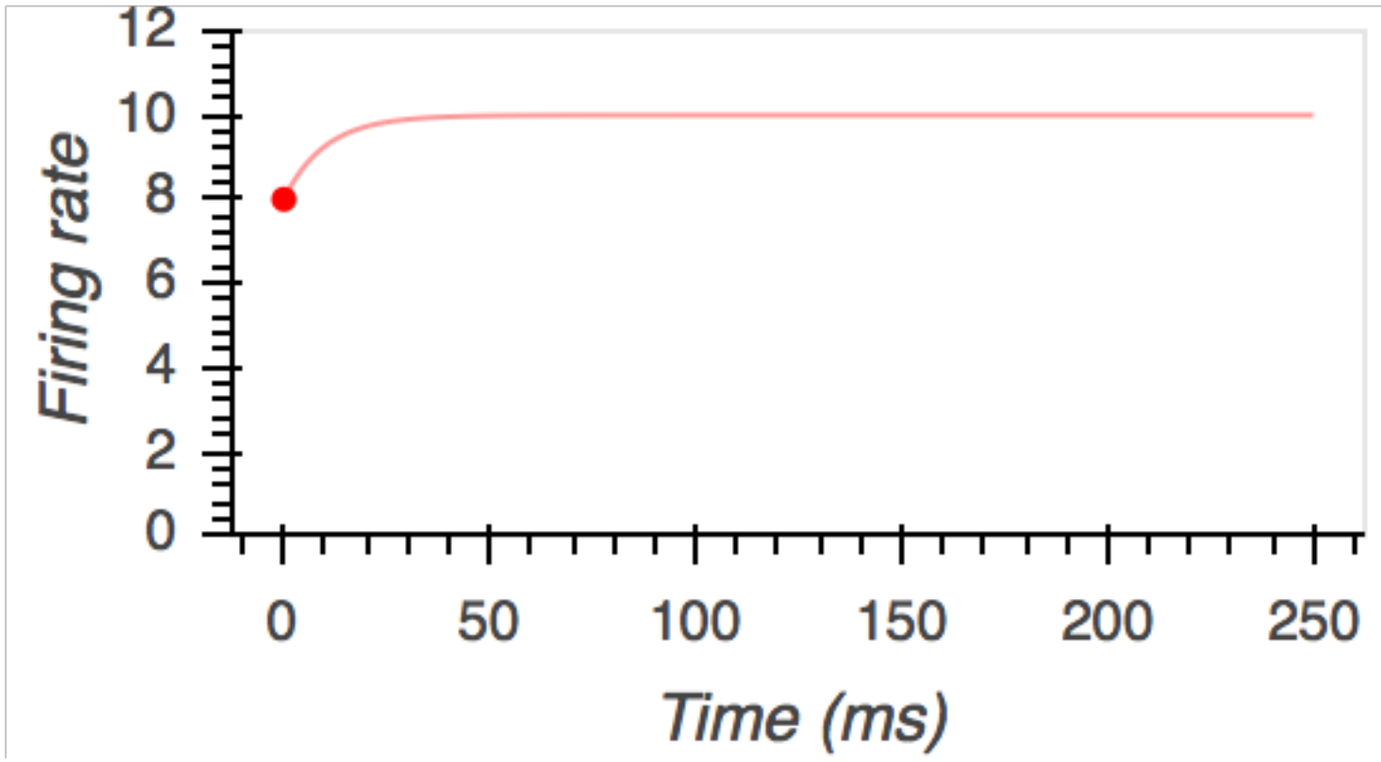
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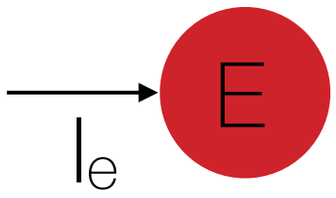
Time (ms)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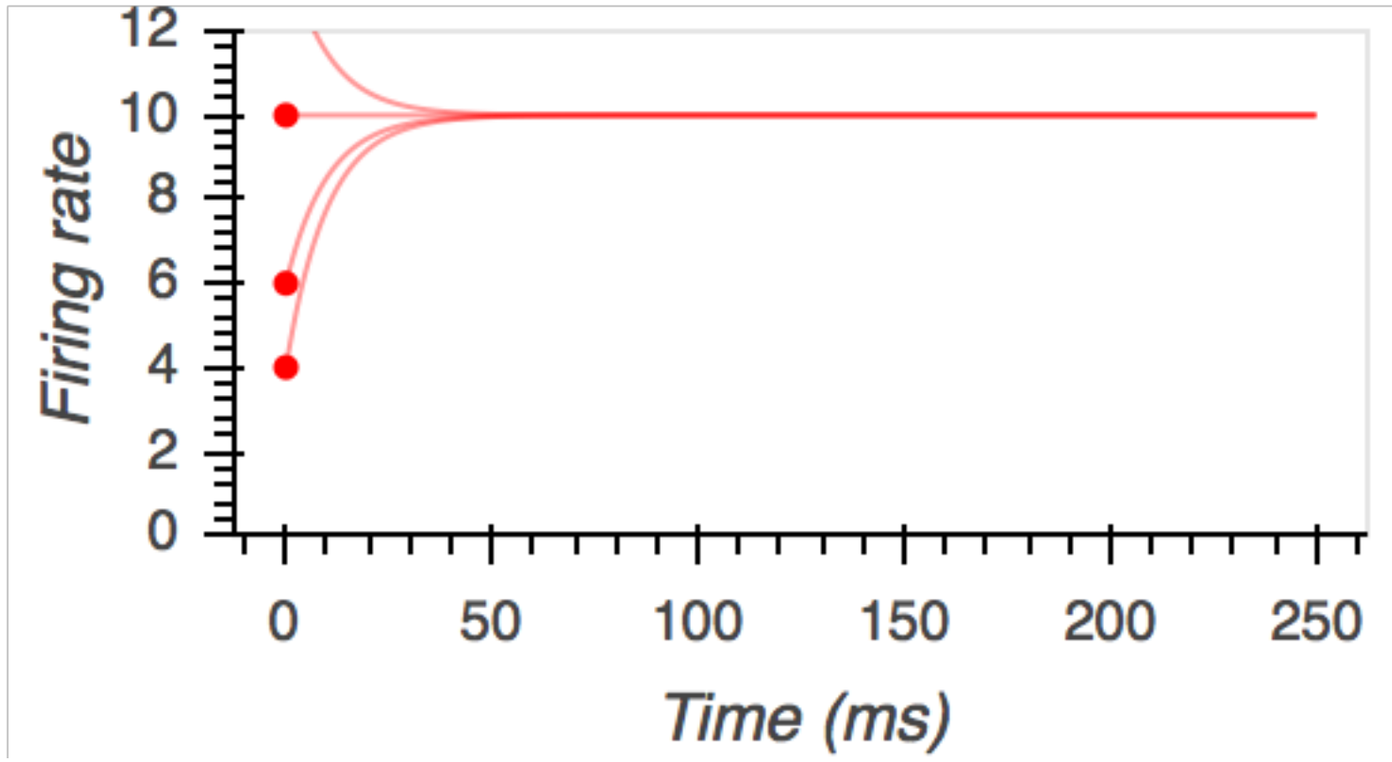
Firing rate
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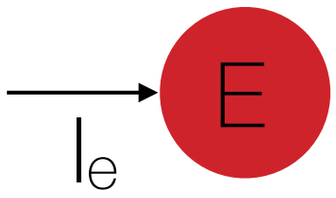
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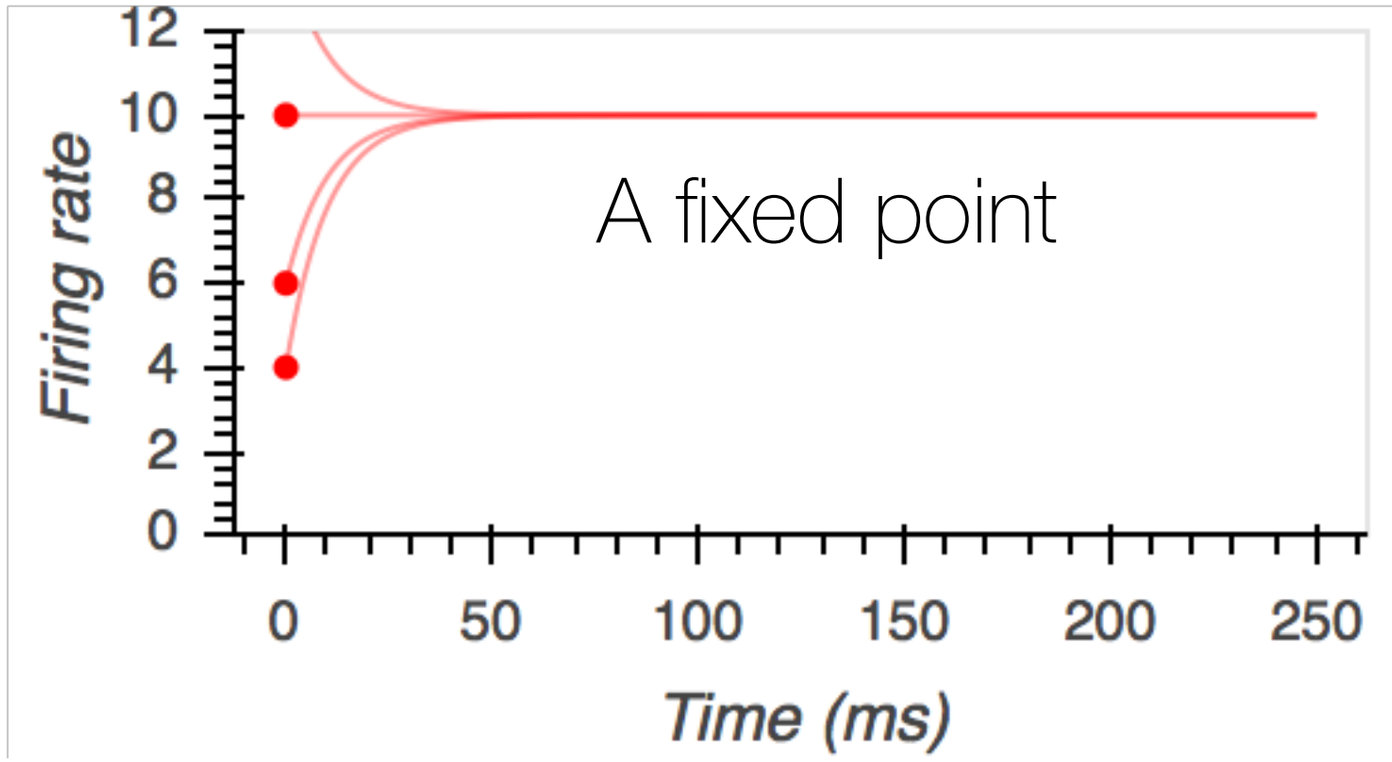
A fixed point
Firing rate
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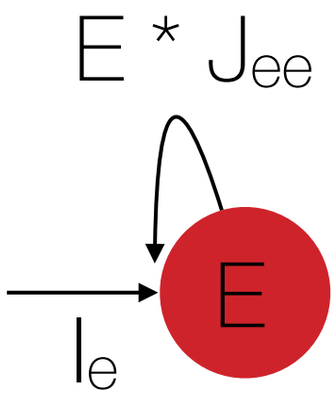
Time (ms)


E * Jee
E
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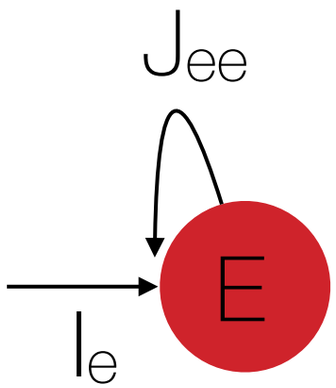
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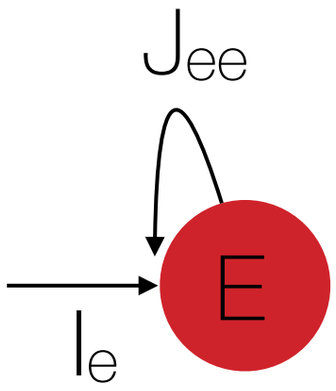
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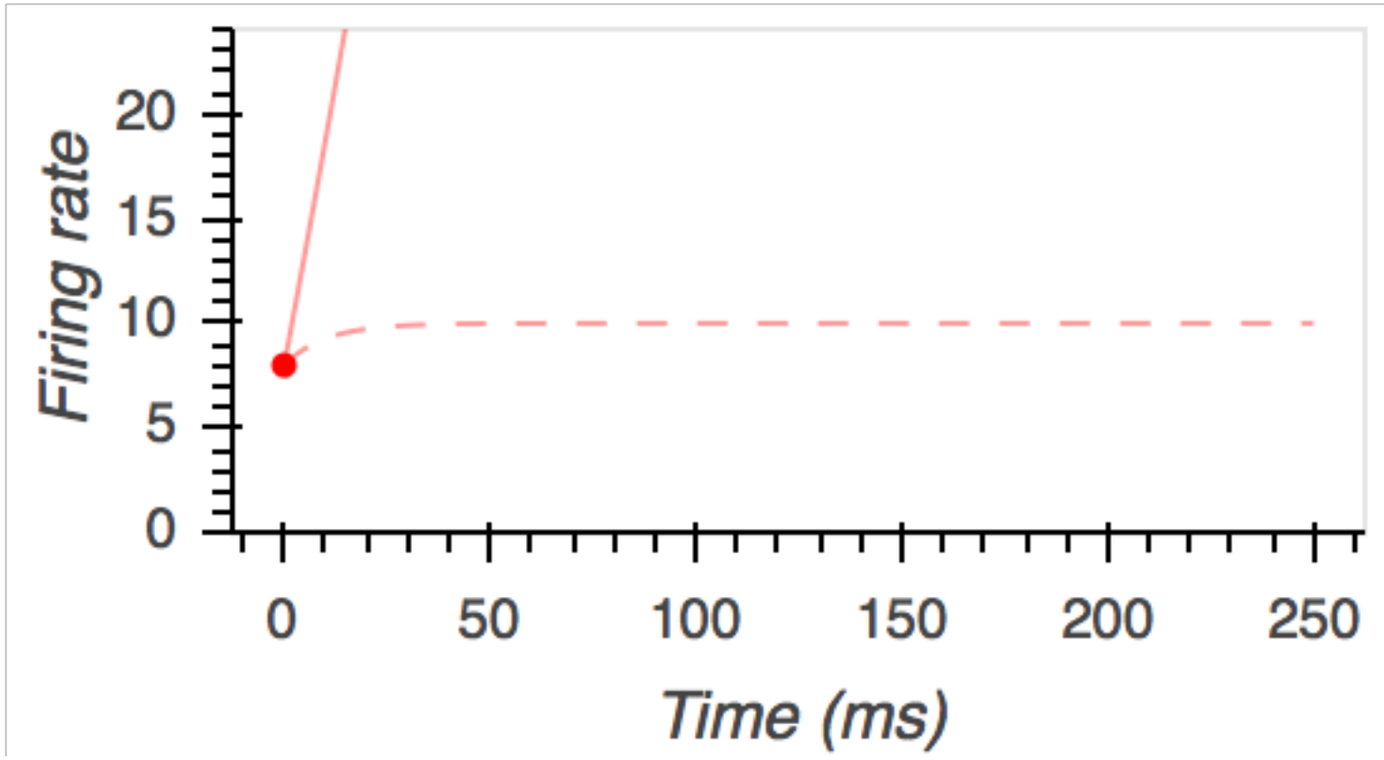
Firing rate
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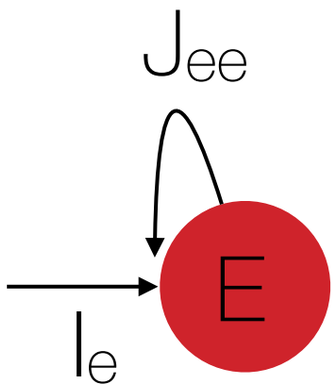
Time (ms)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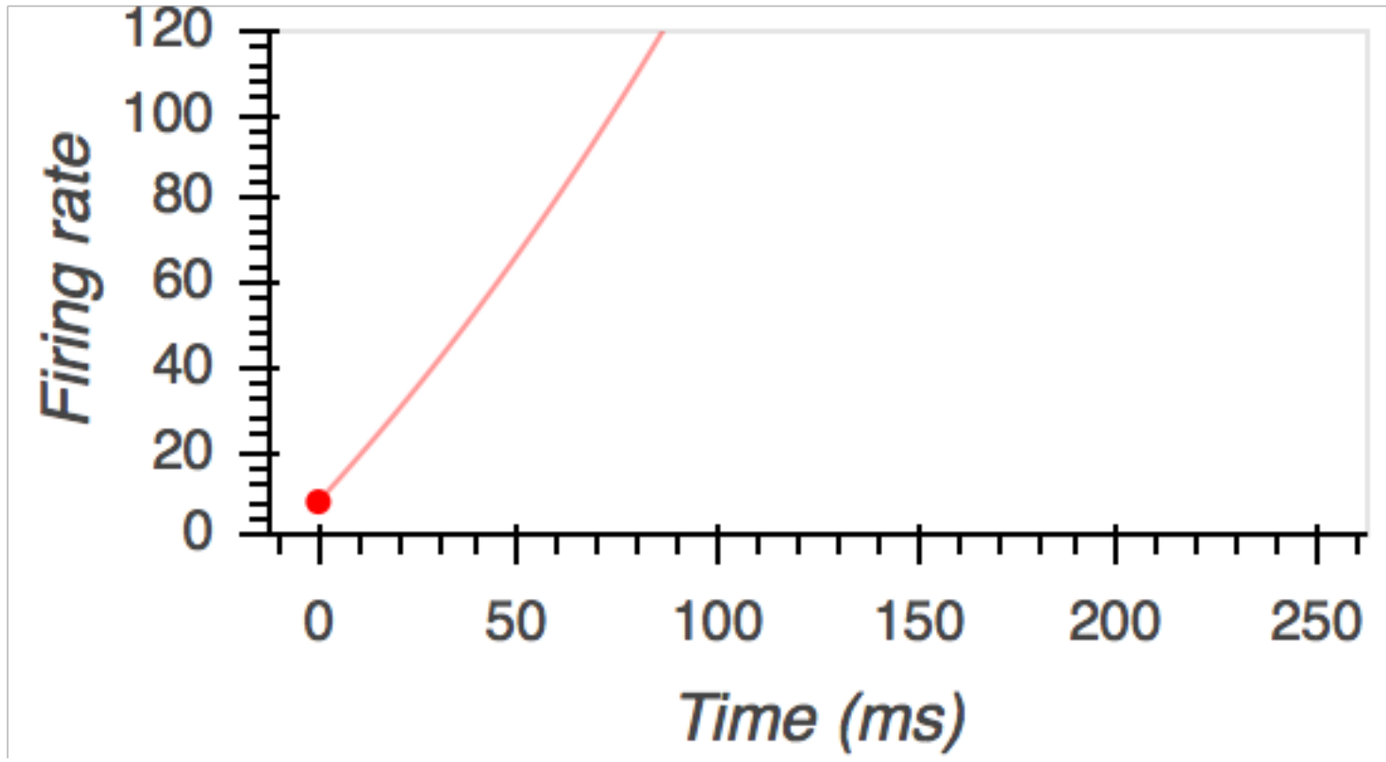
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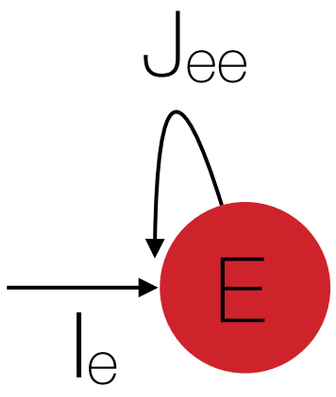
Time (ms)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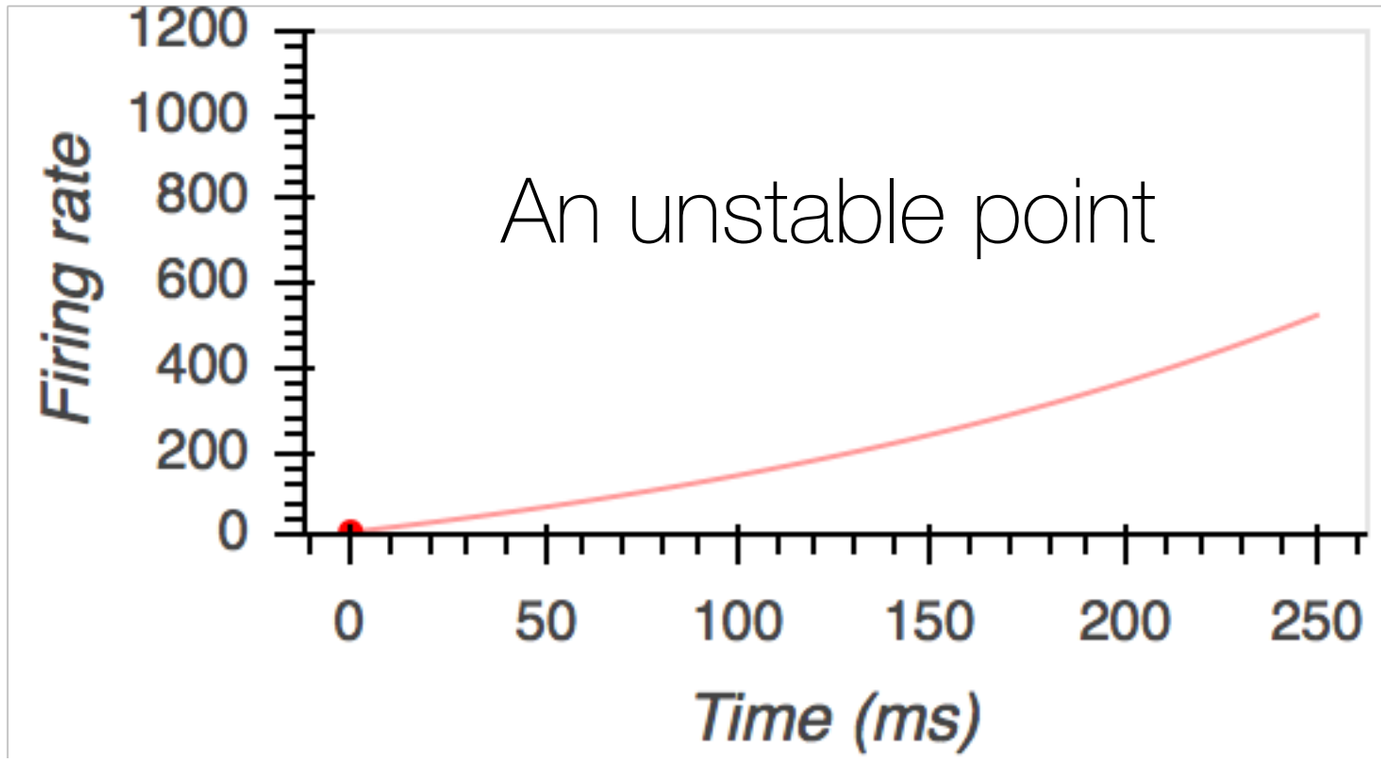
An unstable point
Firing rate
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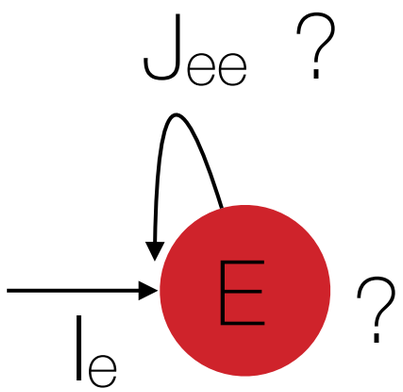
Time (ms)


J_{ee} ?
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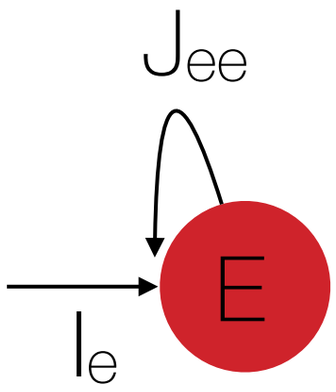
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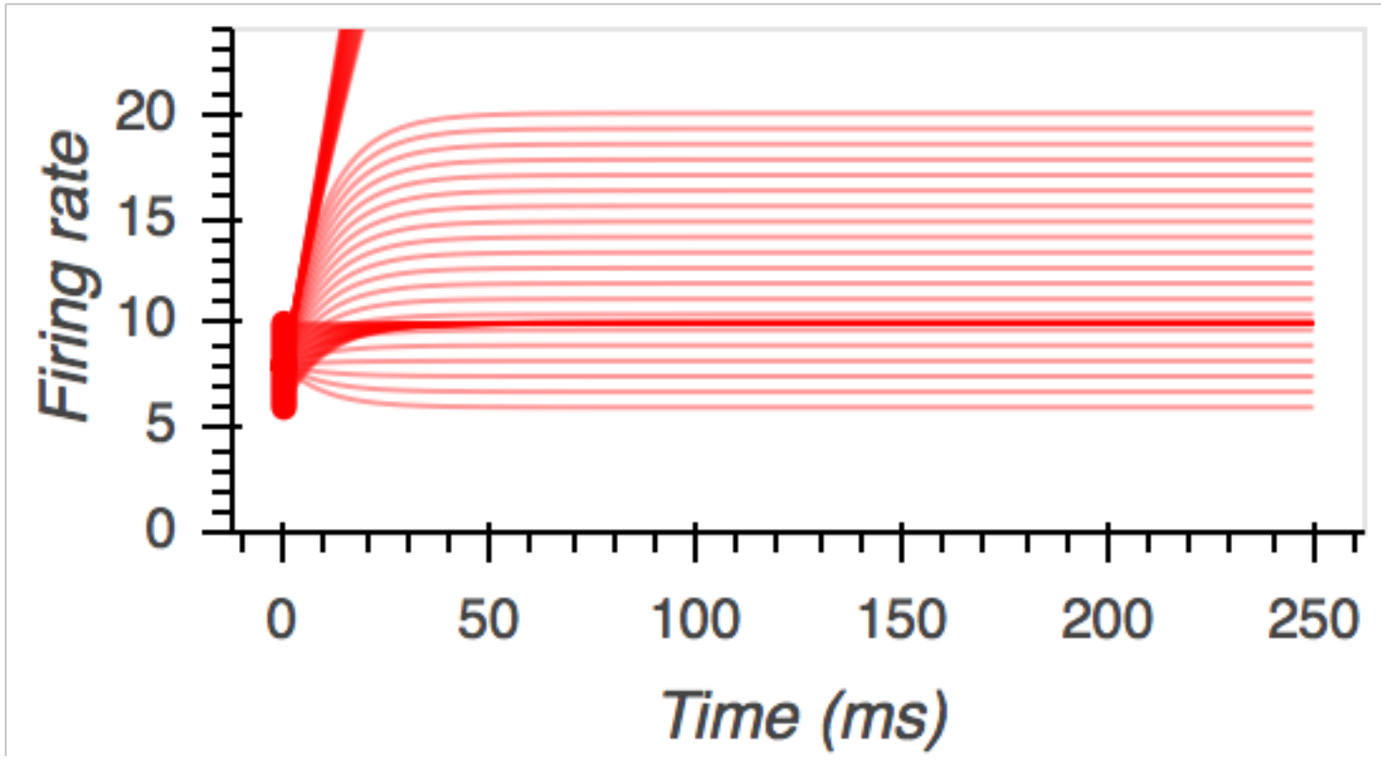
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Time (ms)

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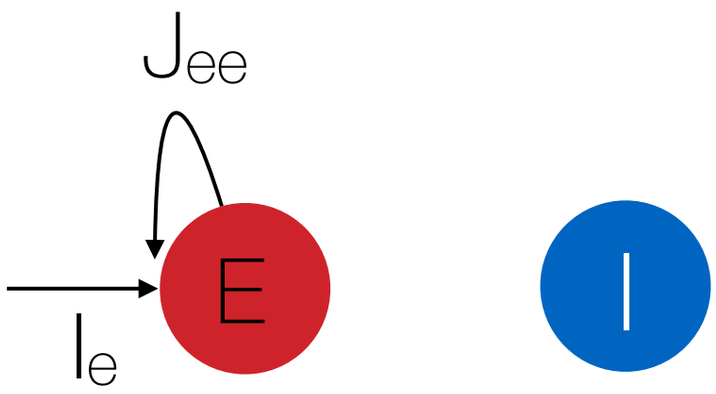
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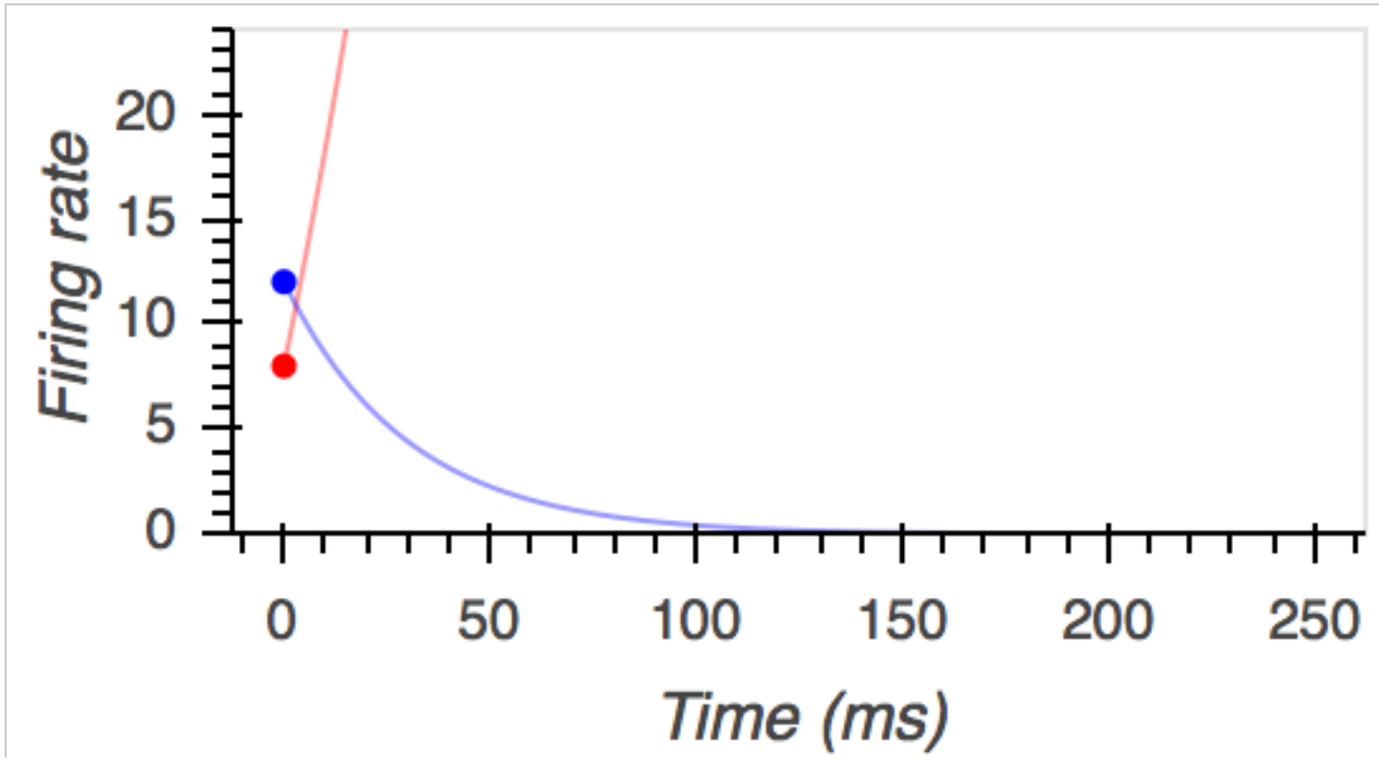
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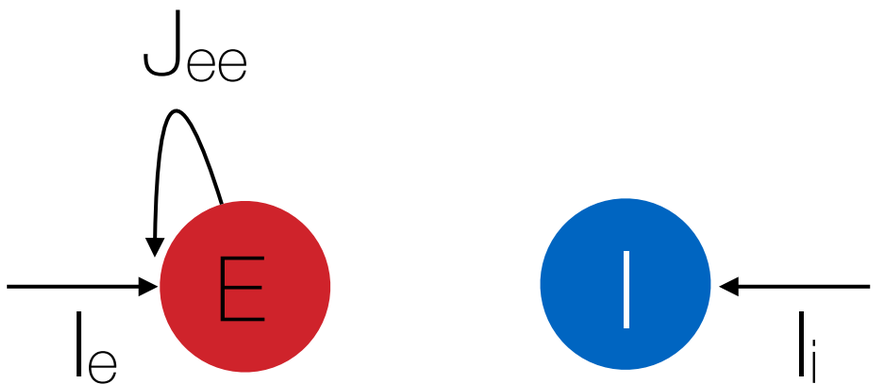
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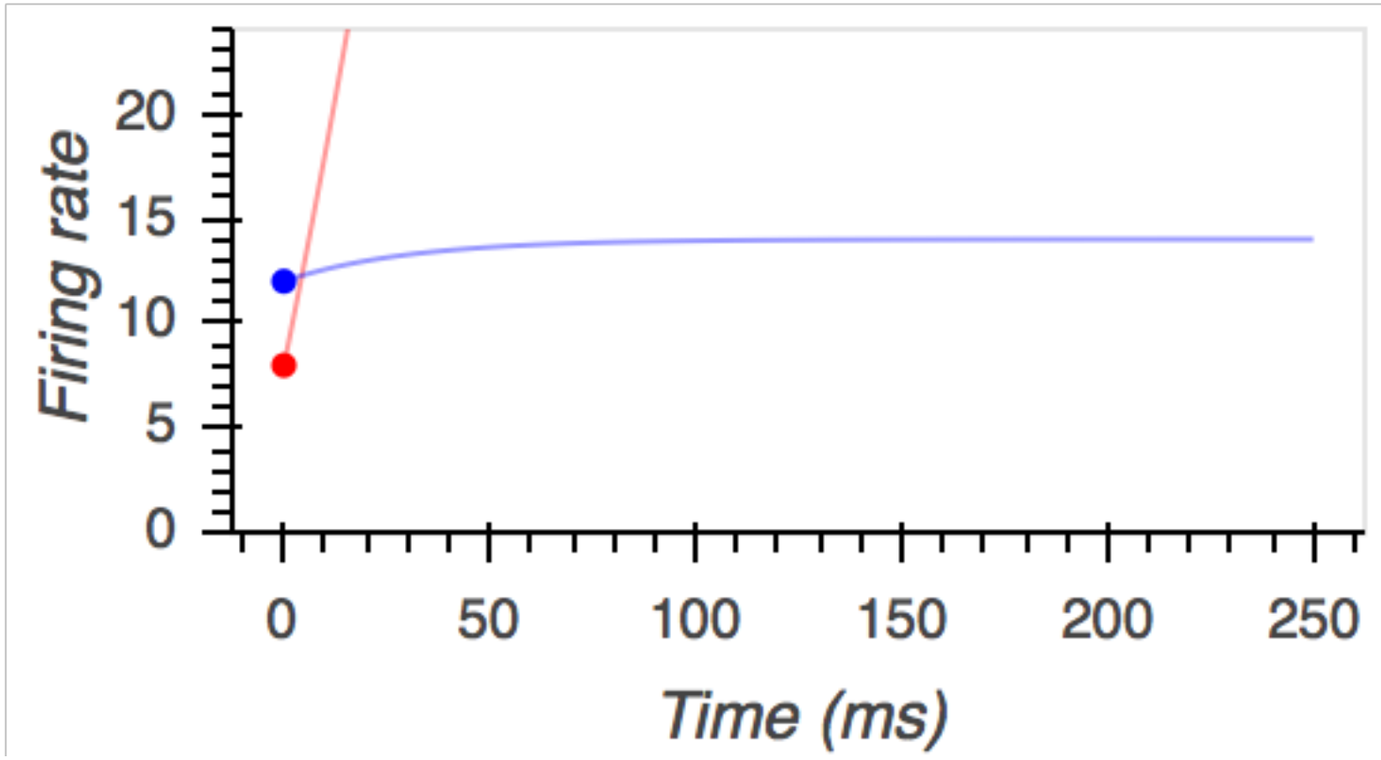
Firing rate
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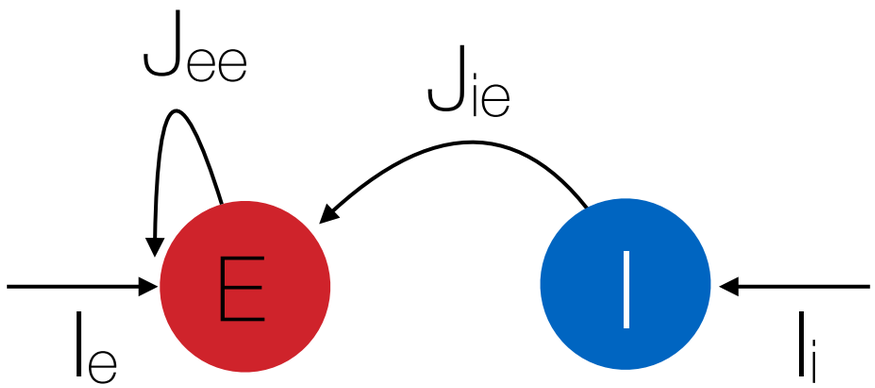
Time (ms)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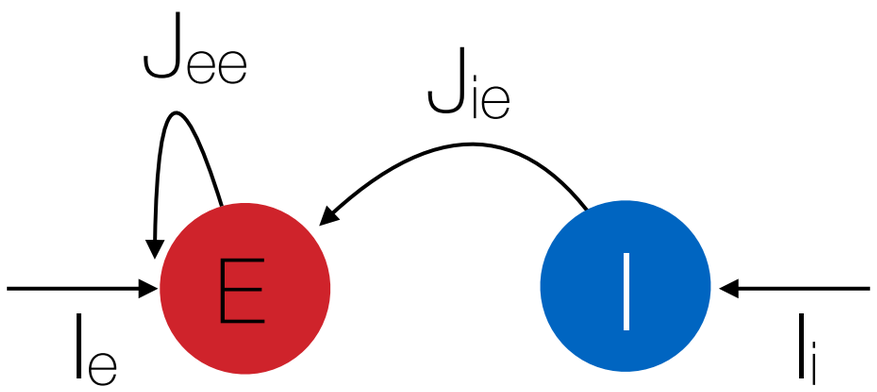
Jee
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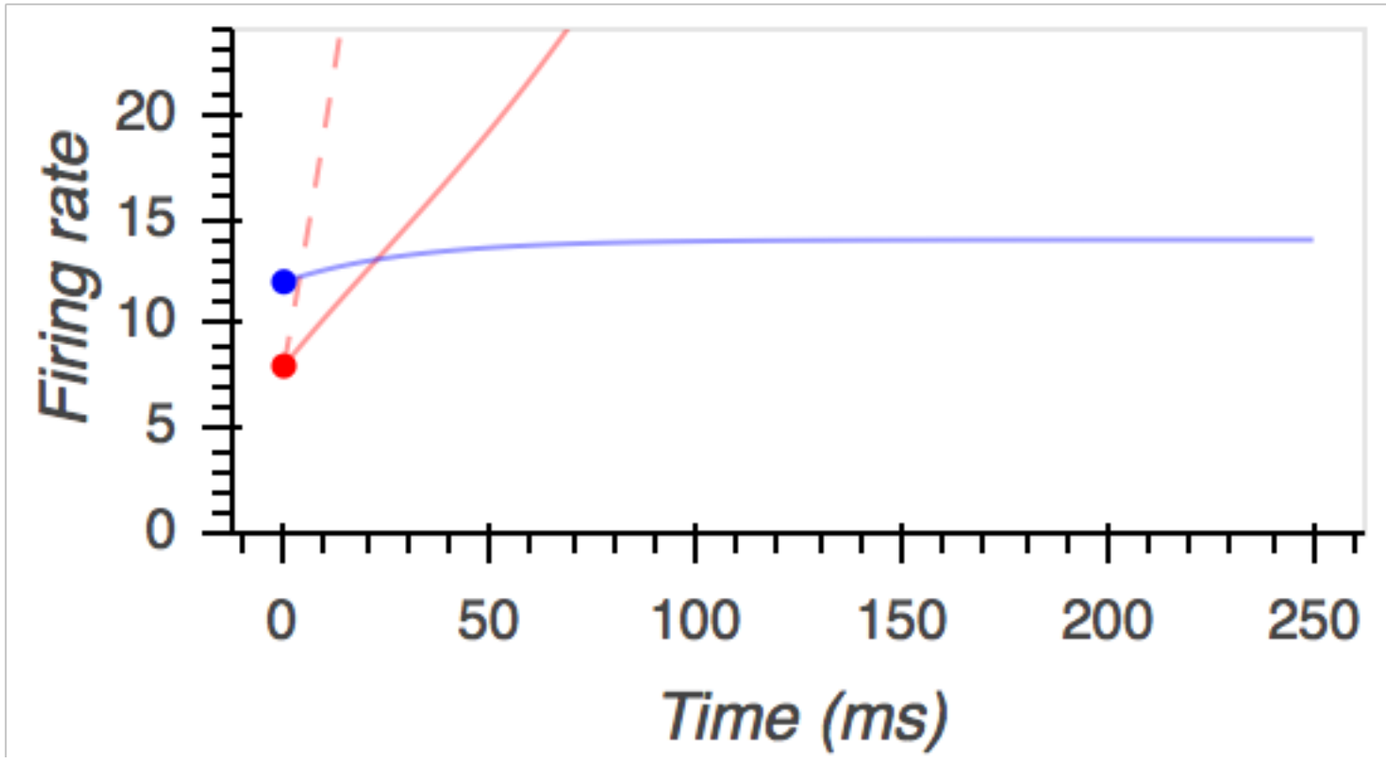
$J_{ie} = 0.7$


Firing rate
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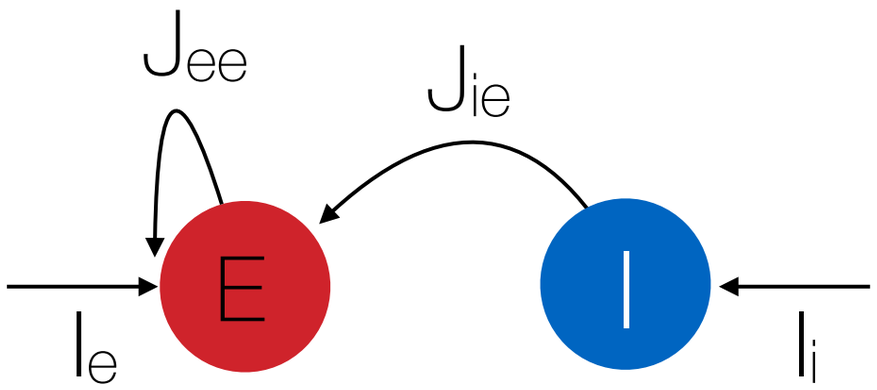
Time (ms)


Jee
Jie
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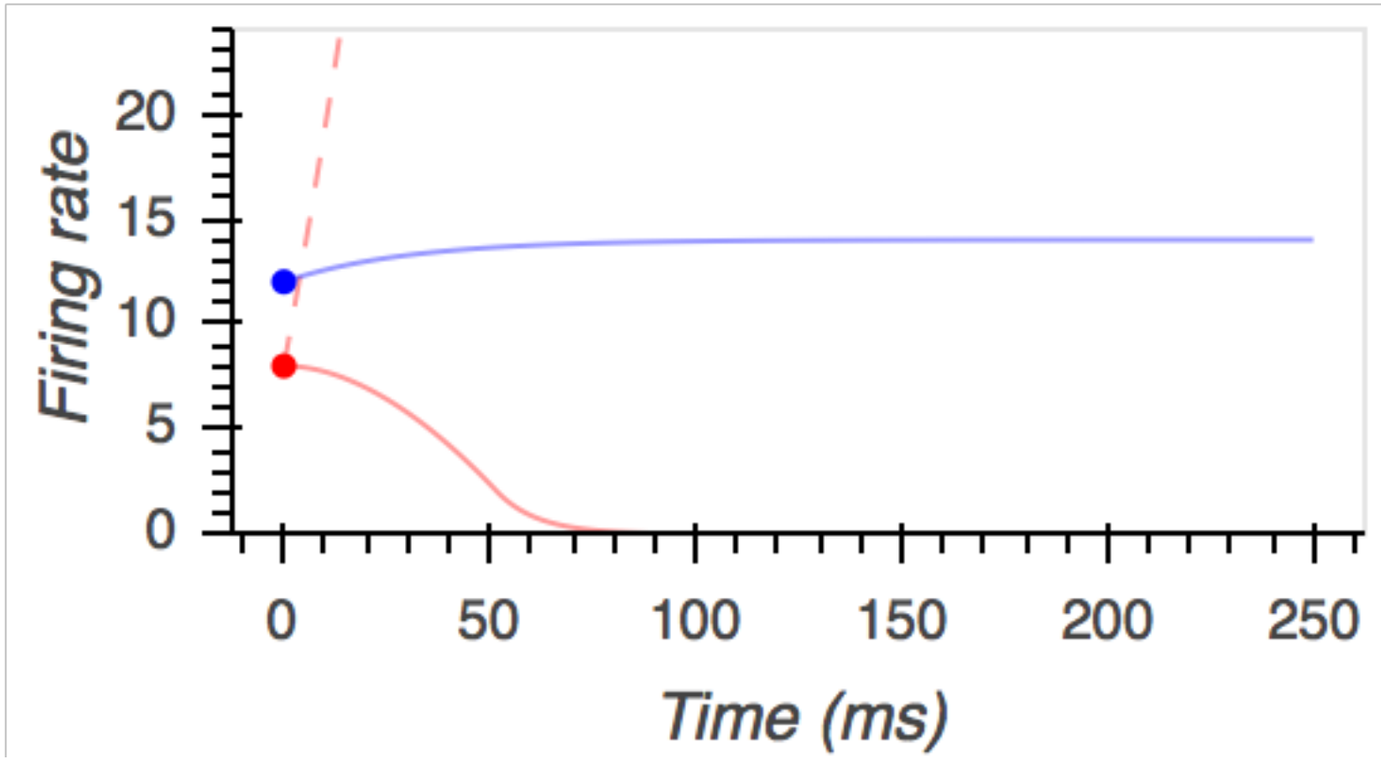
$J_{ie} = 0.9$


Firing rate
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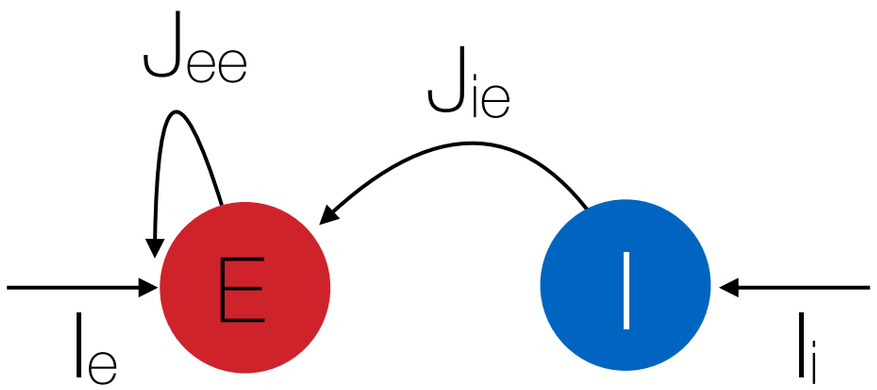
Time (ms)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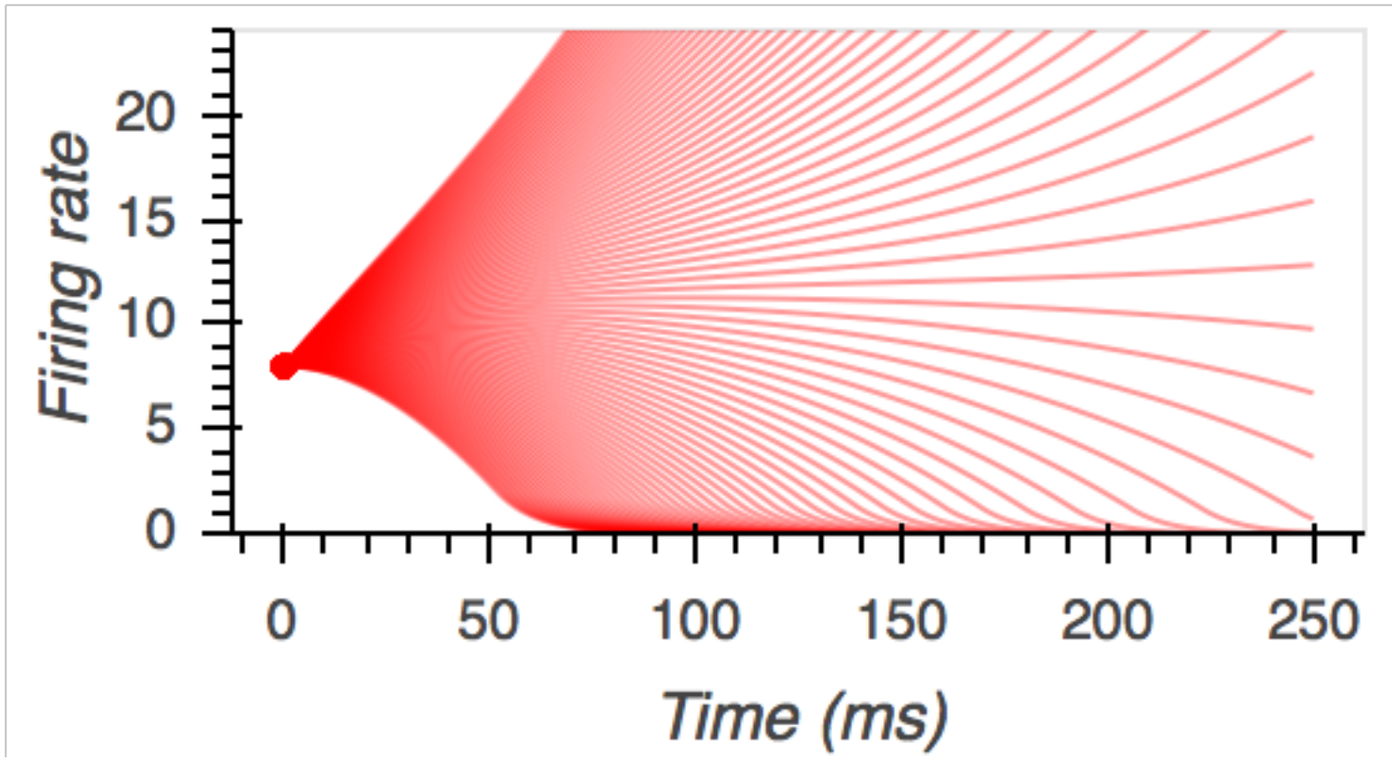
$J_{ie} = 0.7 - 0.9$


Firing rate
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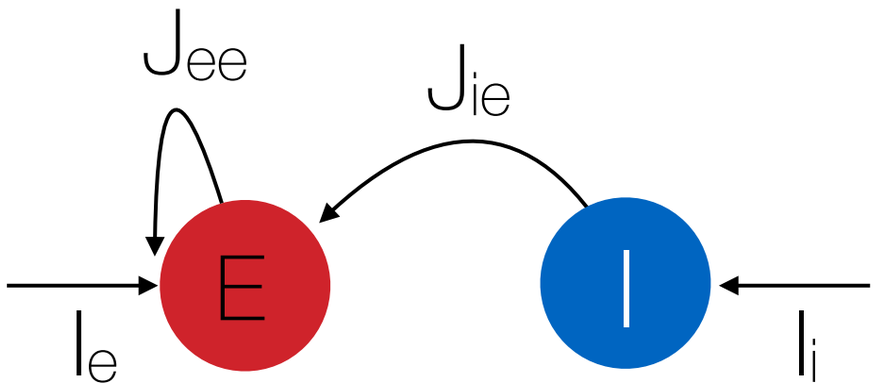
Time (ms)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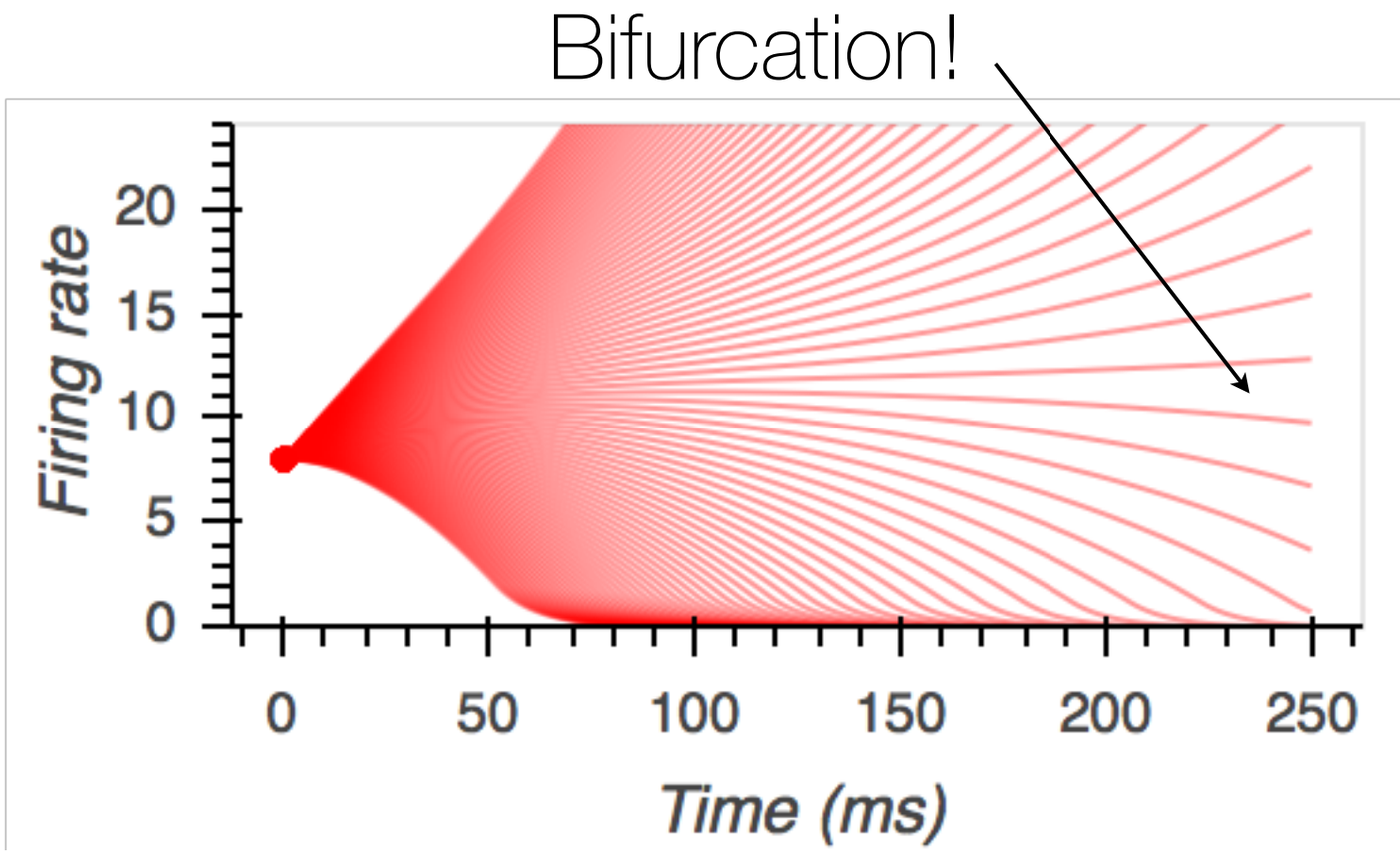
Bifurcation!
Firing rate
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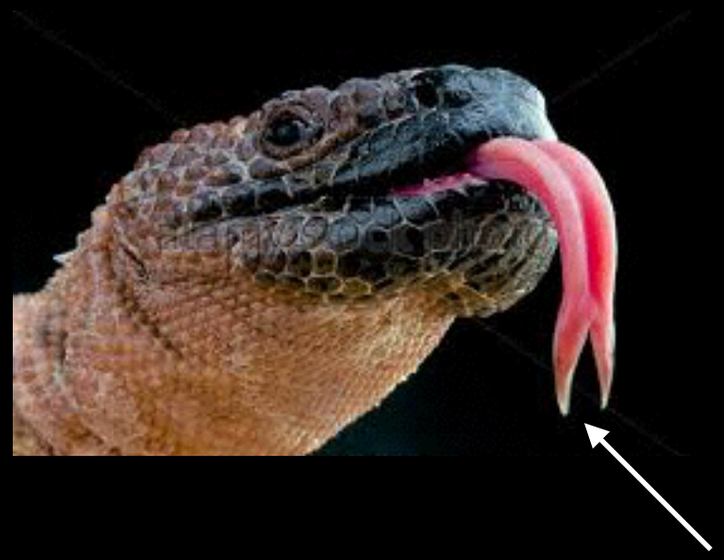
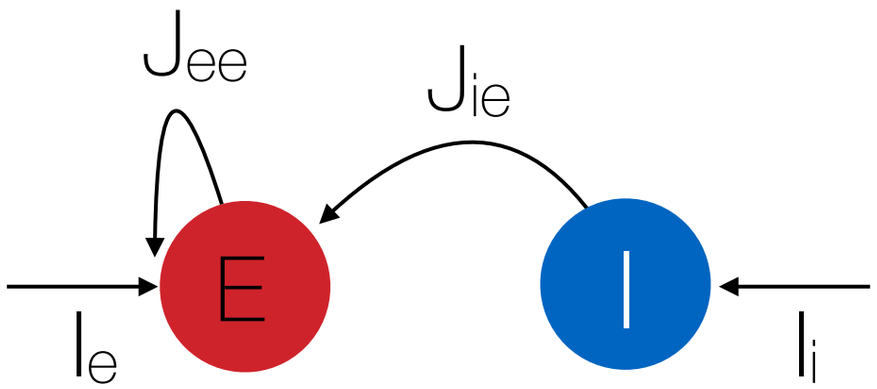
Time (ms)



Bifurcation


Jee
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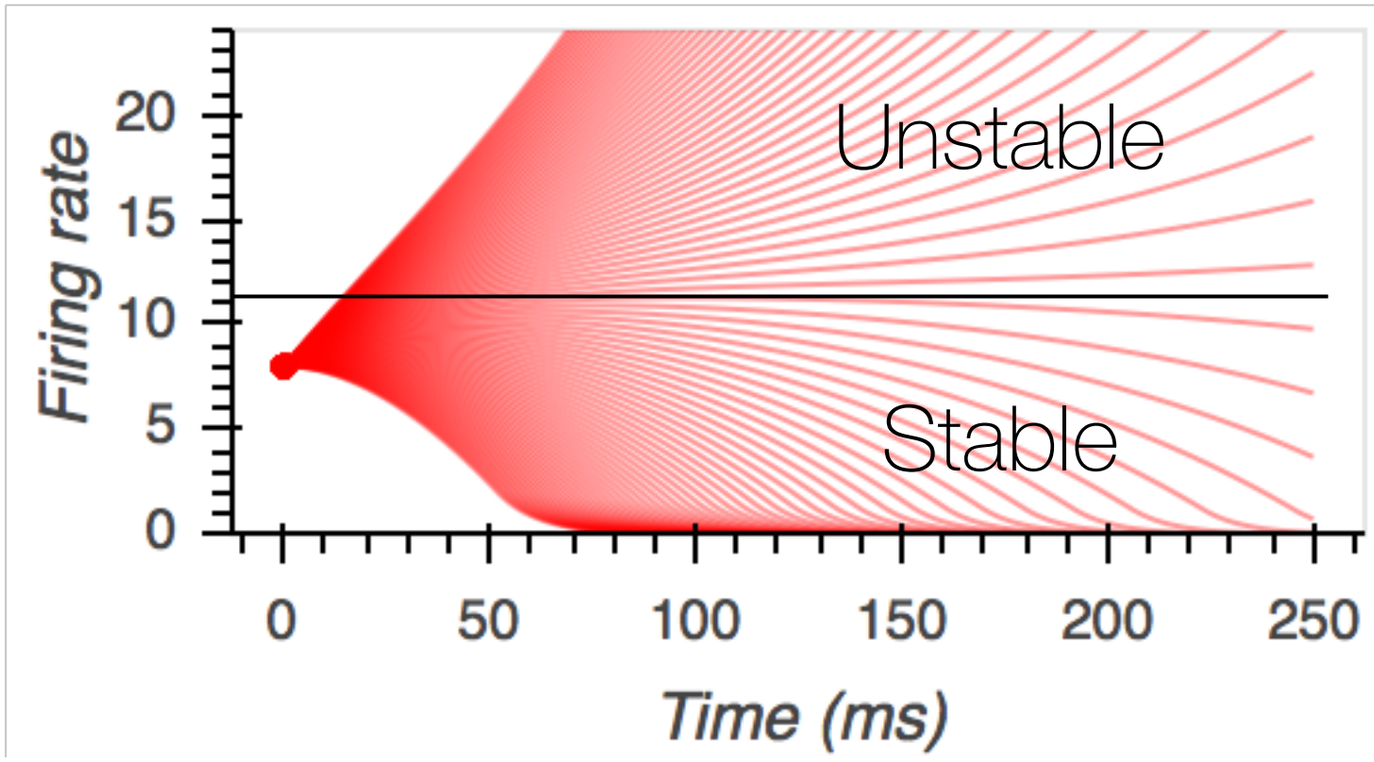
Ii

$J_{ie} = 0.7 - 0.9$


Unstable
Stable
Firing rate
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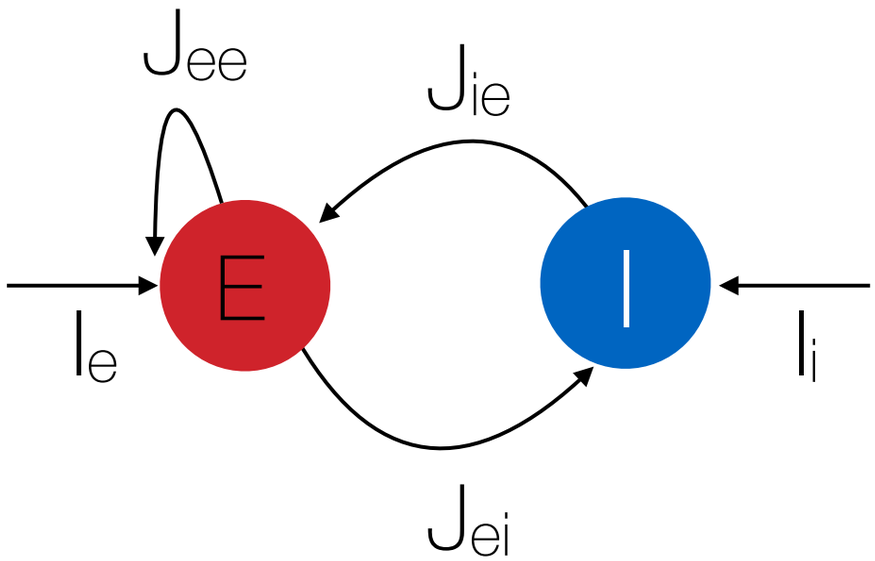
Time (ms)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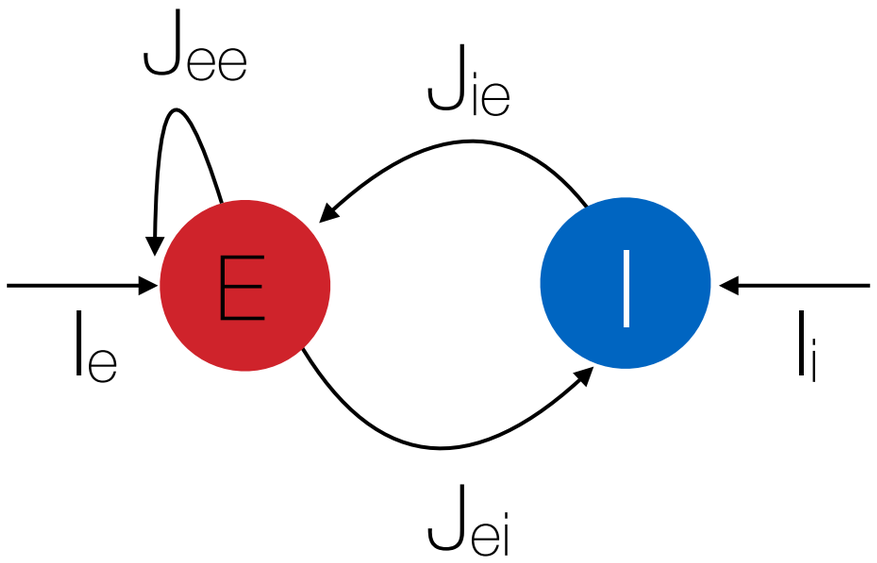
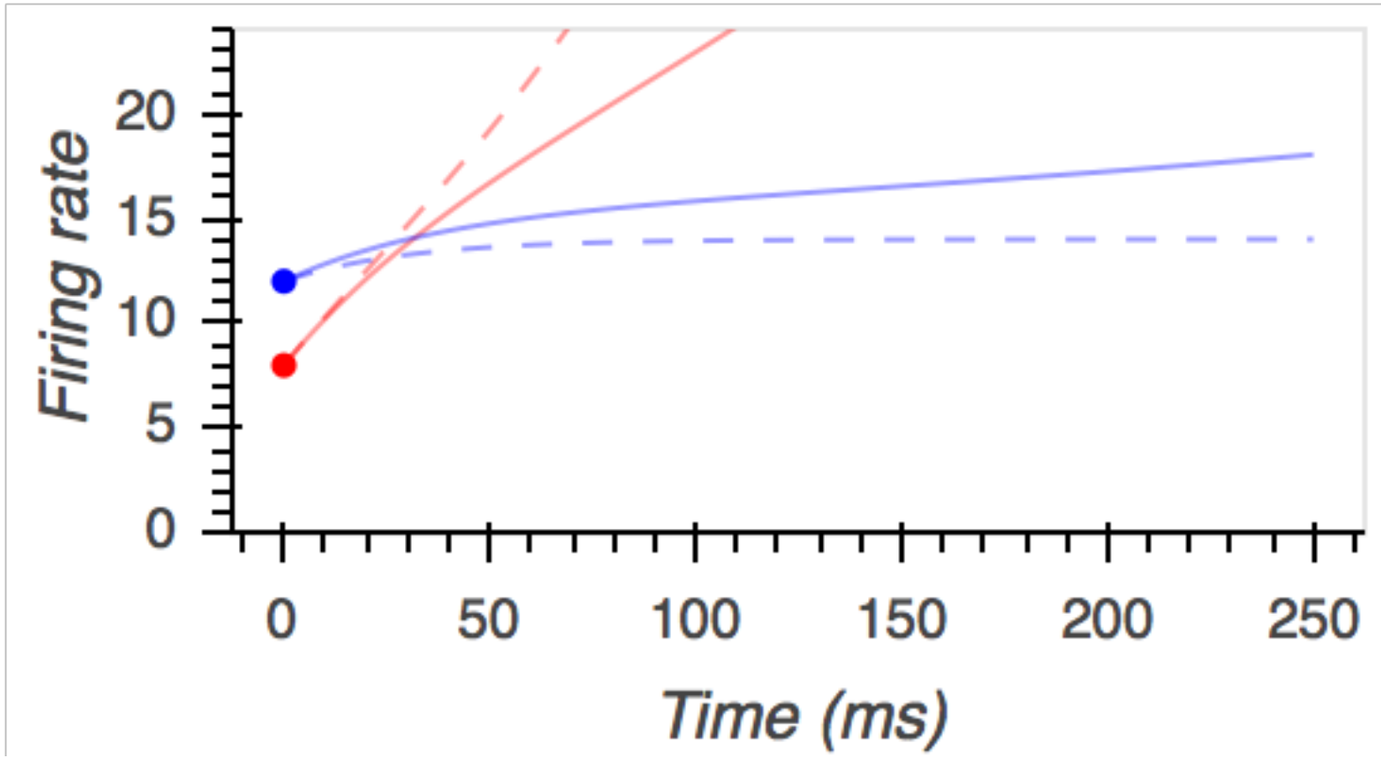
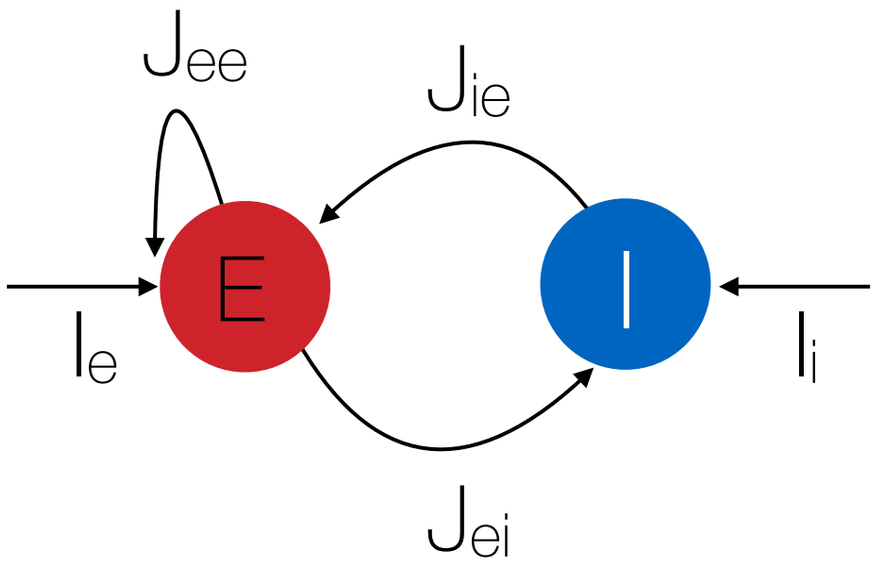
Ii
Jei

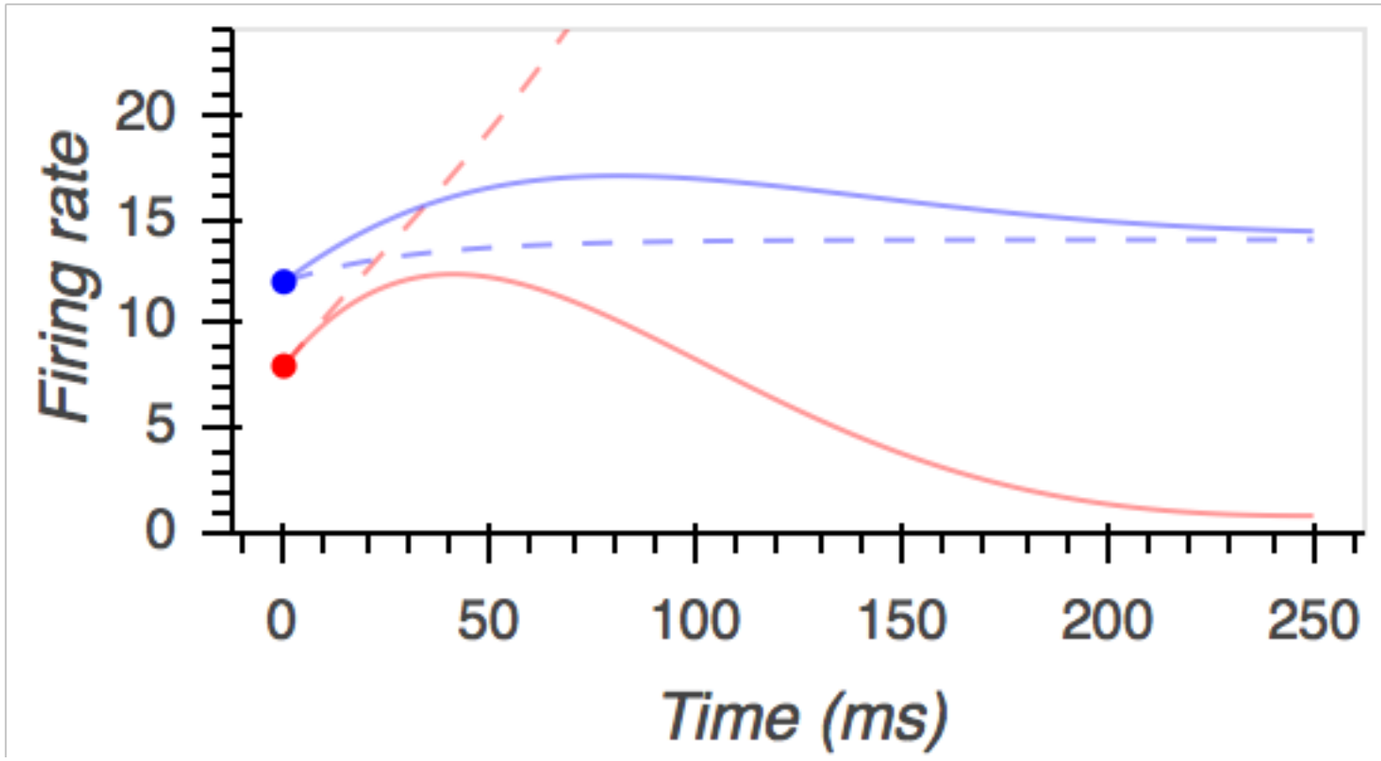

Jee
Jie
E
I
Ie
Ii
Jei

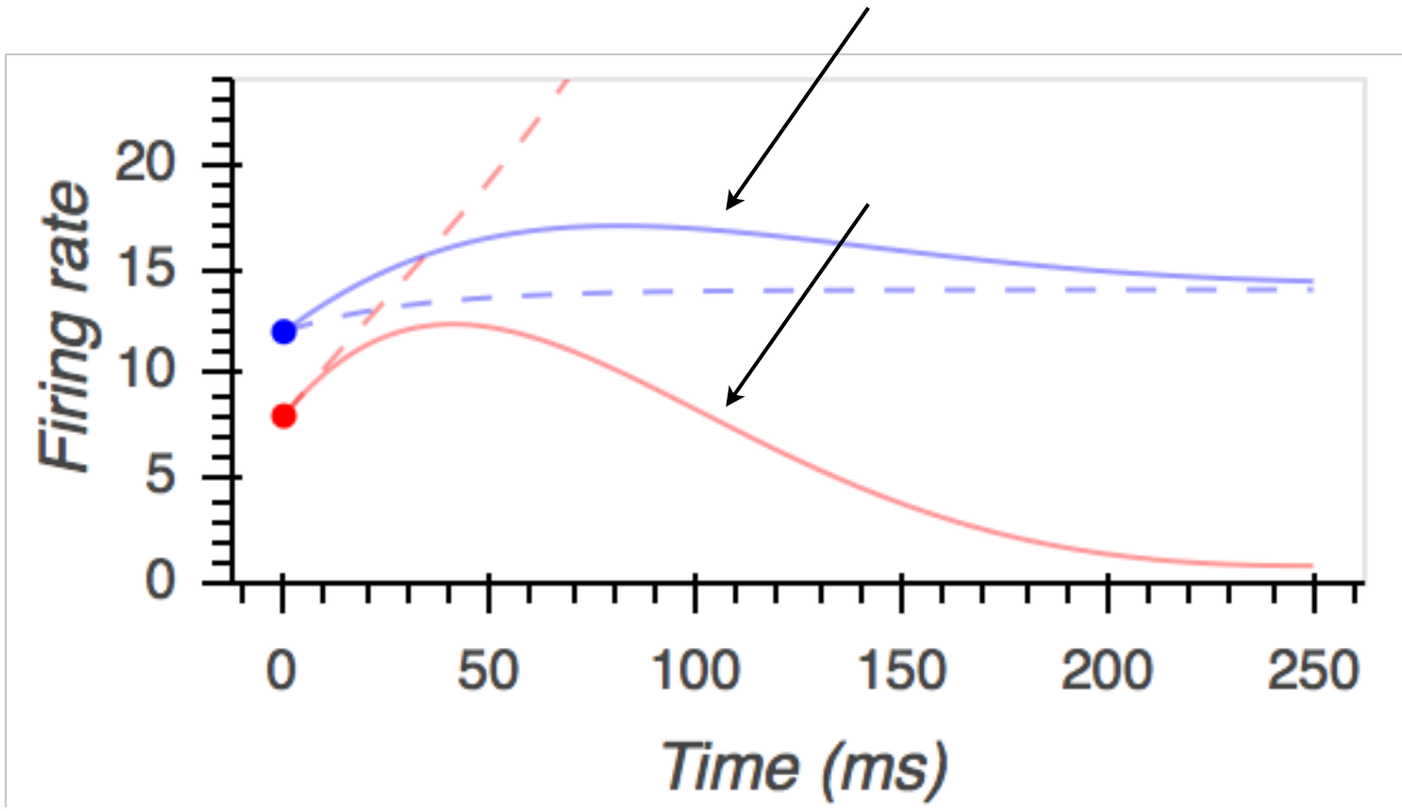
$J_{ie} = 0.7,\ J_{ei} = 0.1$

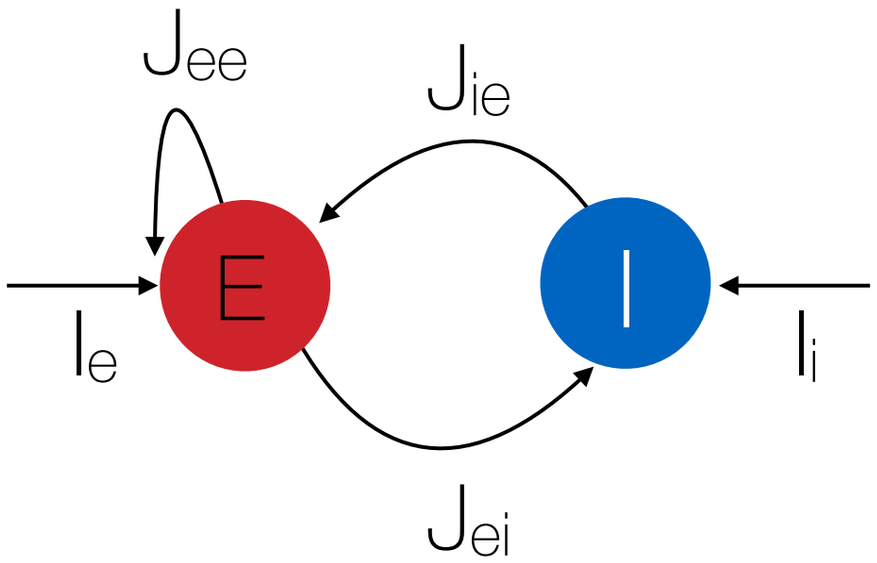

Firing rate
20
15
10
5
0
0
50
100
150
200
250
Time (ms)


Jee
Jie
E
I
Ie
Ii
Jei

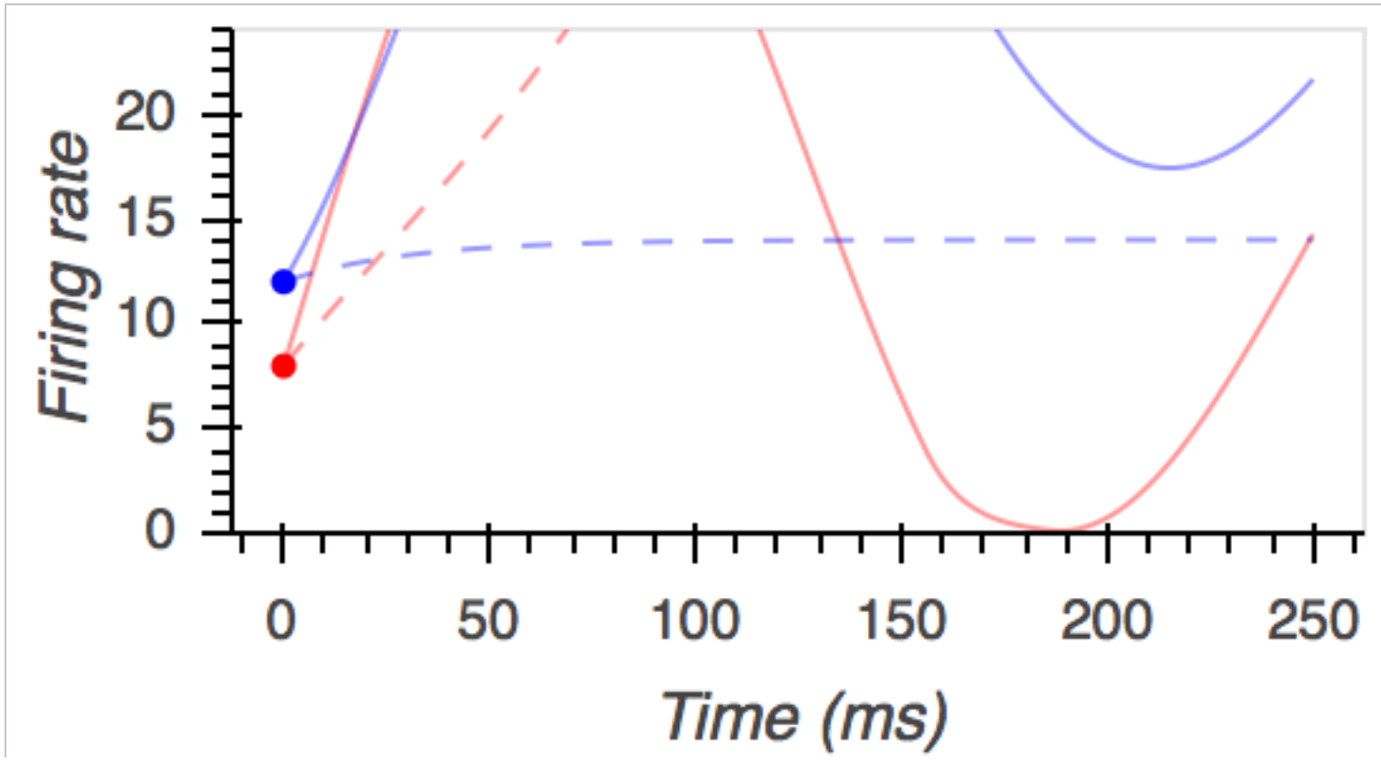
$J_{ie} = 0.7,\ J_{ei} = 0.3$

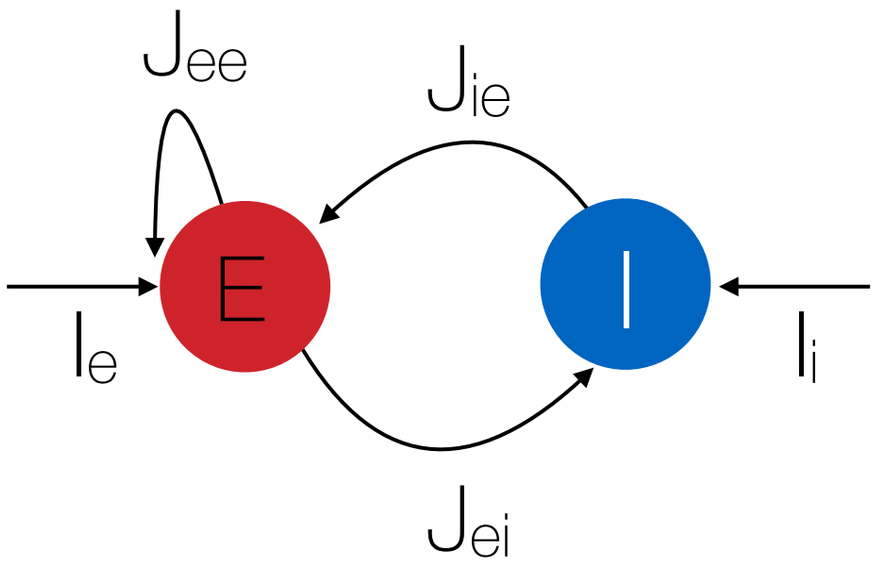

Firing rate
20
15
10
5
0
0
50
100
150
200
250
Time (ms)


Firing rate
20
15
10
5
0
0
50
100
150
200
250
Time (ms)

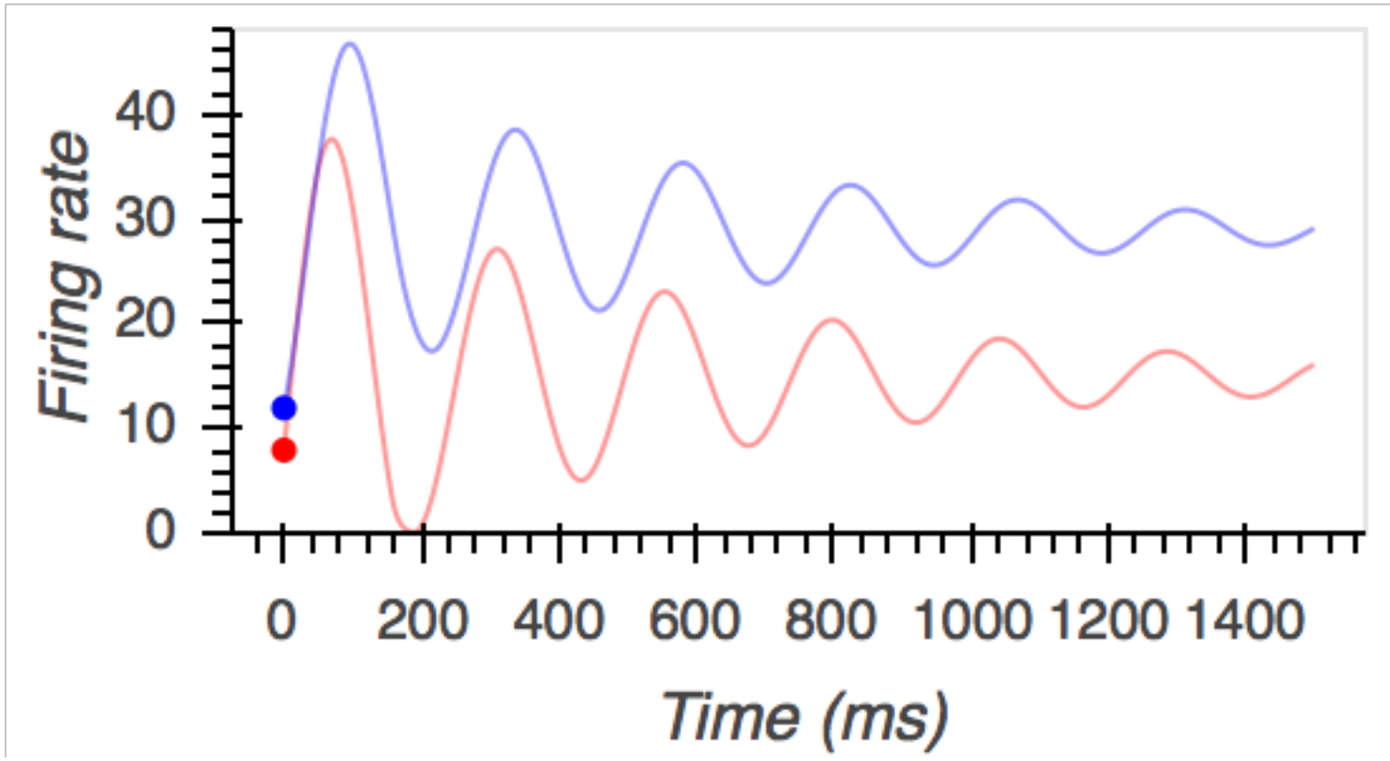

Jee
Jie
E
I
Ie
Ii
Jei

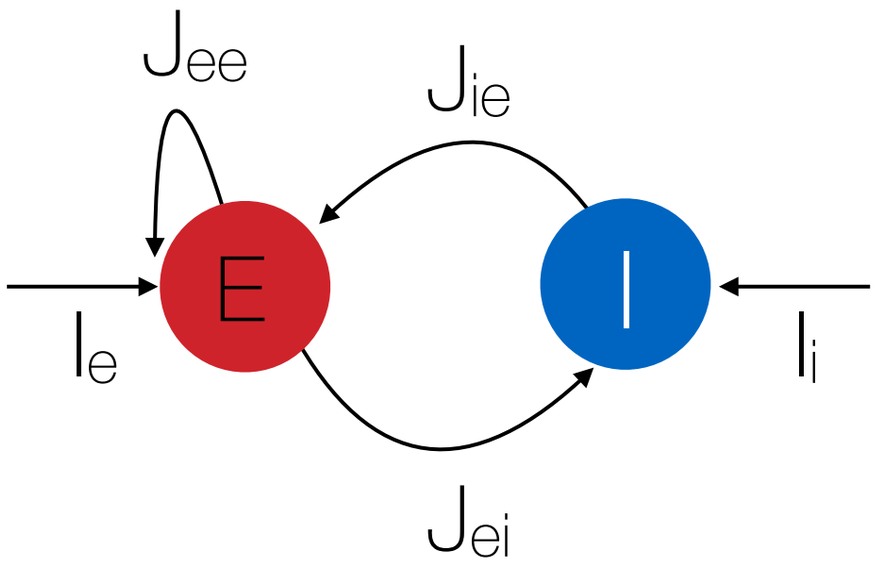
$J_{ie} = 0.5,\ J_{ei} = 1.0$


Firing rate
20
15
10
5
0
0
50
100
150
200
250
Time (ms)

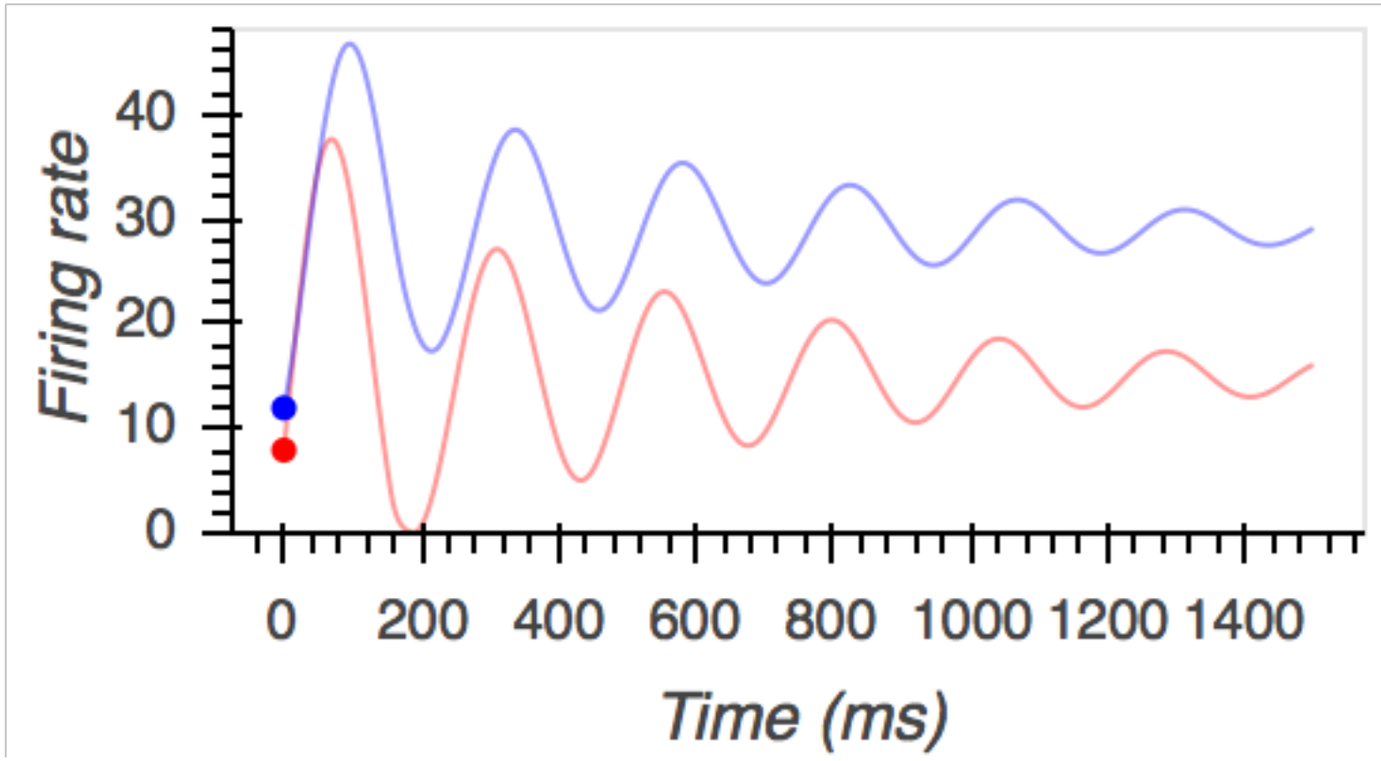

Jee
Jie
E
I
Ie
Ii
Jei

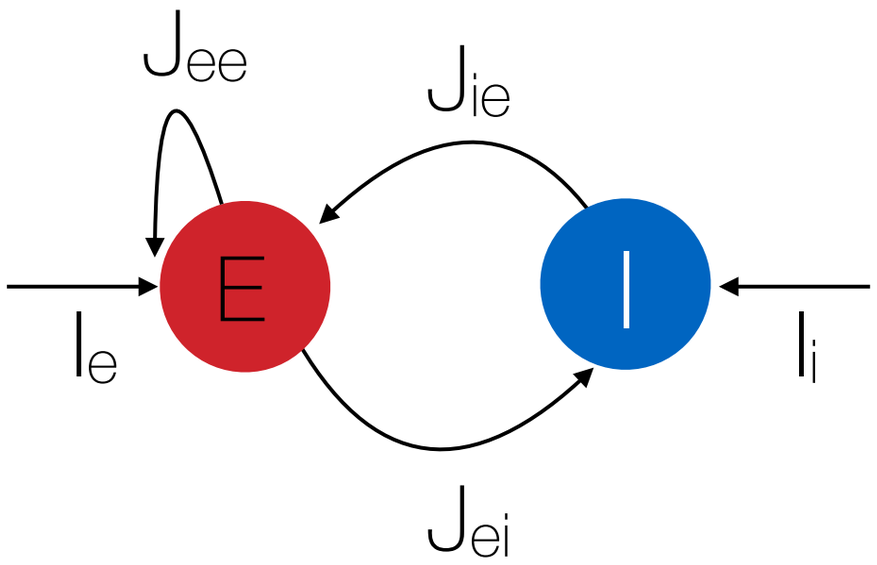
$J_{ie} = 0.5,\ J_{ei} = 1.0$


Firing rate
40
30
20
10
0
0
200
400
600
800
1000
1200
1400
Time (ms)

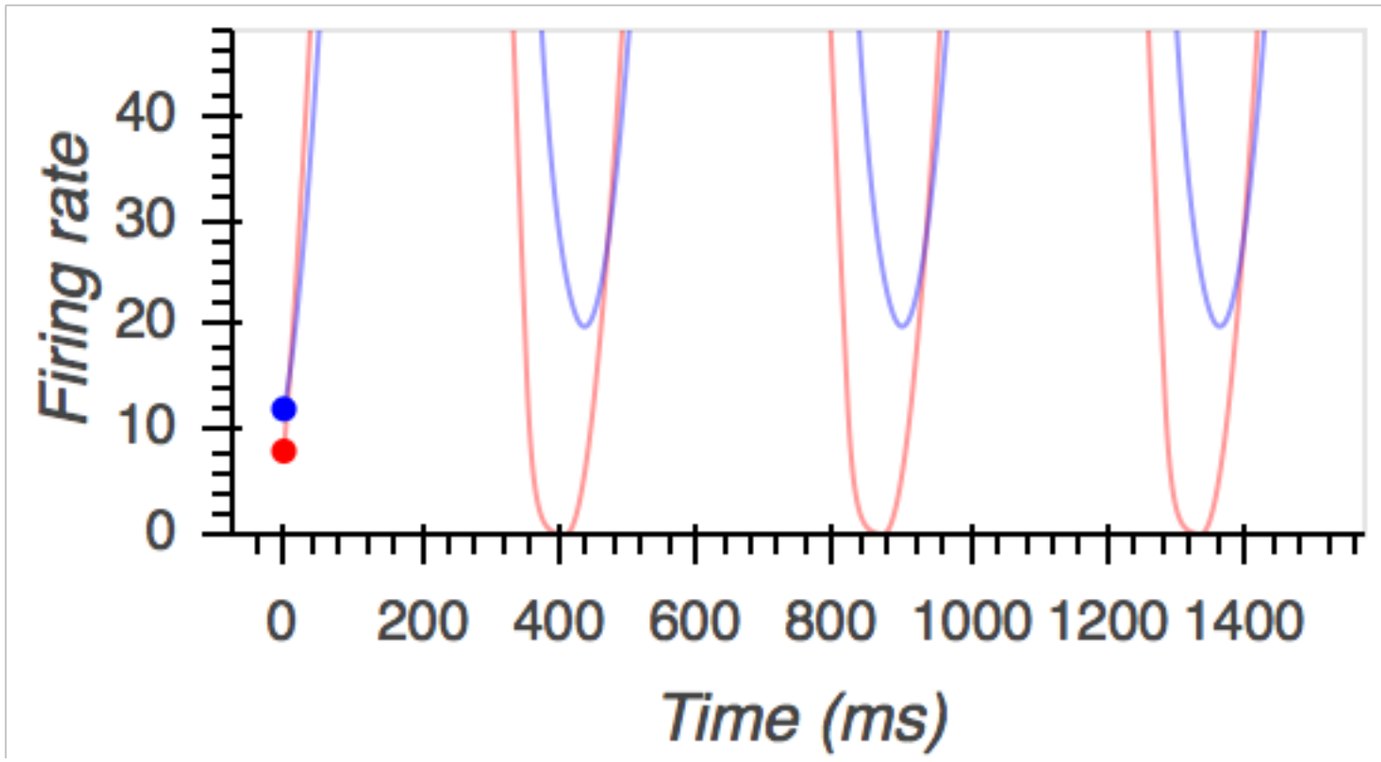


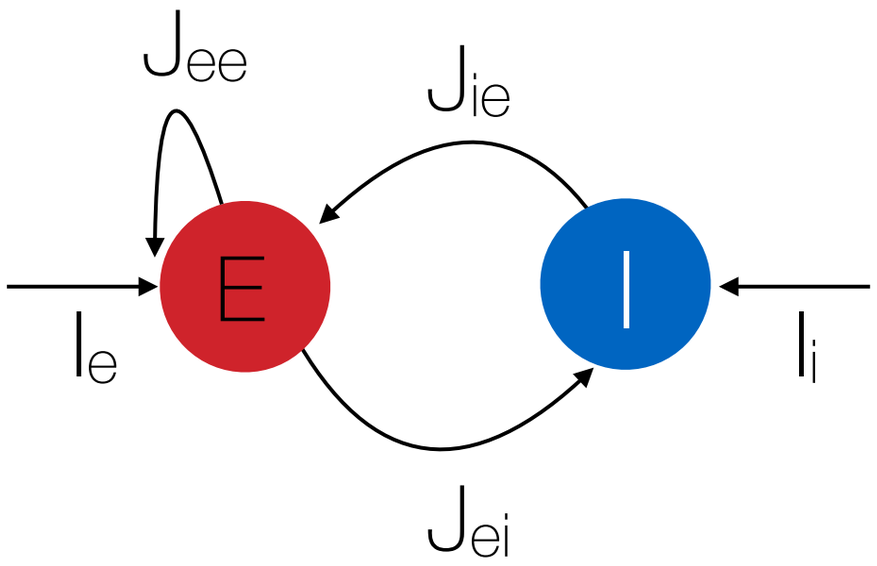
Damped oscillator



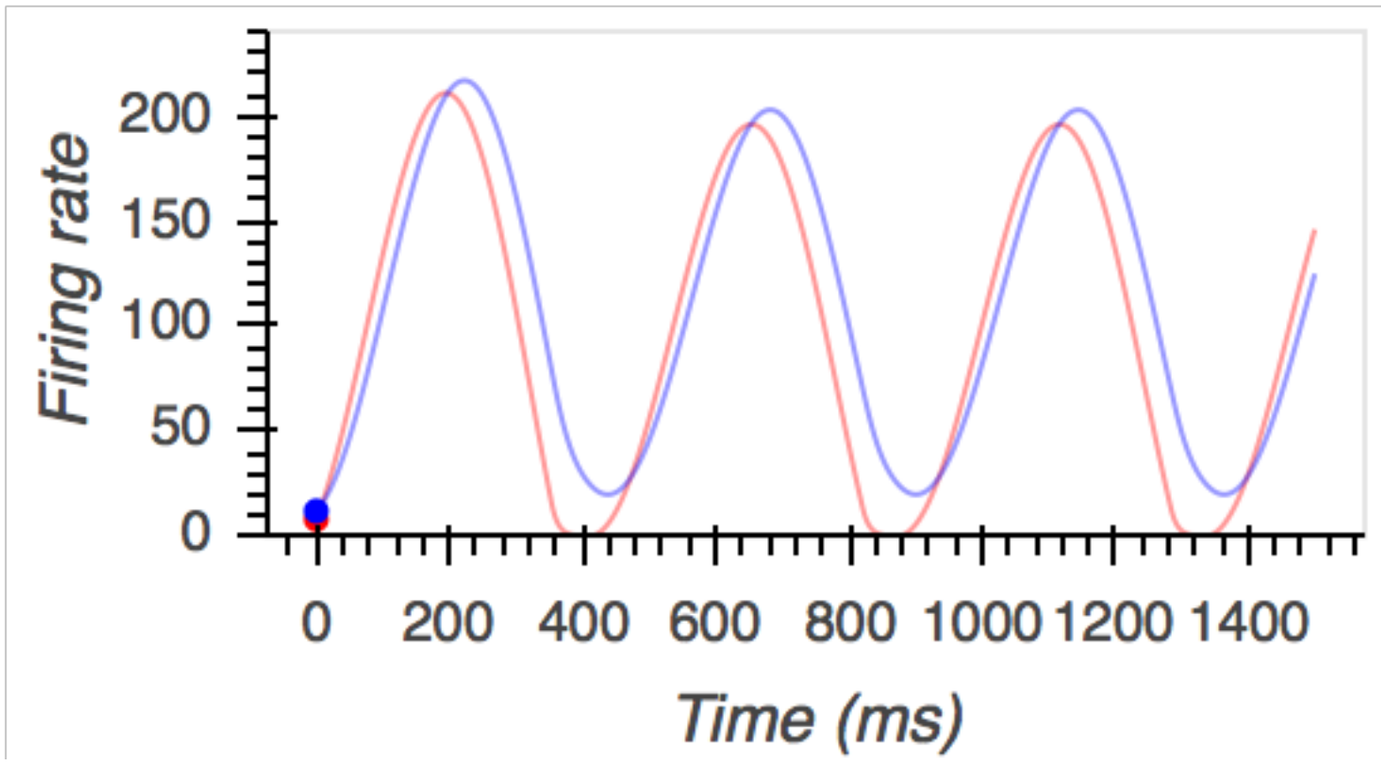

Jee
Jie
E
I
Ie
Ii
Jei

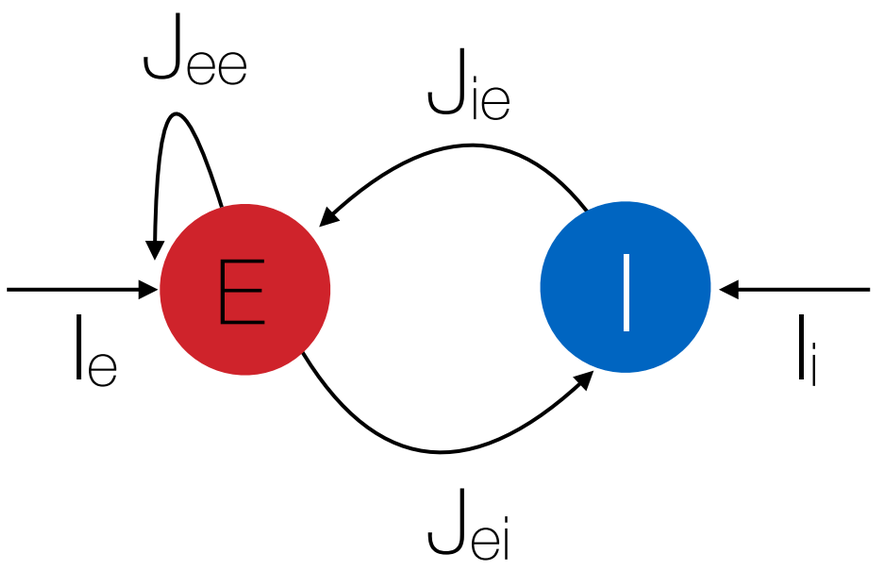
$J_{ie} = 0.4,\ J_{ei} = 1.0$


Firing rate
40
30
20
10
0
0
200
400
600
800
1000
1200
1400
Time (ms)

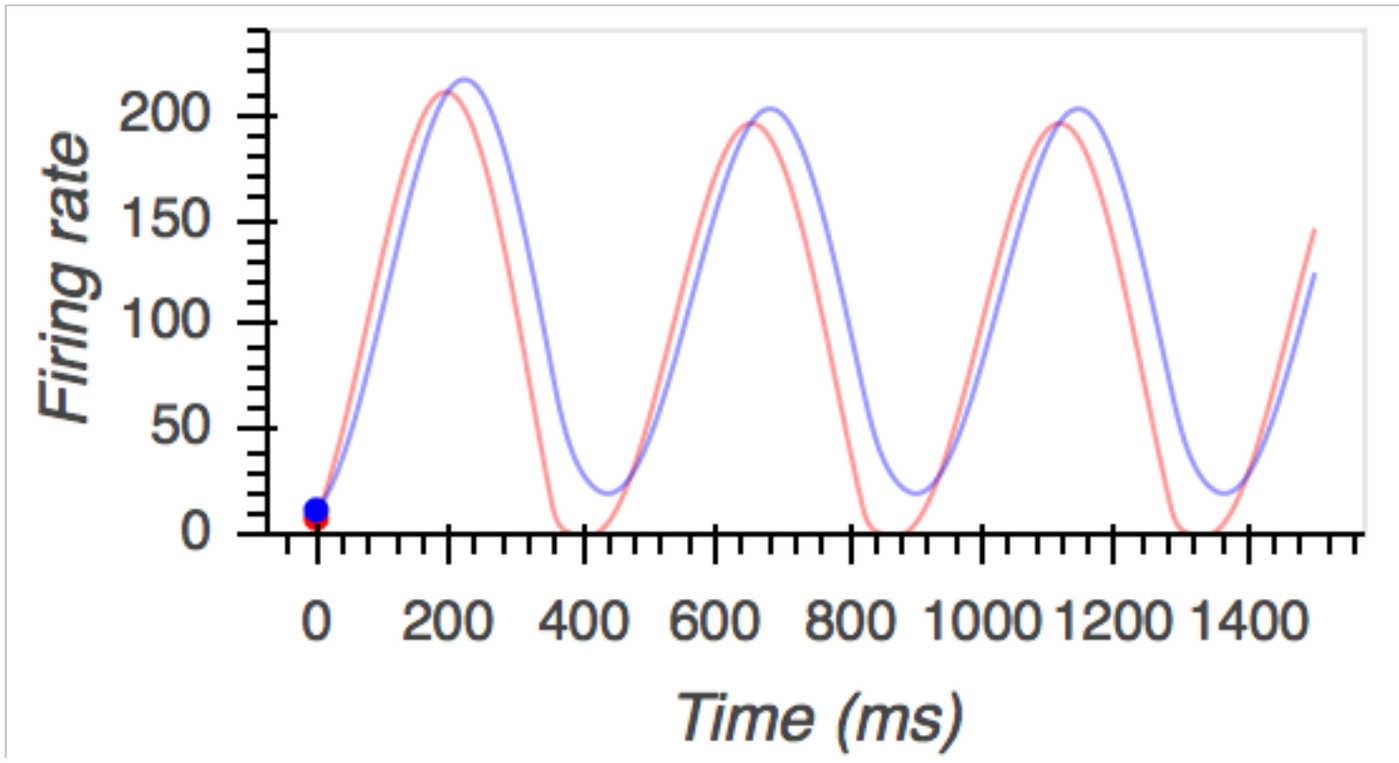

Jee
Jie
E
I
Ie
Ii
Jei

$J_{ie} = 0.4,\ J_{ei} = 1.0$

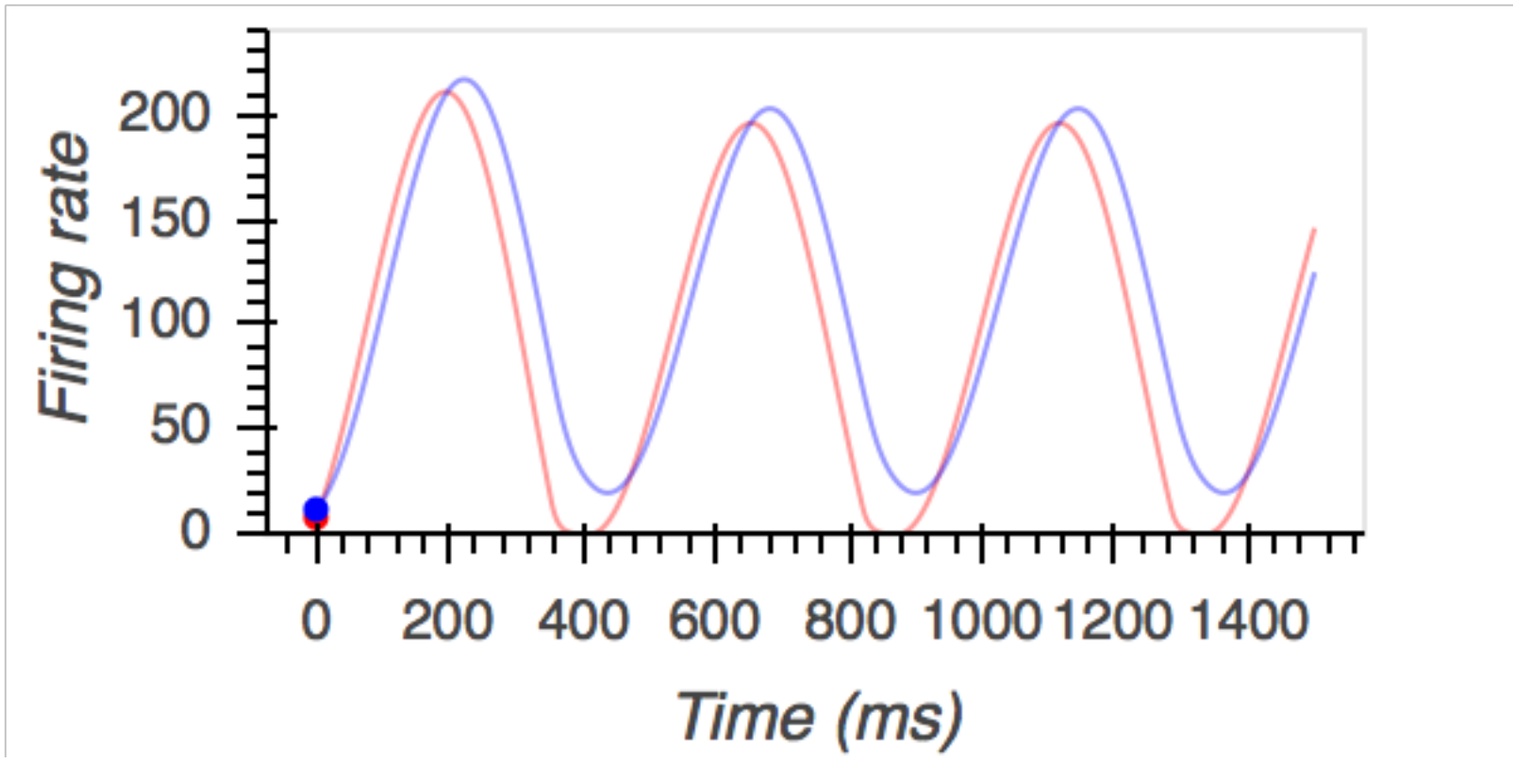

Firing rate
200
150
100
50
0
0
200
400
600
800
1000
1200
1400
Time (ms)



Oscillation!



How many ways to make a

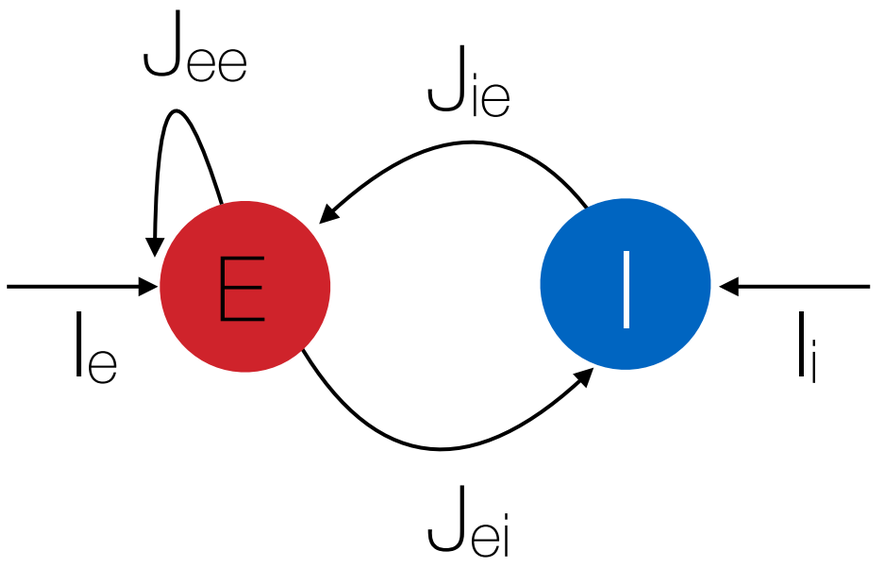


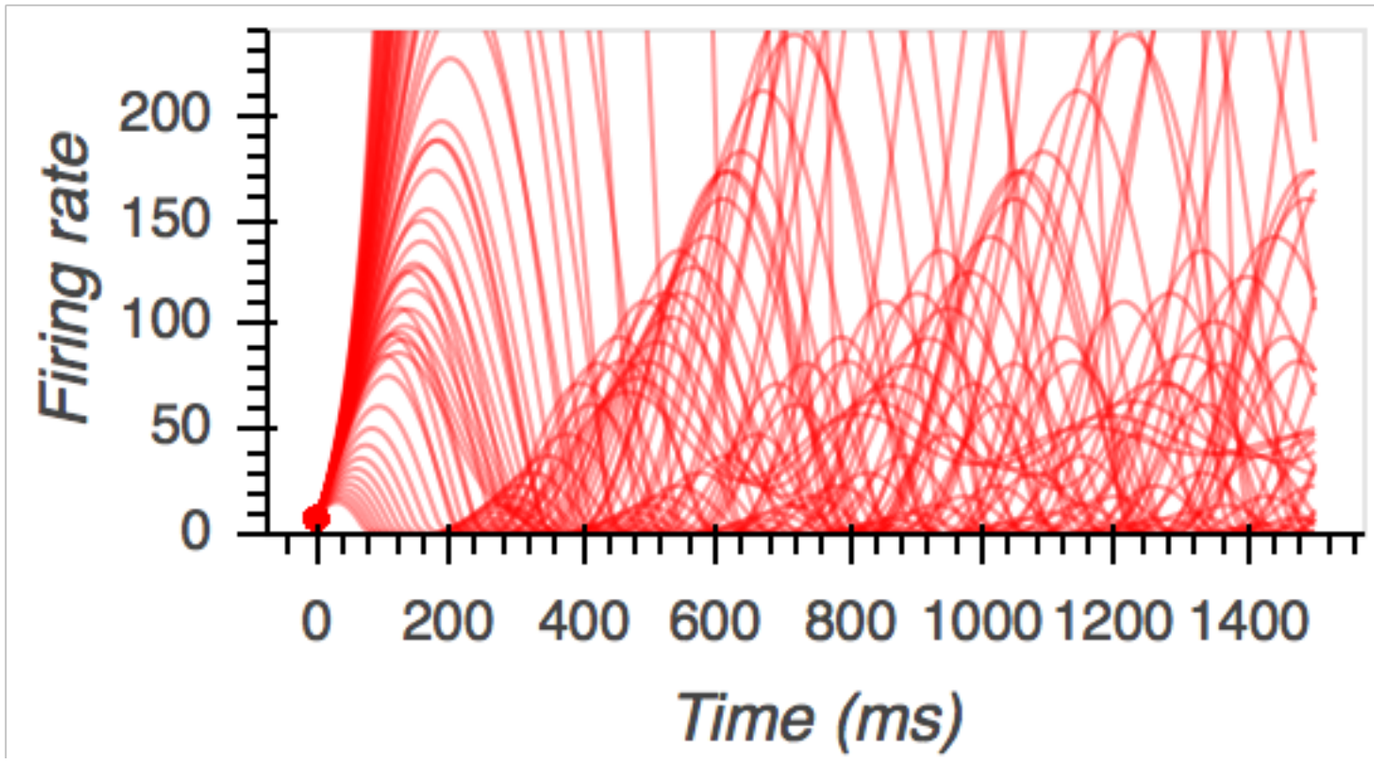
?

$J_{ee} = 0.3 - 0.4$

$J_{ie} = 0.3 - 0.7$

$J_{ei} = 0.5 - 1.2$





(Stable, Unstable, & Waves)

Eigenvalues!

λ

Eigenvalues...

What The F***!!?!?!?

What The F***:

. . .a set of values of a parameter for which a differential equation has a nonzero solution (an eigenfunction) under given conditions.

E = 0

I = 0

Linearize

Matrix form

	E	I
E	$(J_{ee} - 1) / \tau_e$	J_{ei} / τ_e
I	J_{ie} / τ_i	$(J_{ii} - 1) / \tau_i$

Dayan P & Abbott LF, Theoretical Neuroscience, MIT Press, 2005, p266.

	E	I
E	$(J_{ee} - 1) / \tau_e$	J_{ei} / τ_e
I	J_{ie} / τ_i	$(J_{ii} - 1) / \tau_i$

$$\lambda = 0.5(\frac{Jee - 1}{\tau_e} + \frac{Jii - 1}{\tau_i} \pm \sqrt{(\frac{Jee - 1}{\tau_e} - \frac{Jii - 1}{\tau_i}) + \frac{4JeiJie}{\tau_i\tau_e}})$$

Dayan P & Abbott LF, Theoretical Neuroscience, MIT Press, 2005, p266.

$$i = \sqrt{-1}$$

ONLY THREE THINGS MATTER

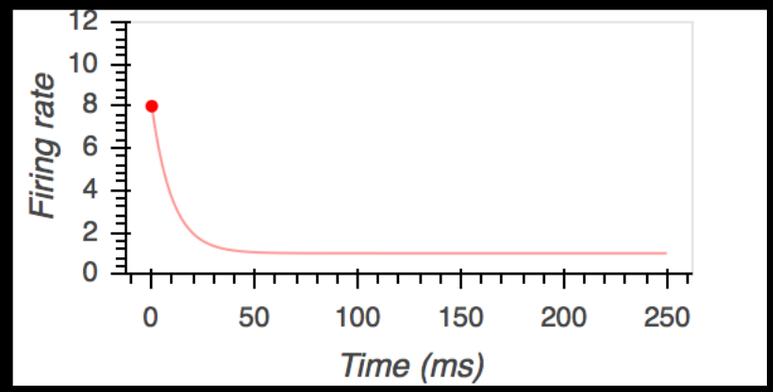
1. $\lambda = 0.5((\ldots) \pm \sqrt{-1?})$

2. $\lambda > 0$

3. $\lambda < 0$

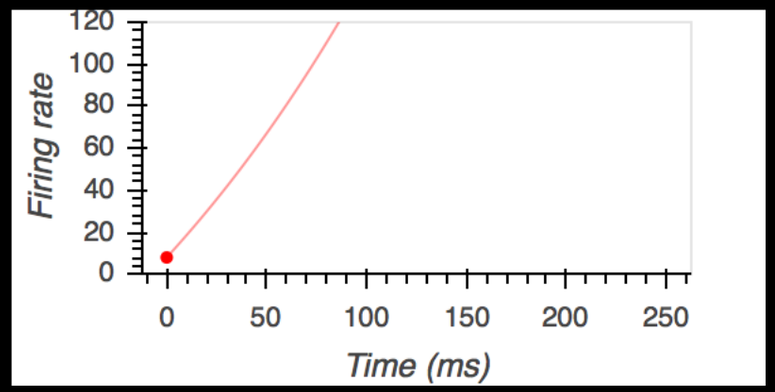
$$\lambda \neq i$$

$$\lambda < 0$$



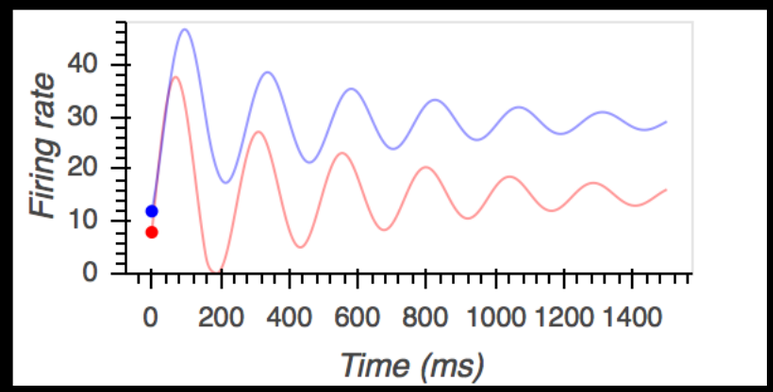
$$\lambda \neq i$$

$$\lambda > 0$$



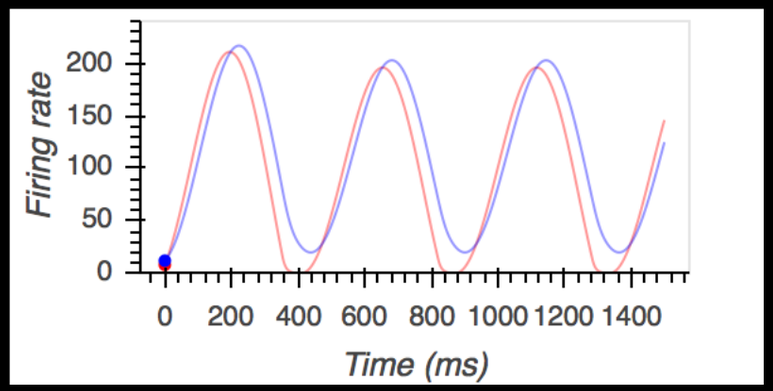
$$\lambda = i$$

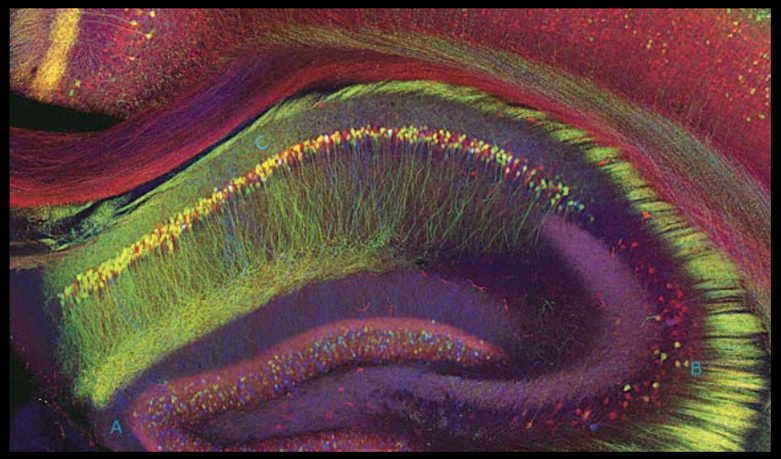
$$\lambda < 0$$

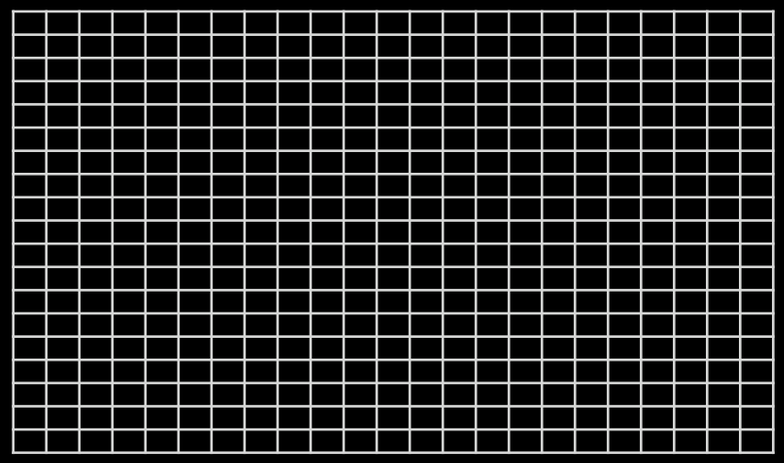


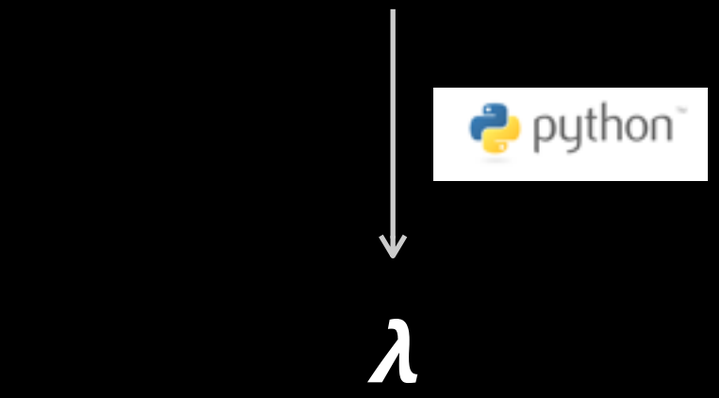
$$\lambda = i$$

$$\lambda > 0$$



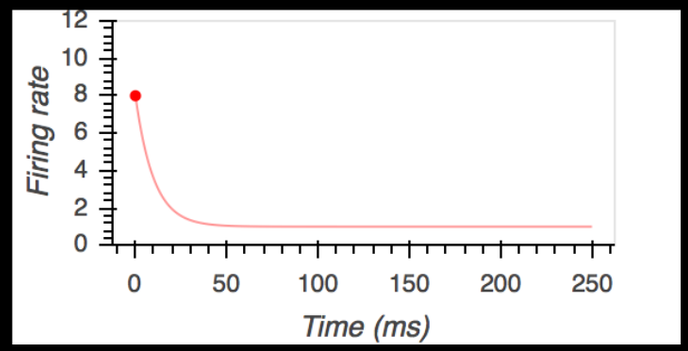


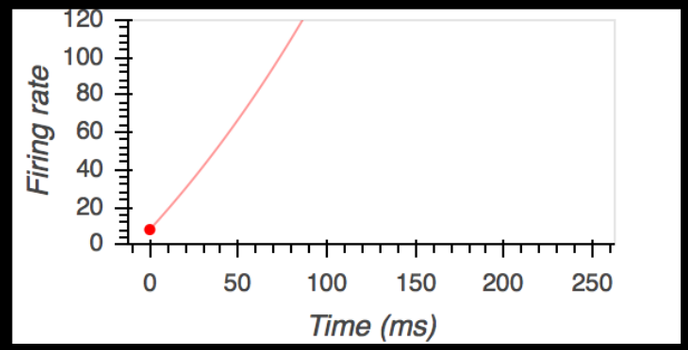


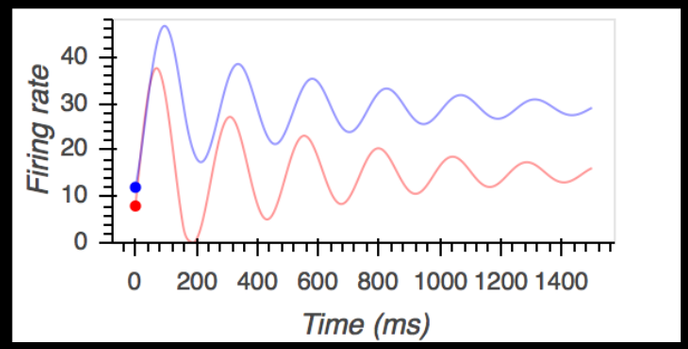


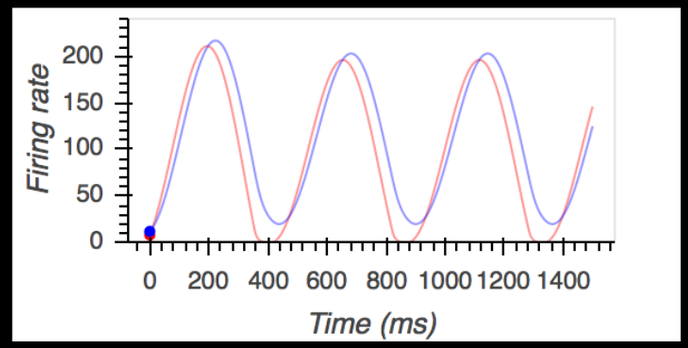
λ

$$\lambda = \begin{cases} \\ \\ \\ \end{cases}$$

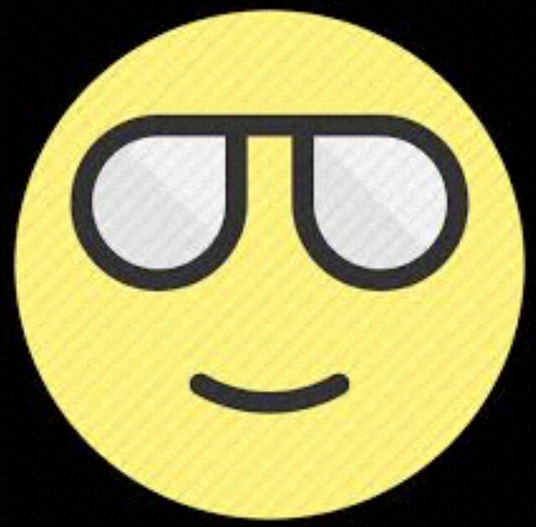








EIGEN-



A Brainwave recipe:

- At least two cells,
- reciprocally connected.
- One imaginary eigenvalue.

- Neuroscience
- Data science
- Statistics
- Programming

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