Step Current Response of the HH Model

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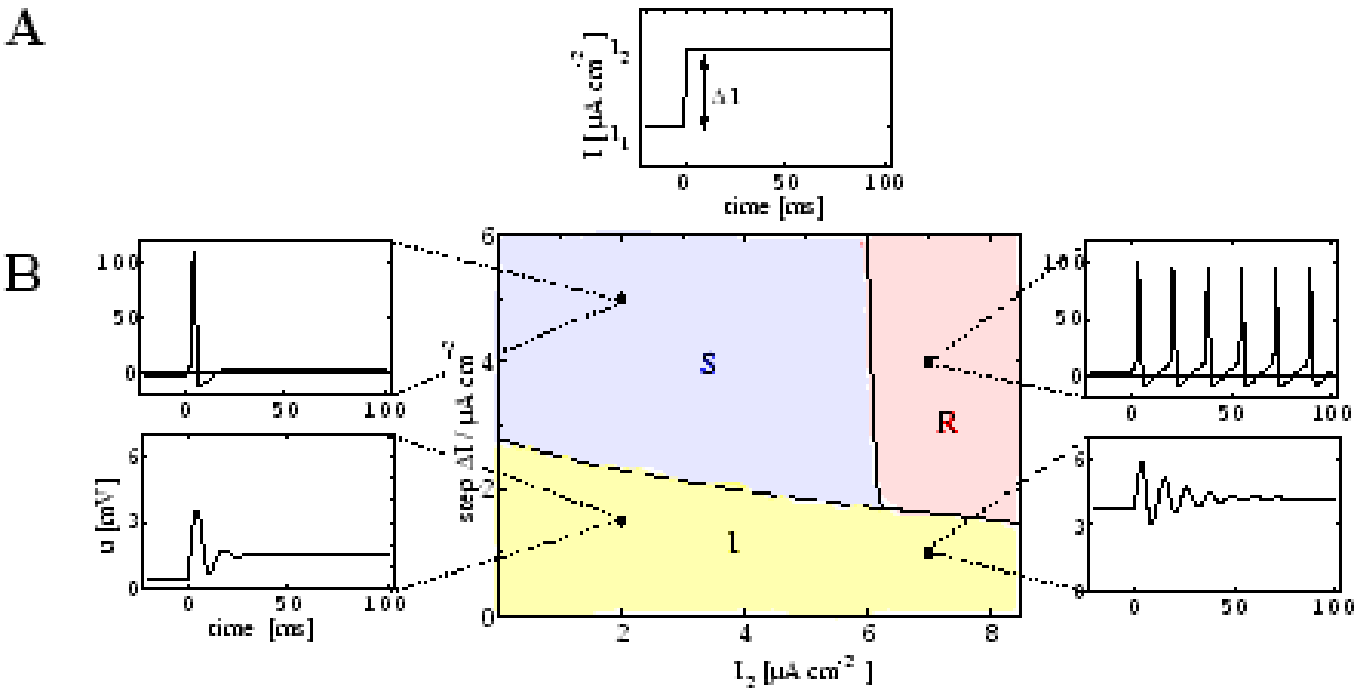
HH Model Step Current Response



Step Current Stimulation Phase diagram

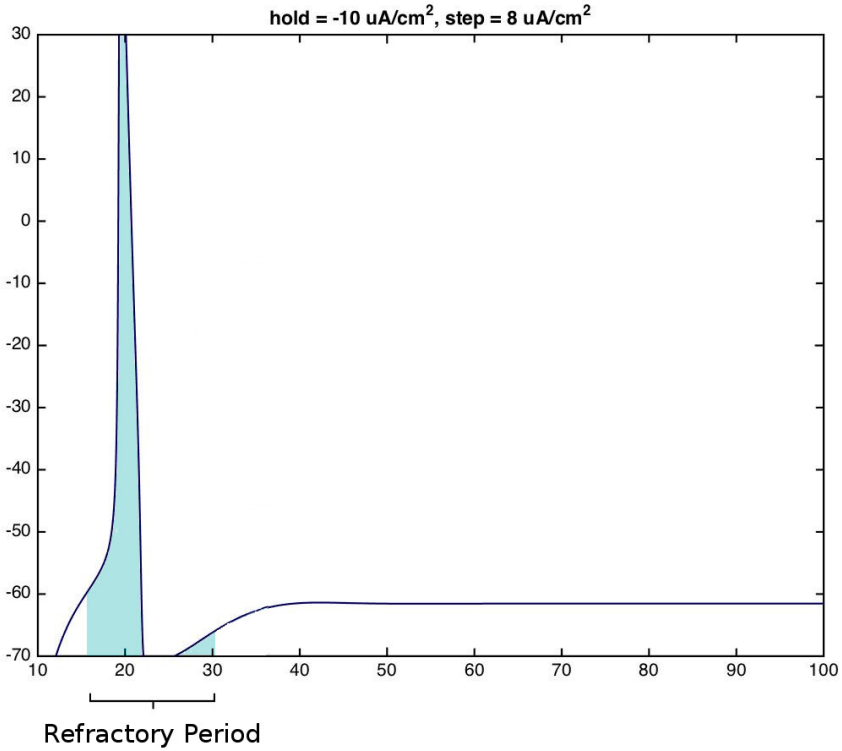
Hypothesis

$$t = \frac{C_m}{I_m V_a}$$

$$f \propto J$$

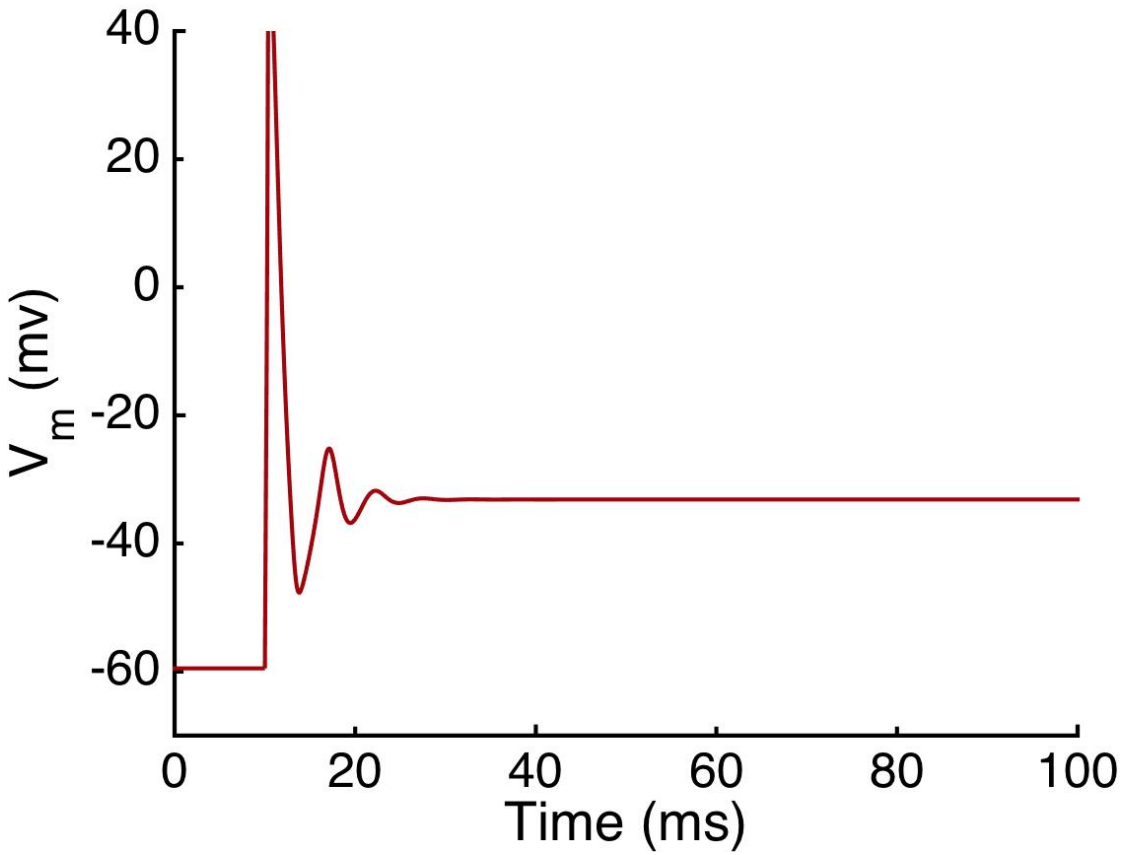
The train frequency is proportional to the current density

Applications: Refractory Period



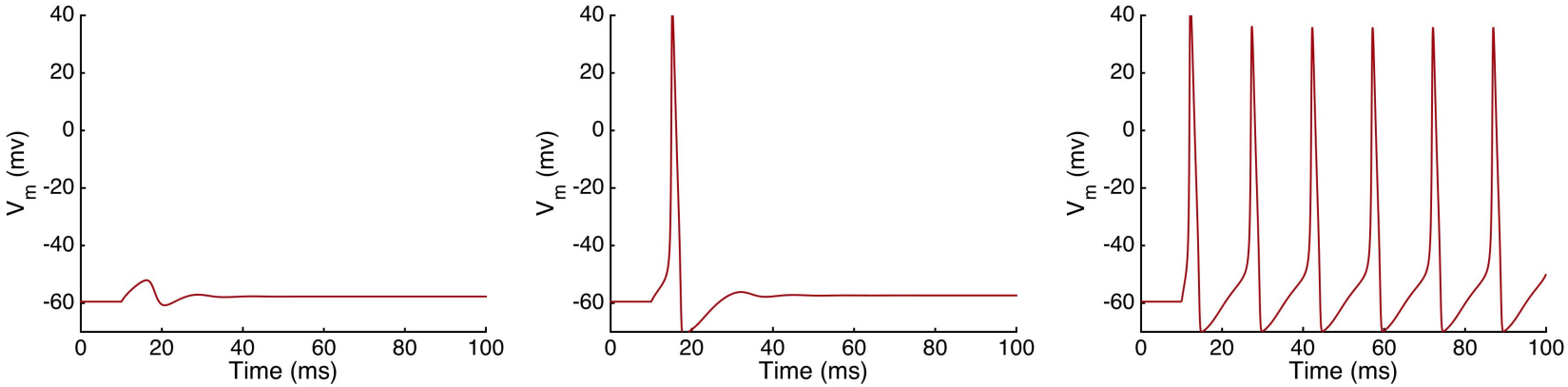
Reducing the Refractory Period can lead to faster reflexes.

Applications: Neuron Inhibition



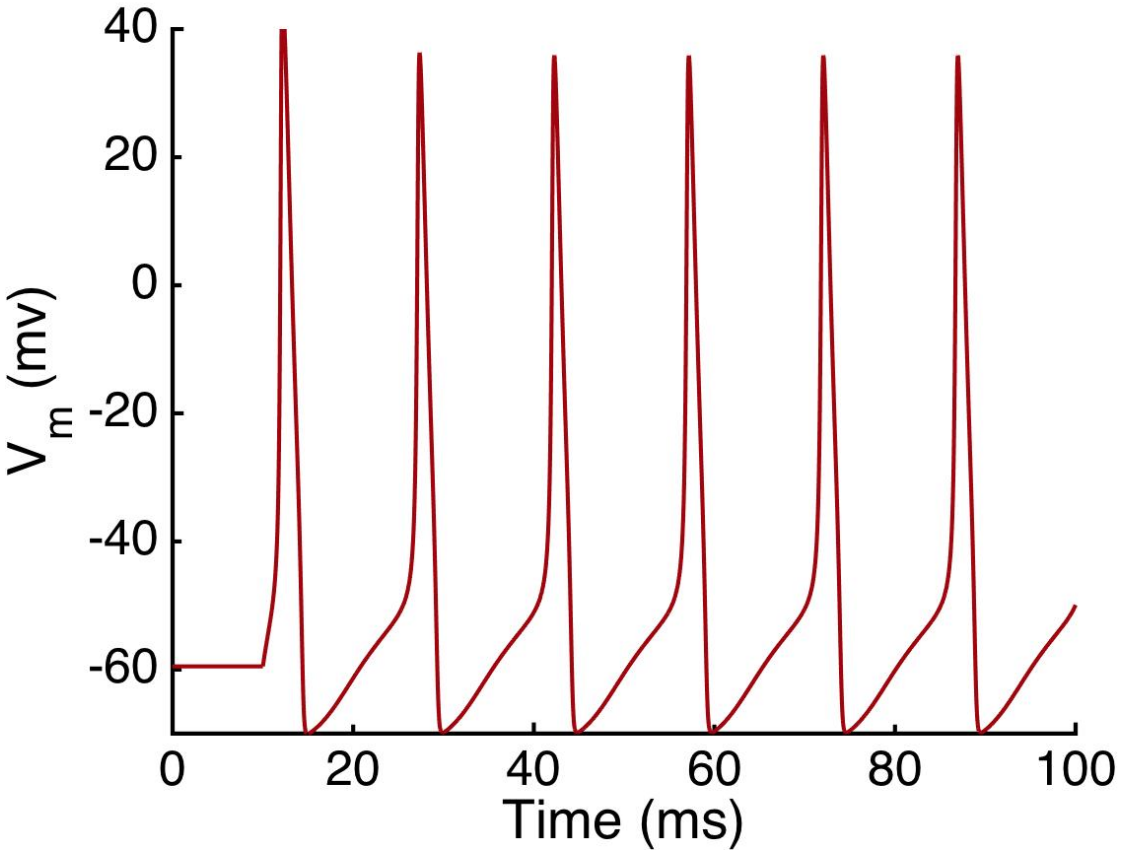
High current fully damps neuron response

Simulation Response Regions



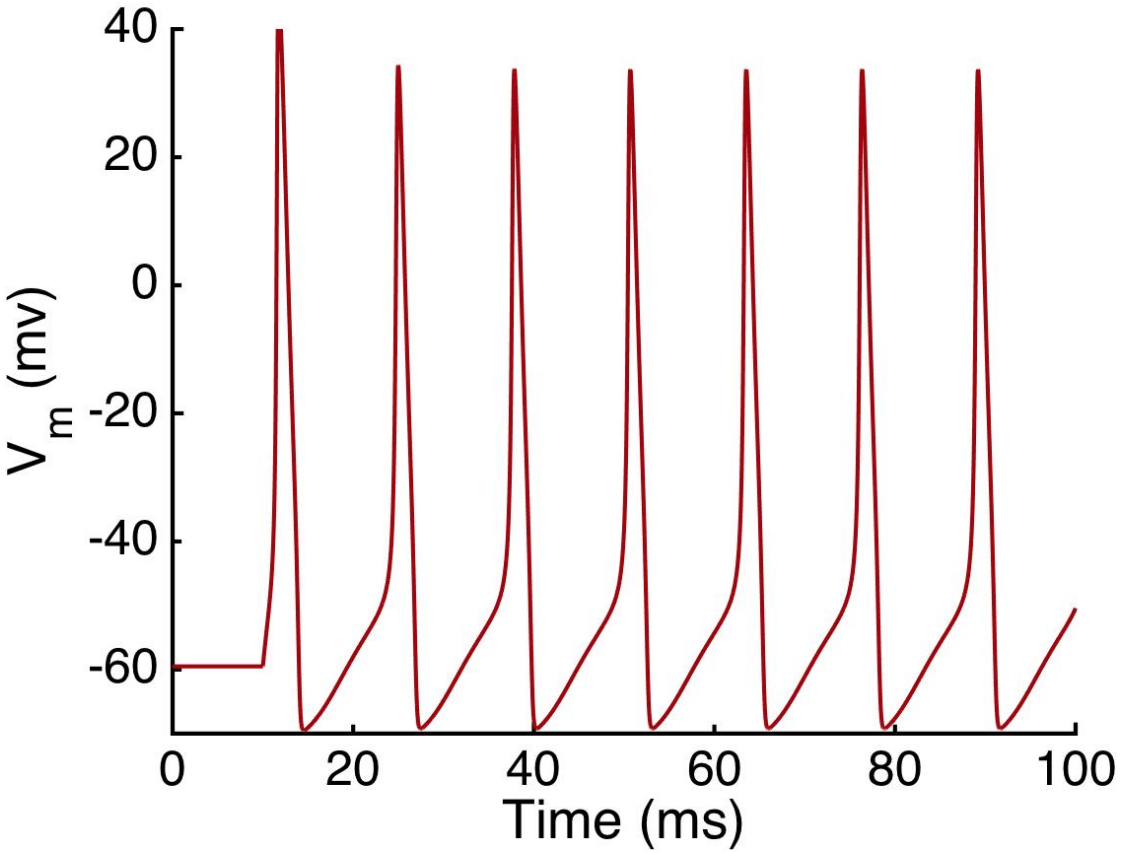
Response in the *Ringing*, *Single AP* and *AP Train* regions

HH Model Action Train



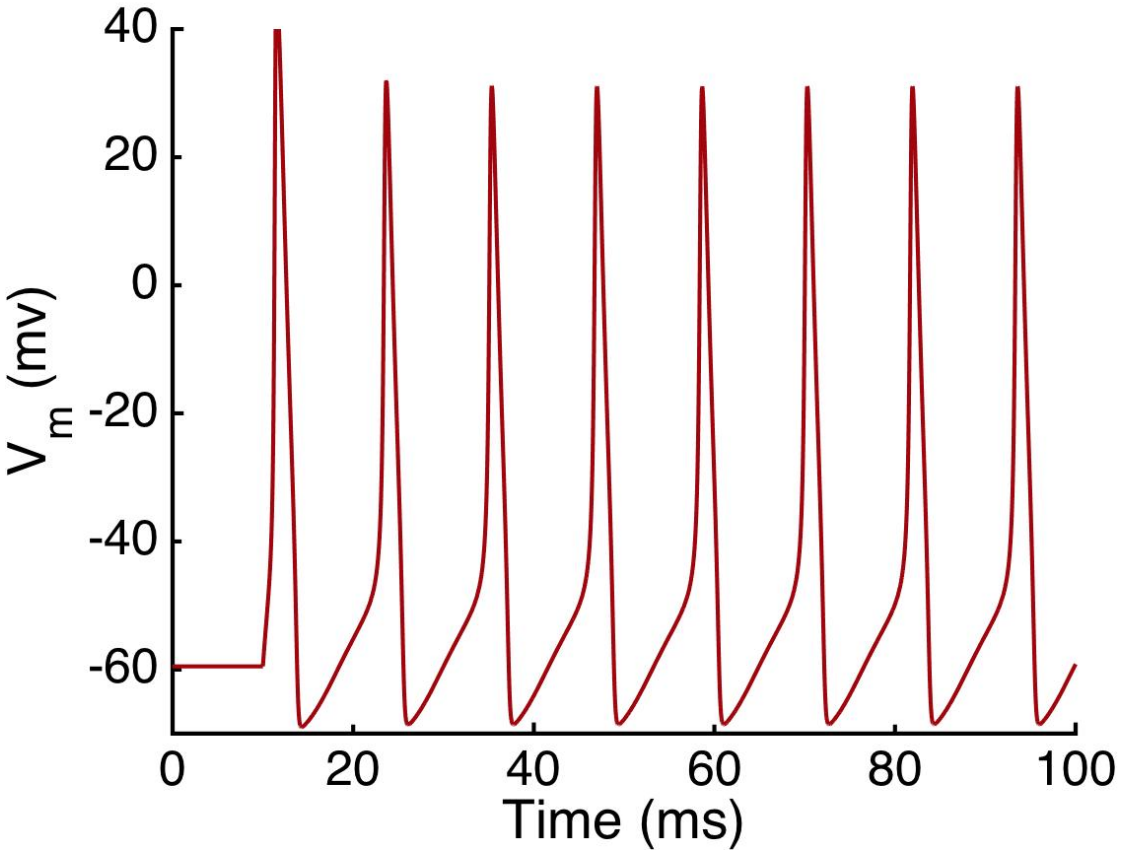
Stepping to 10 $\mu A/cm^2$

HH Model Action Train



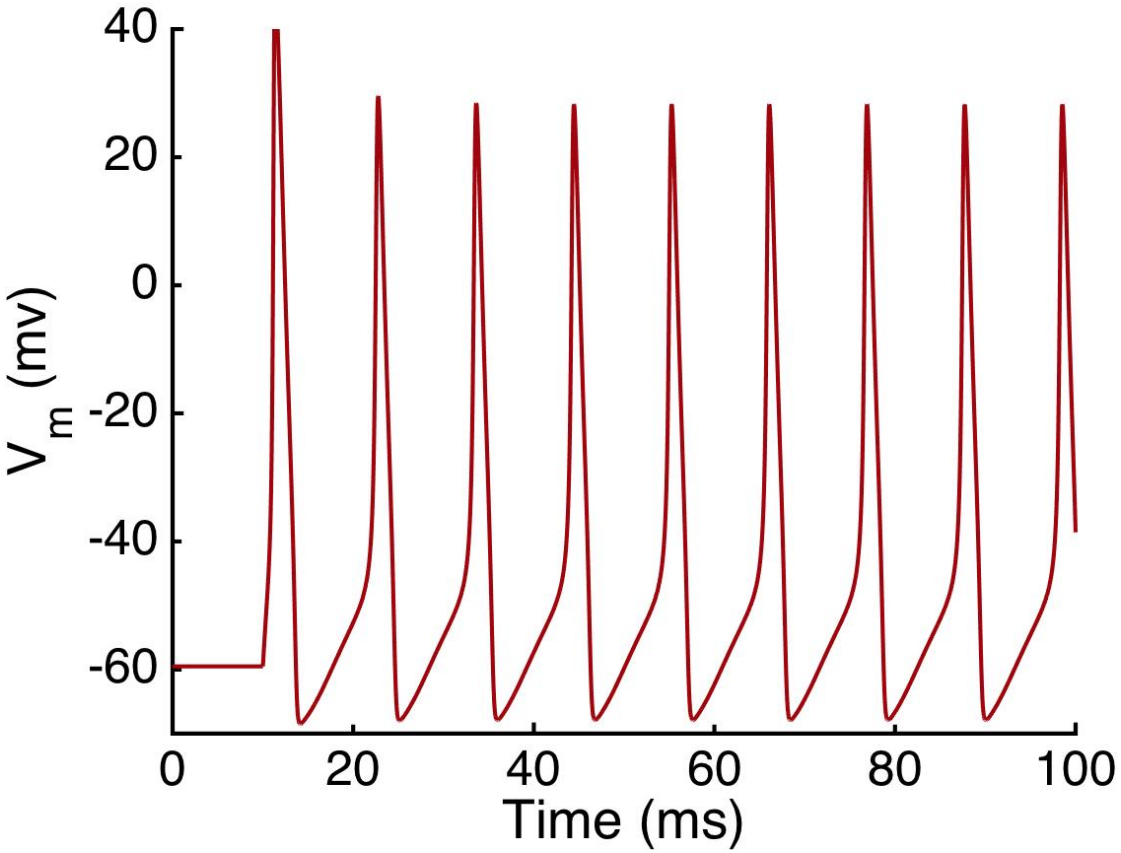
Stepping to 15 $\mu A/cm^2$

HH Model Action Train



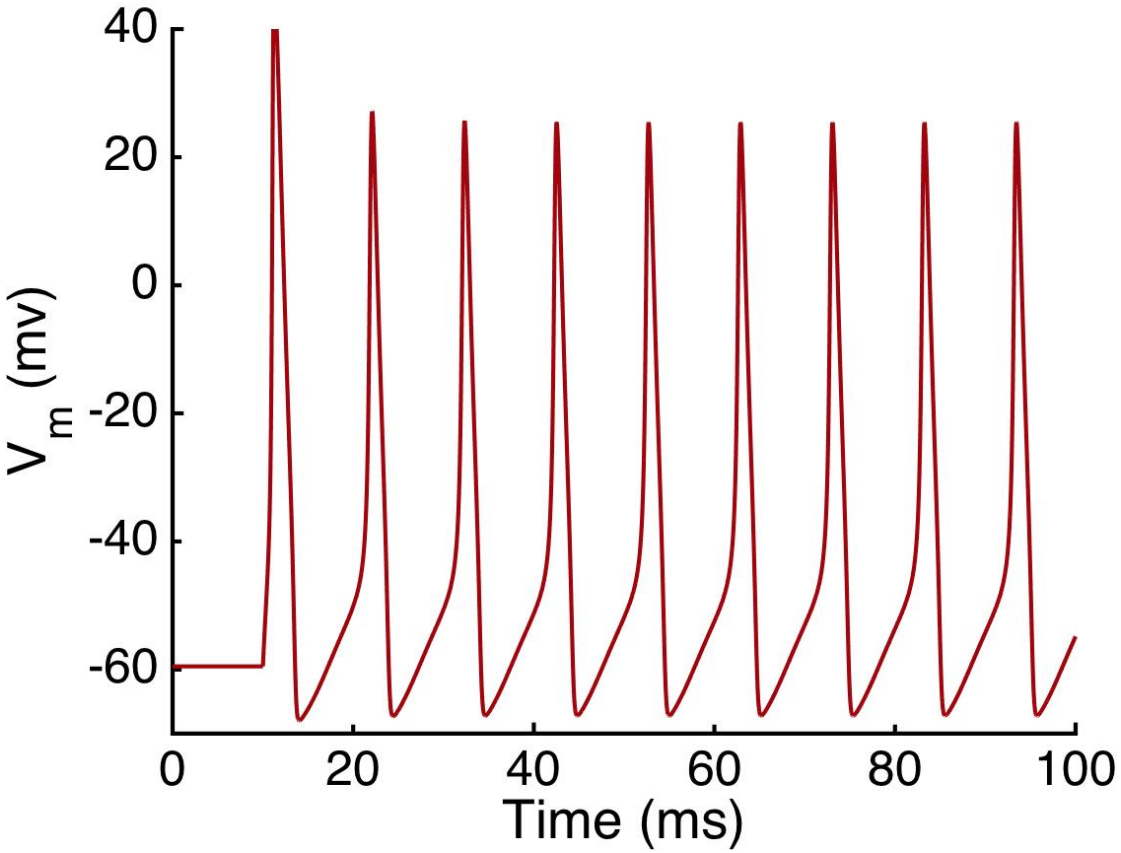
Stepping to 20 $\mu A/cm^2$

HH Model Action Train



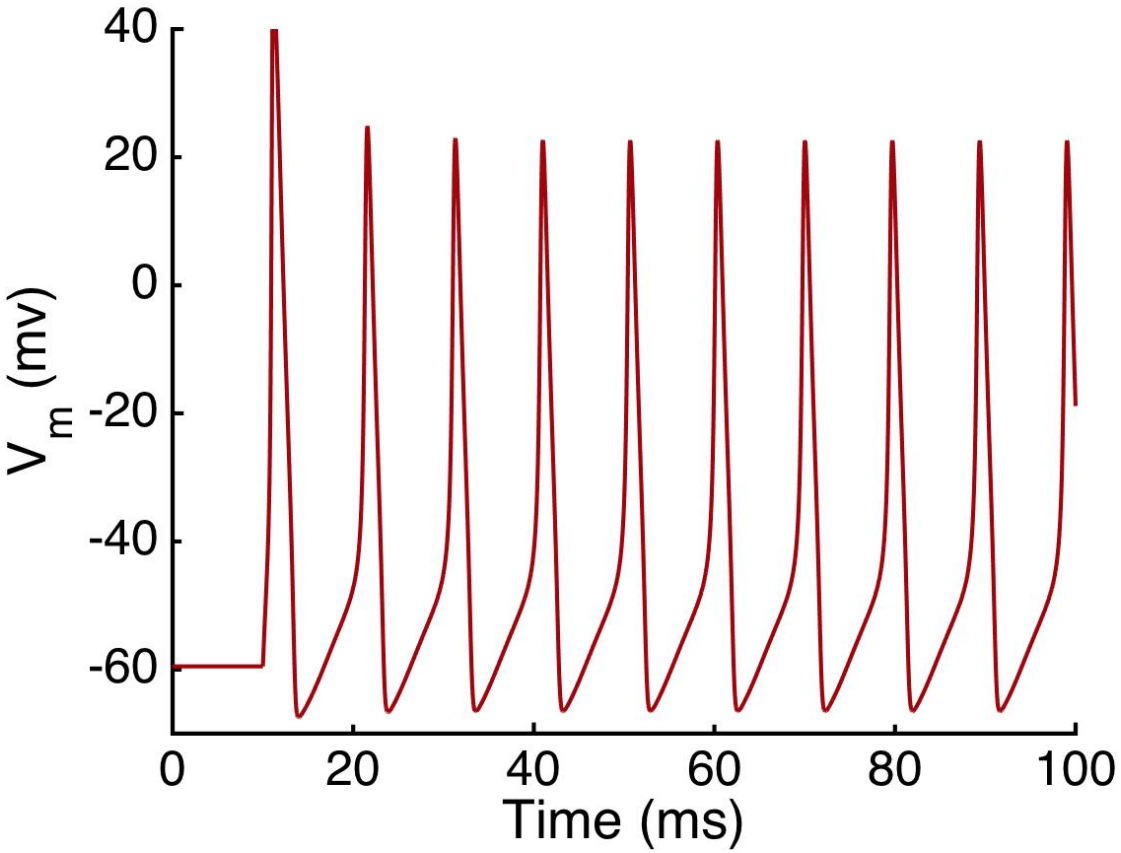
Stepping to 25 $\mu A/cm^2$

HH Model Action Train



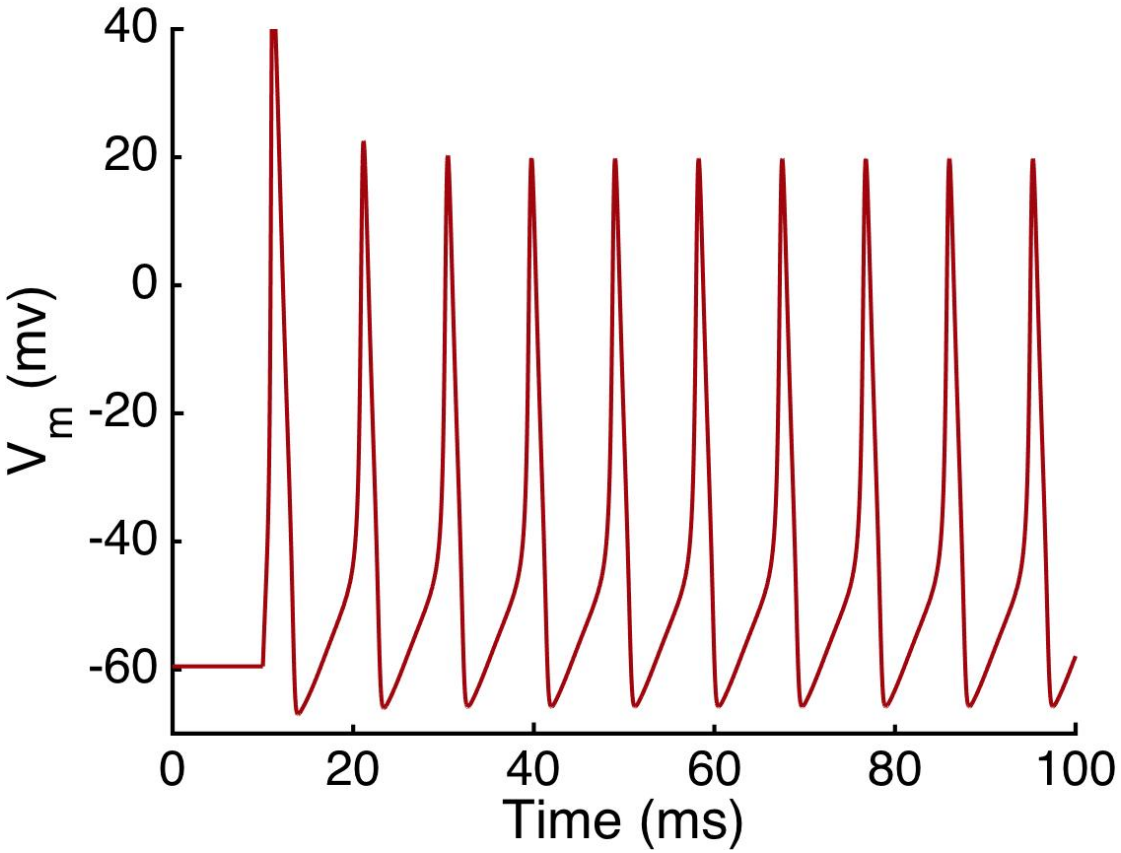
Stepping to 30 $\mu A/cm^2$

HH Model Action Train



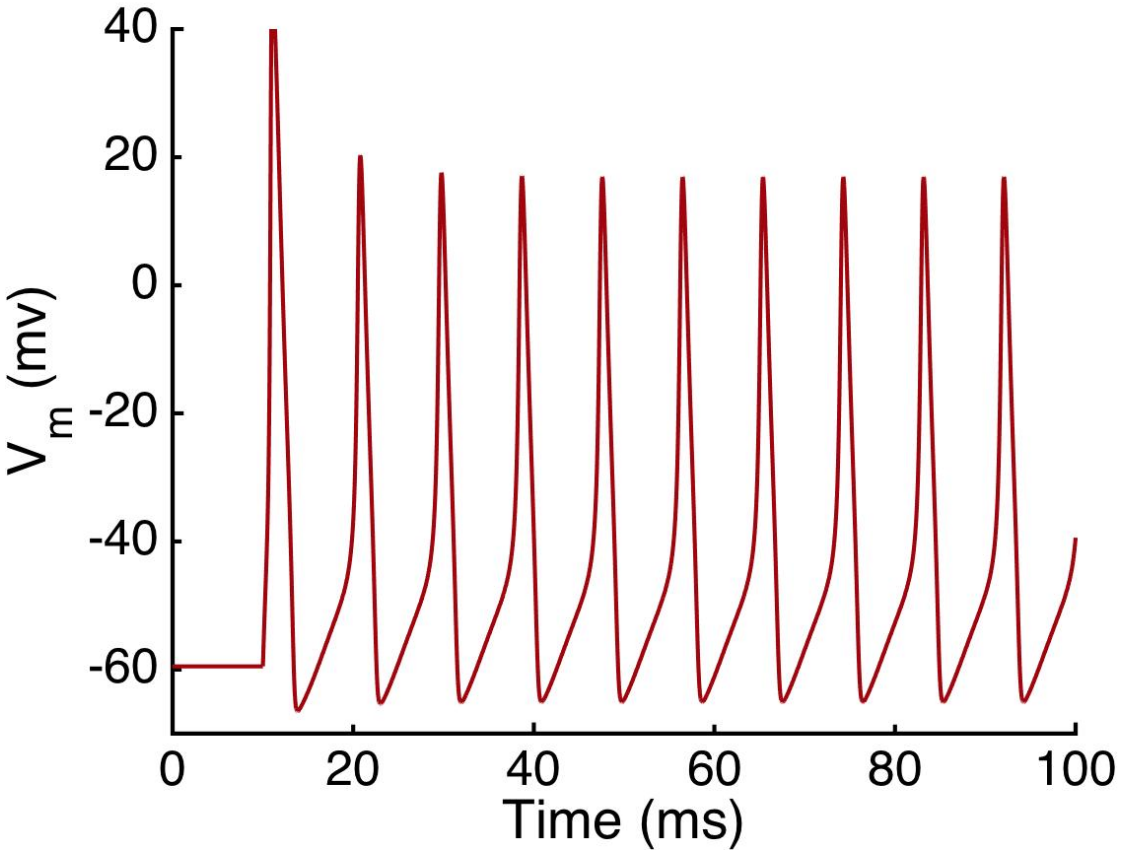
Stepping to 35 $\mu A/cm^2$

HH Model Action Train



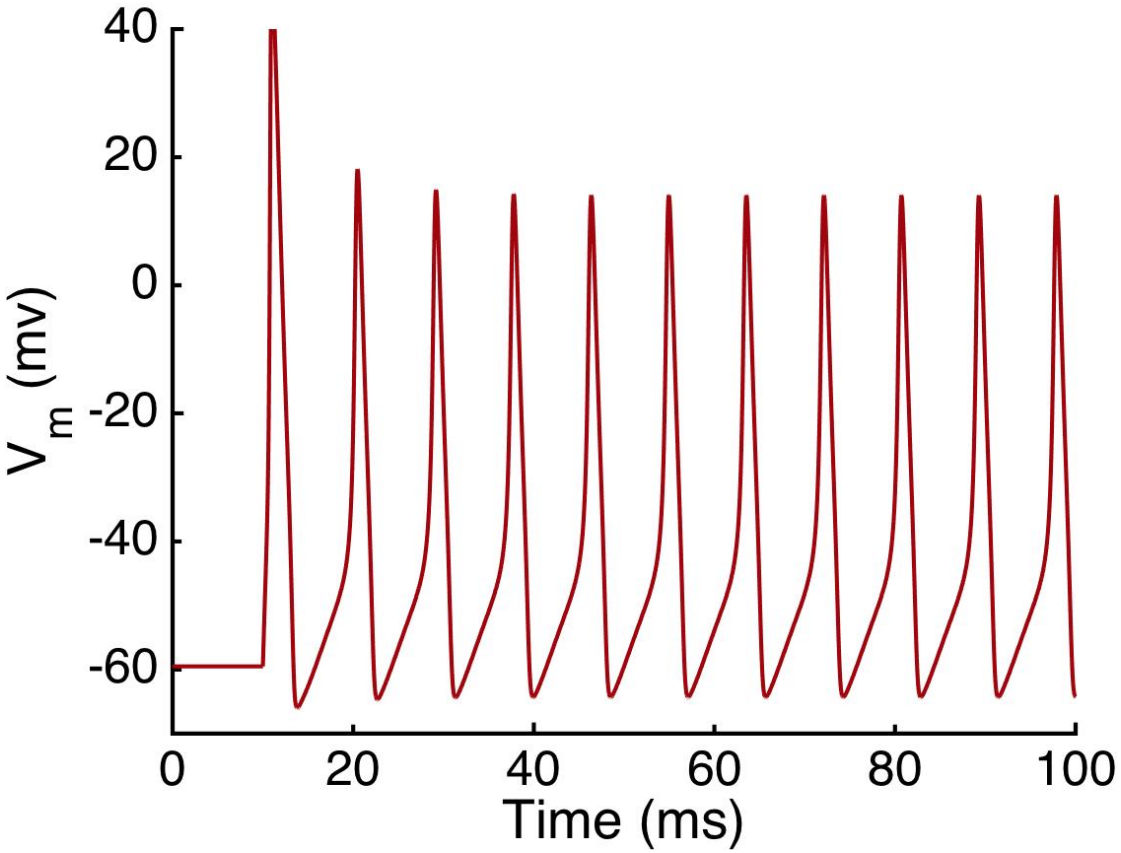
Stepping to 40 $\mu A/cm^2$

HH Model Action Train



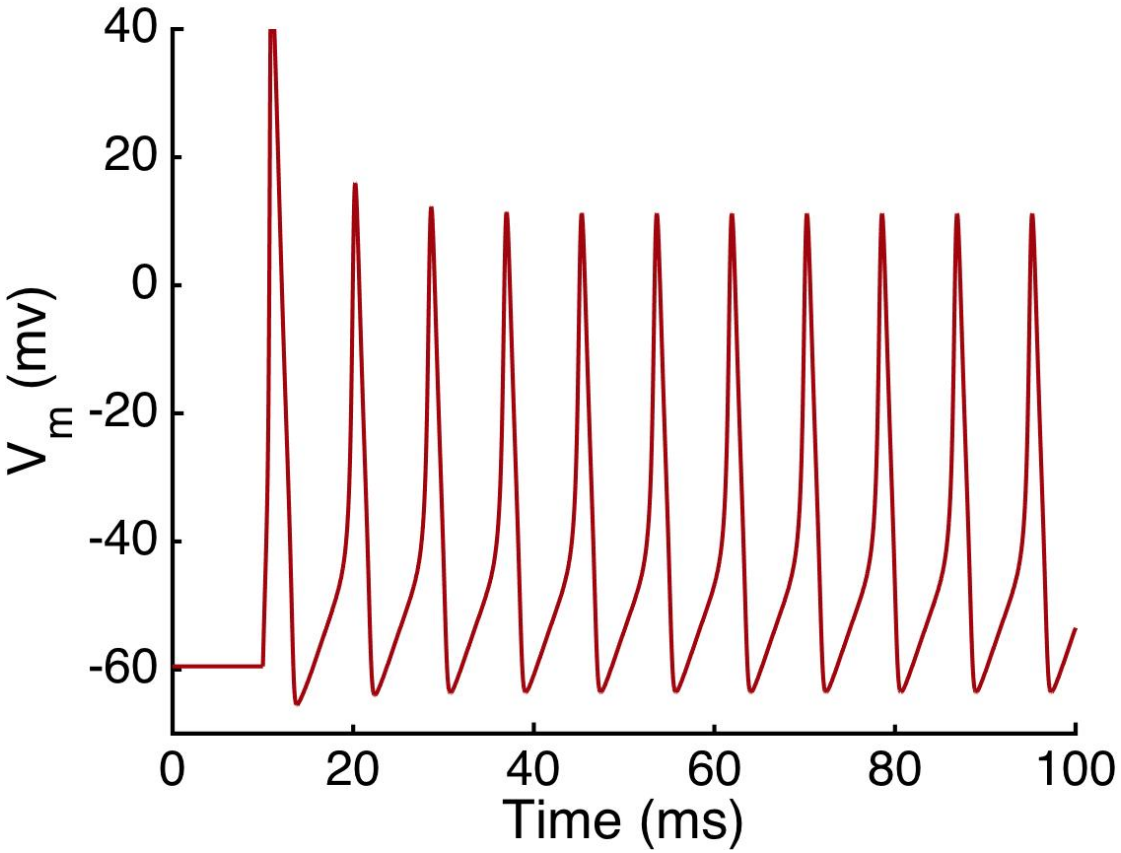
Stepping to 45 $\mu A/cm^2$

HH Model Action Train



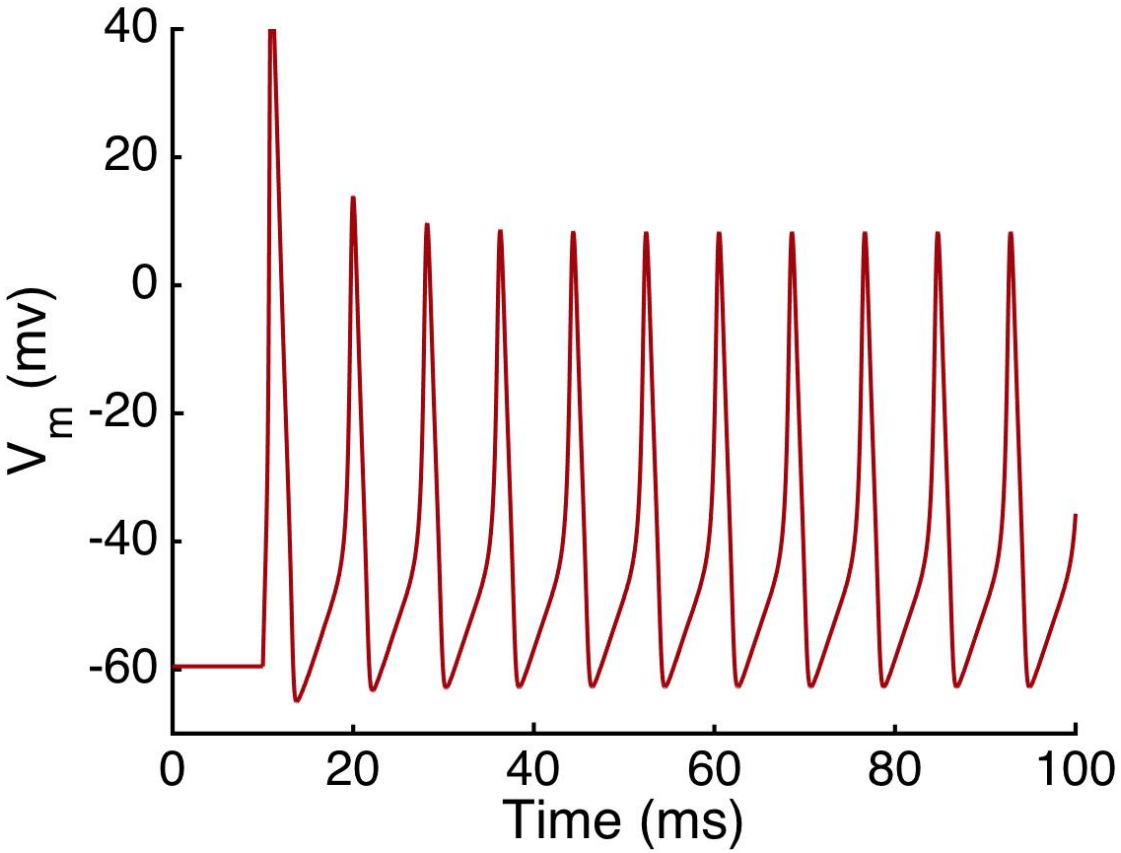
Stepping to 50 $\mu A/cm^2$

HH Model Action Train



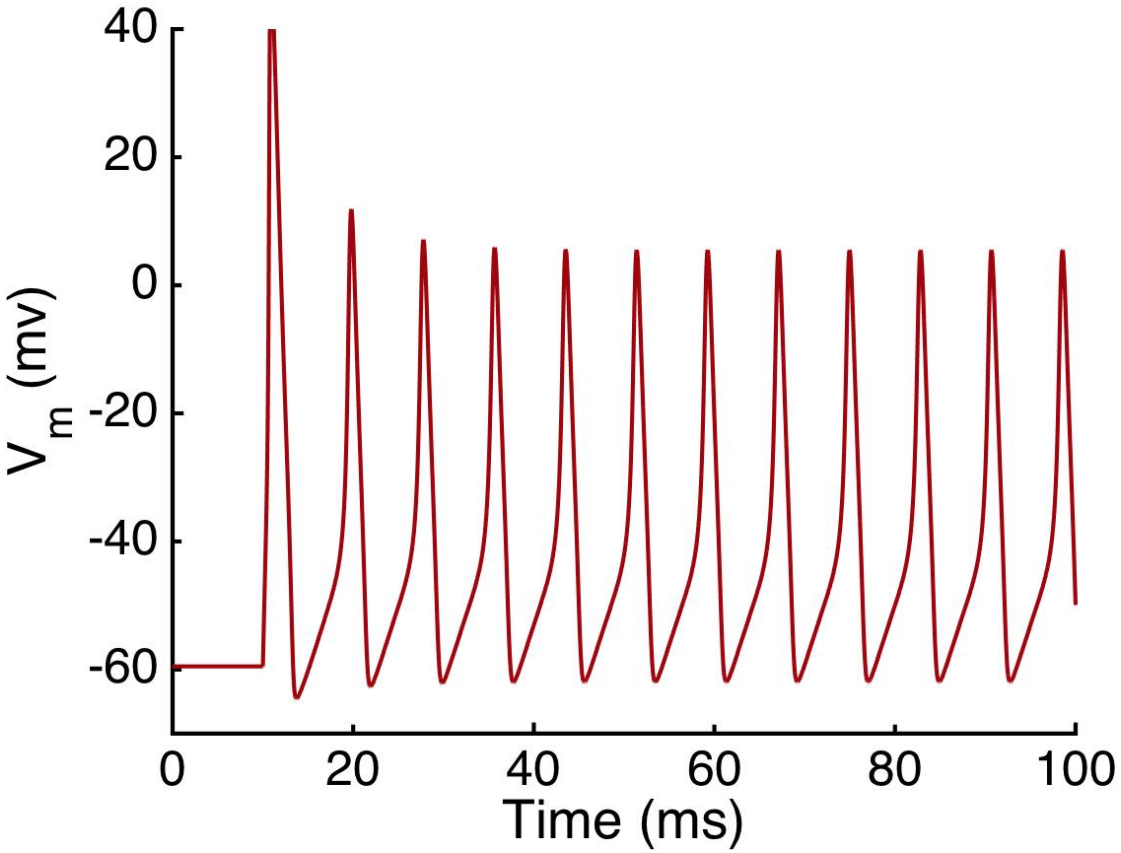
Stepping to 55 $\mu A/cm^2$

HH Model Action Train



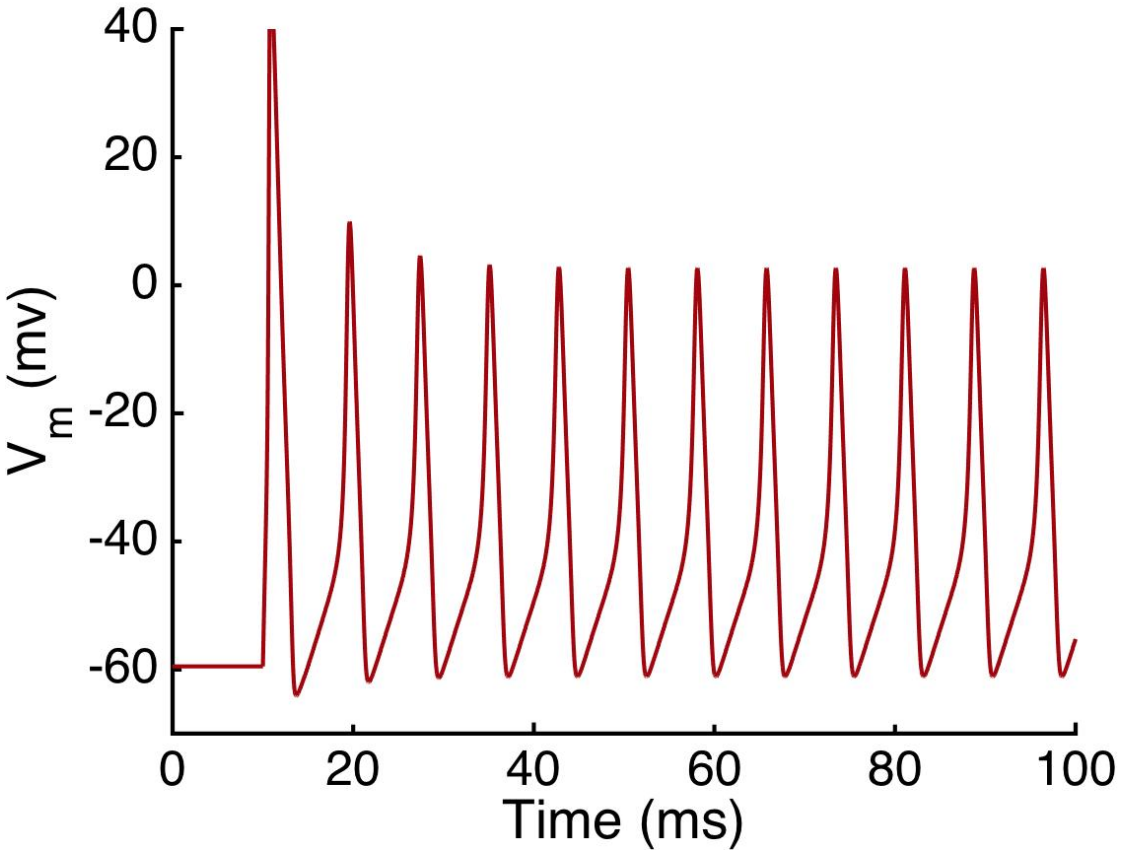
Stepping to 60 $\mu A/cm^2$

HH Model Action Train



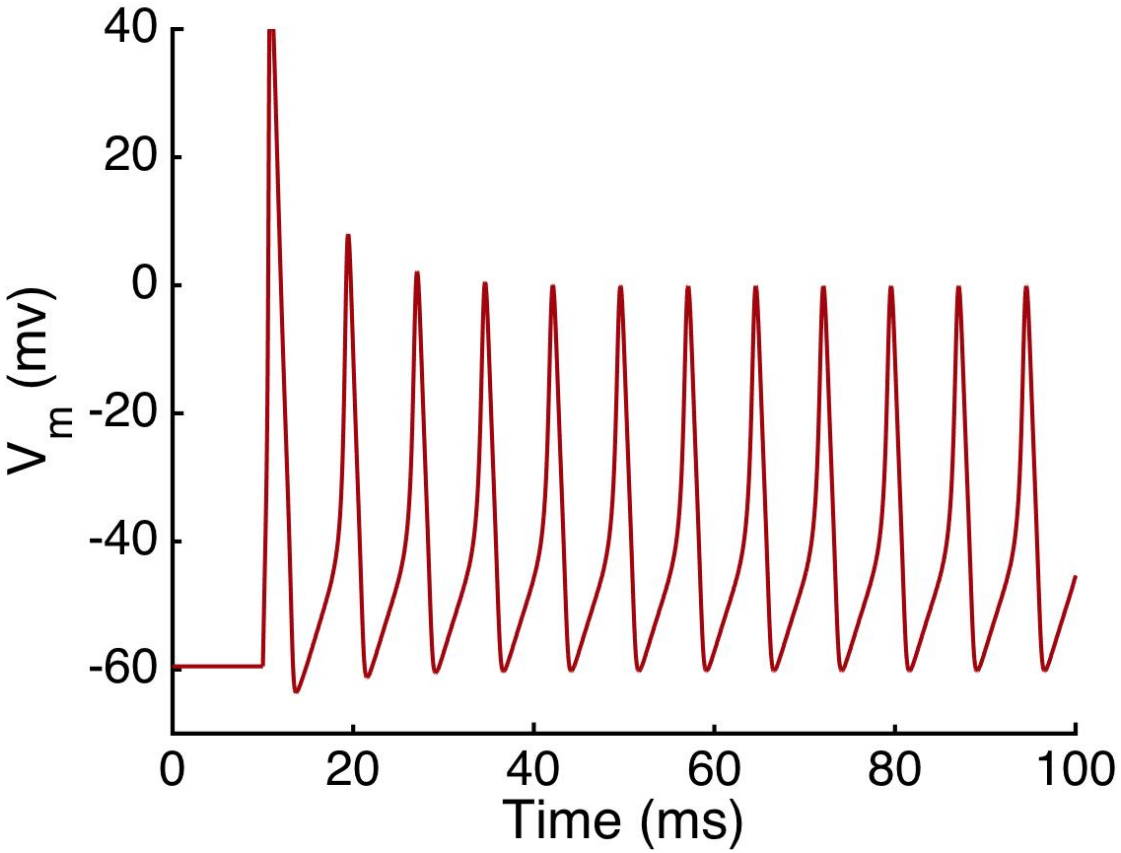
Stepping to 65 $\mu A/cm^2$

HH Model Action Train



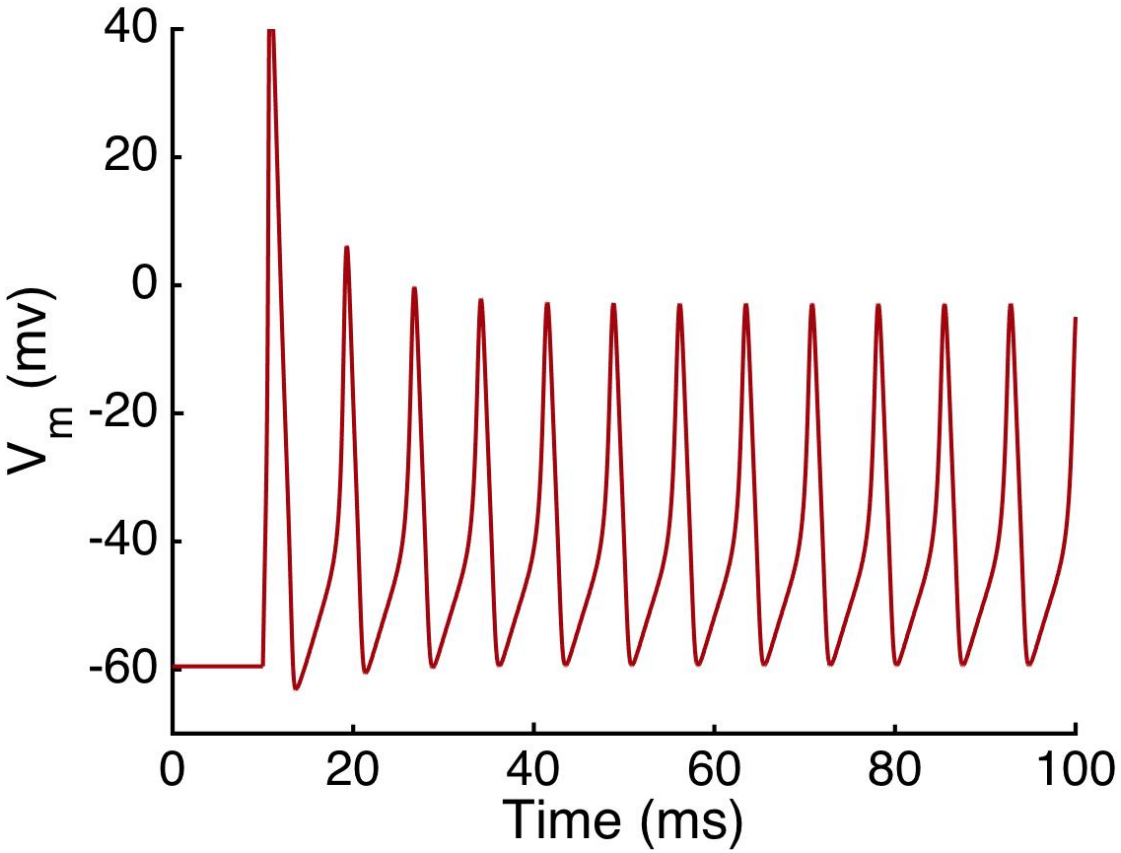
Stepping to 70 $\mu A/cm^2$

HH Model Action Train



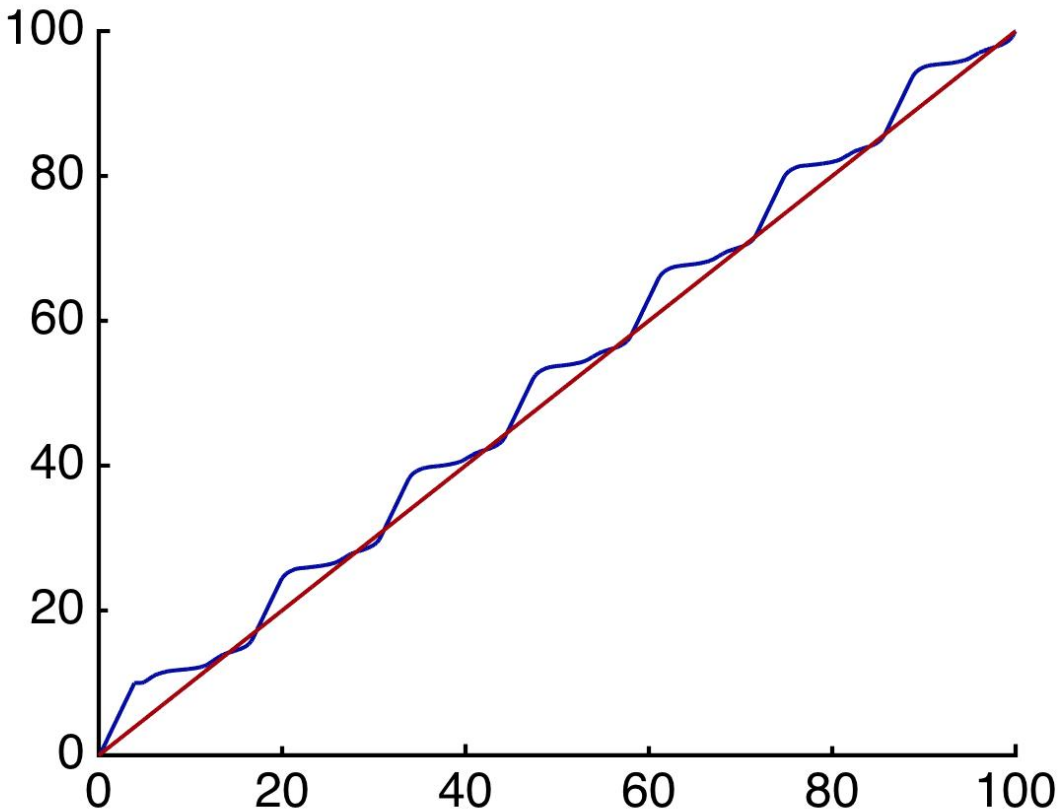
Stepping to 75 $\mu A/cm^2$

HH Model Action Train



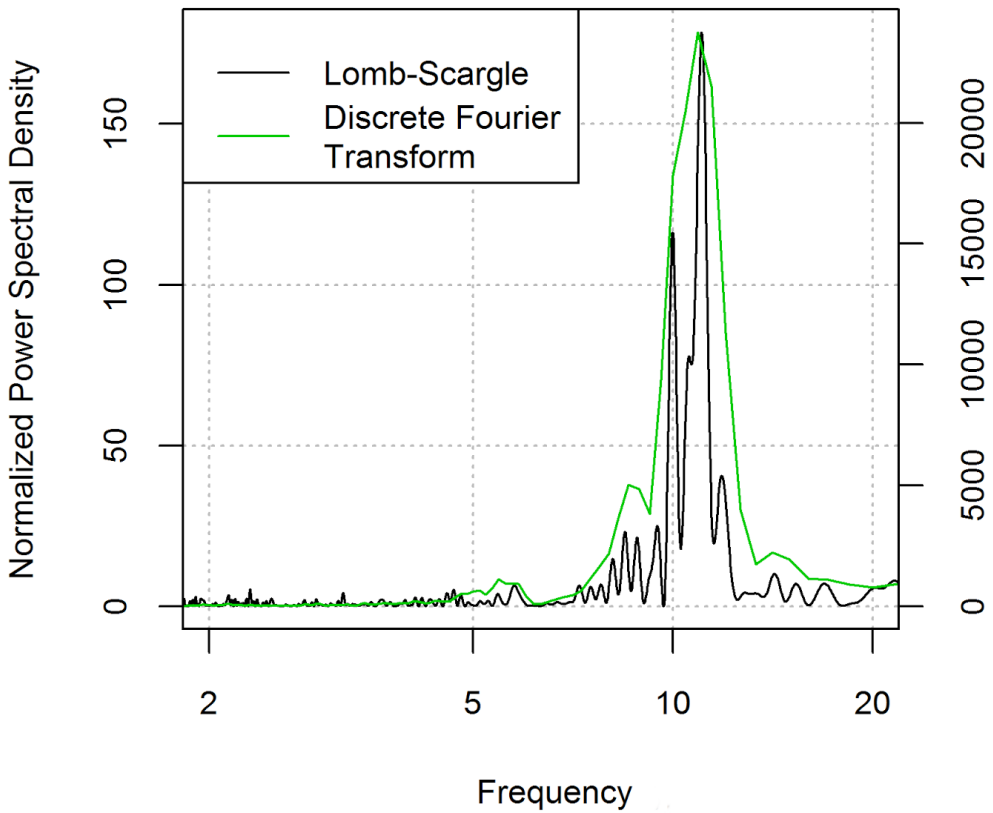
Stepping to 80 $\mu A/cm^2$

Fourier Transform Insufficient: Inconsistent Time Intervals



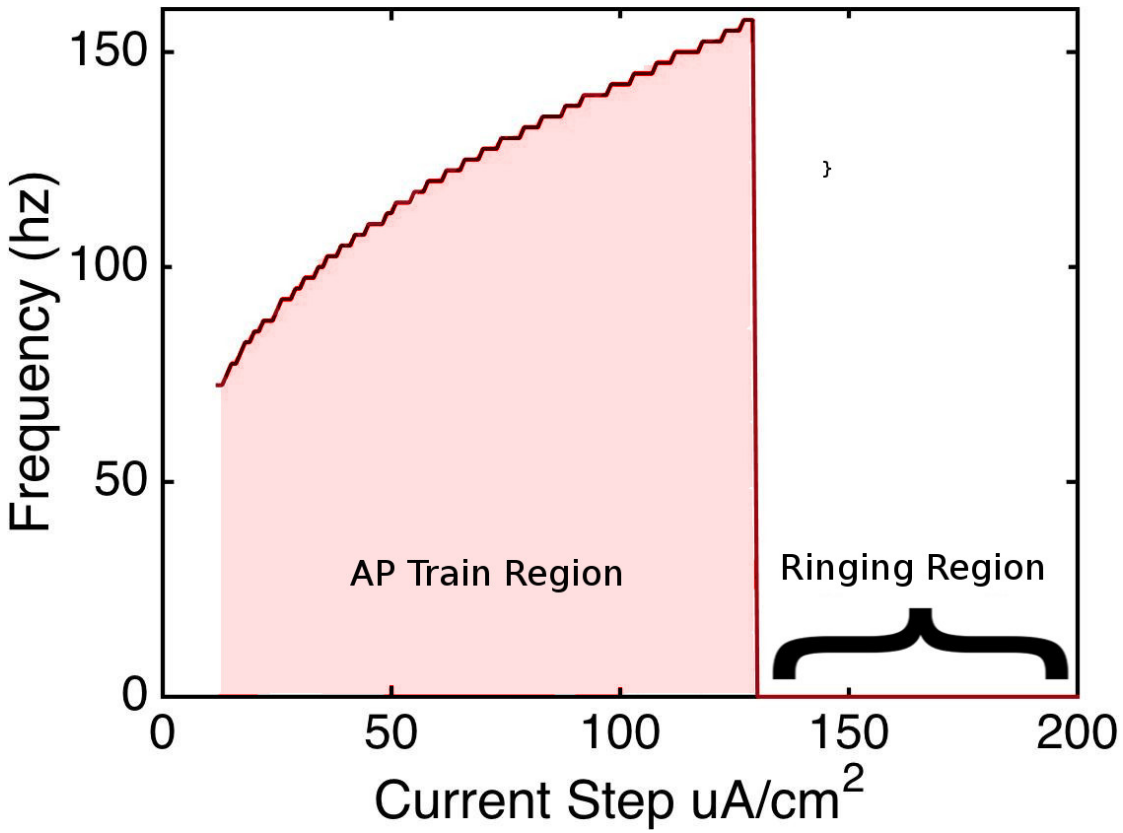
FFT insufficient, need a better Spectral Analysis Method

Least-Squares Spectral Analysis



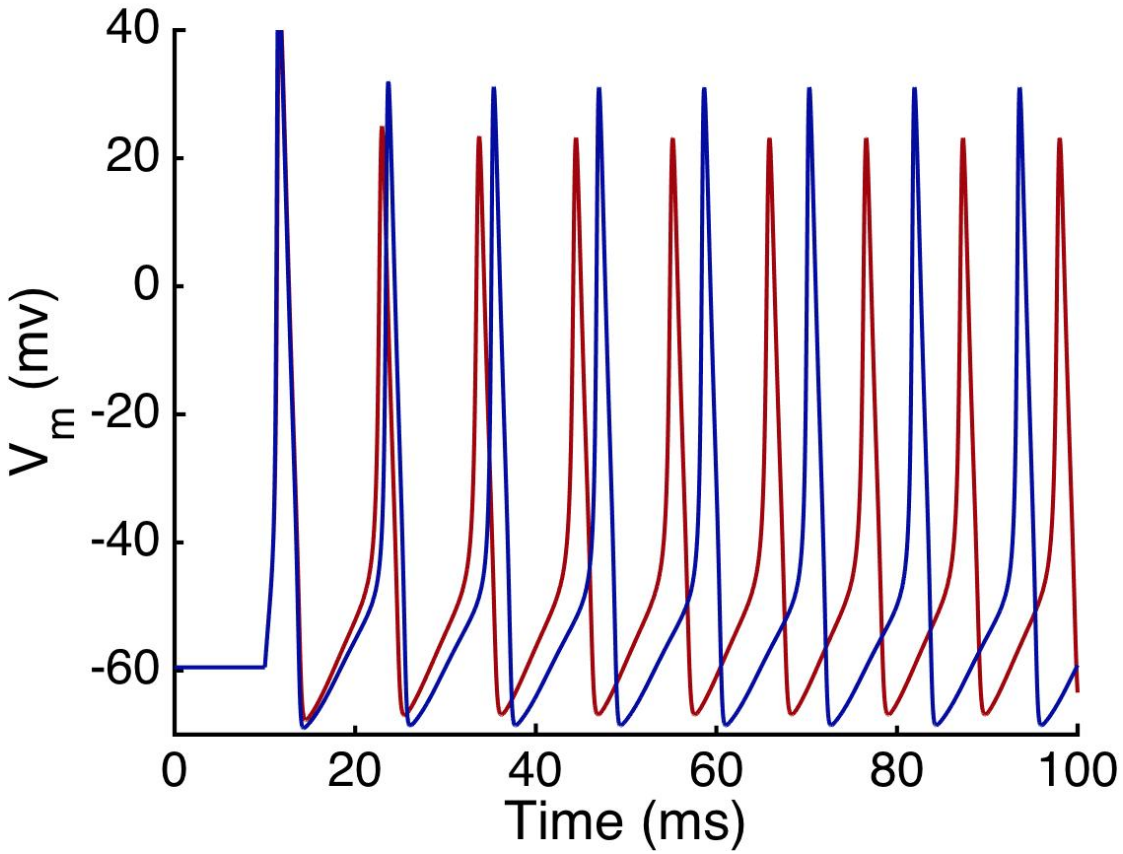
The Lomb-Scargle Periodogram works with variable intervals.

Graphing the Train Frequency



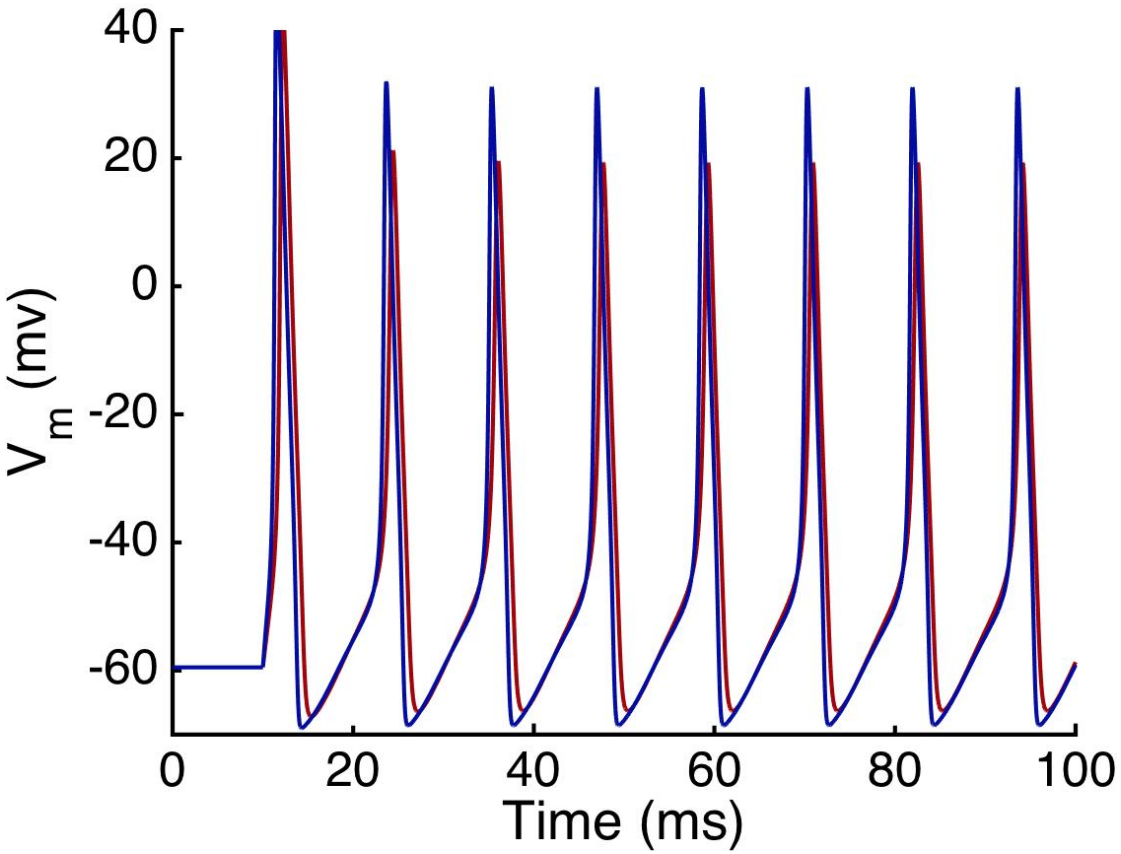
Nonlinearity shows complexity of behavior

Naive Mechanism



Equal ratio of current to capacitance

Mechanism



Unequal ratio of current to capacitance

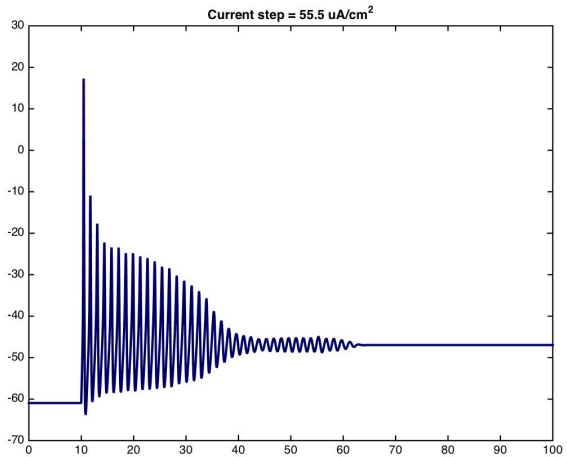
Conclusion

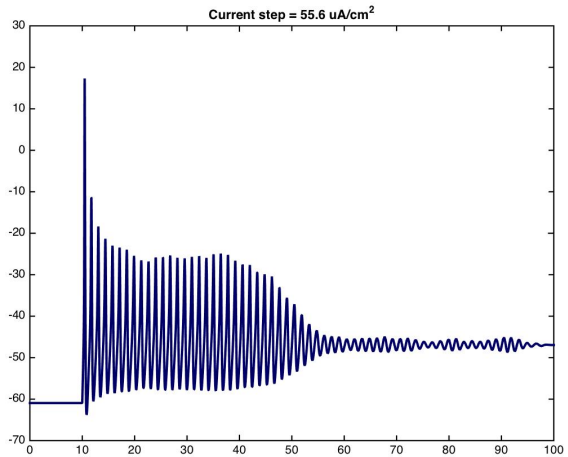
1. Innovative experimental method
2. Clear definition of saturation threshold
3. High accuracy prediction of cell response
4. Refuted possible simplification

References

1. Weiss, T. F. (1995).Cellular Biophysics. Volume 1: Transport, MIT Press.
2. Weiss, T. F. (1995).Cellular Biophysics. Volume 2: Electrical Properties, MIT Press.
3. Blaustein, M.P., Kao, J.P.Y., Matteson, D.R. (2012). Cellular Physiology and Neurophysiology, 2nd edition, Elsevier-Mosby.
4. Gerstner, Wulfram, and Werner M. Kistler. Spiking neuron models: Single neurons, populations, plasticity. Cambridge university press, 2002.
5. Press, William H., and George B. Rybicki. "Fast algorithm for spectral analysis of unevenly sampled data." The Astrophysical Journal 338 (1989): 277–280.

Anomalies With Default HH Model Settings





Incorrect behavior due to low precision