# Step Current Response of the HH Model

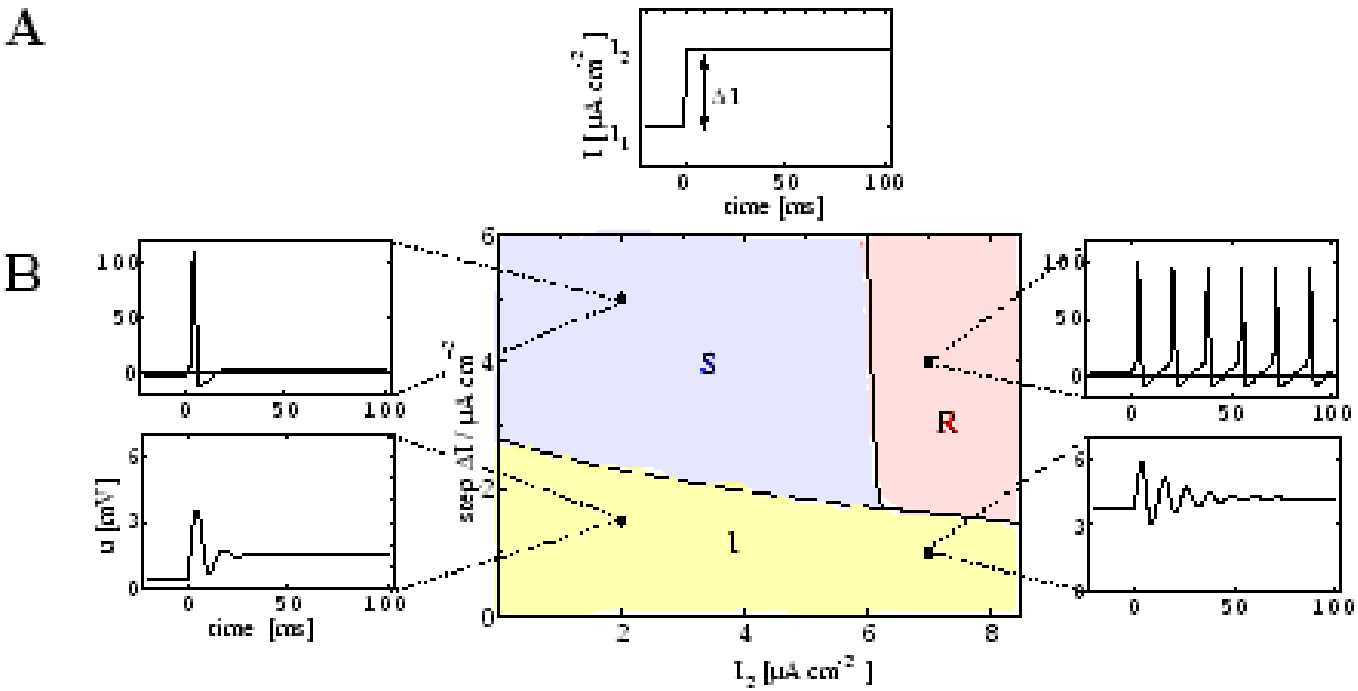
Eleftherios Ioannidis
elefthei@mit.edu

James Hobin
hobinjk@mit.edu

MIT EECS

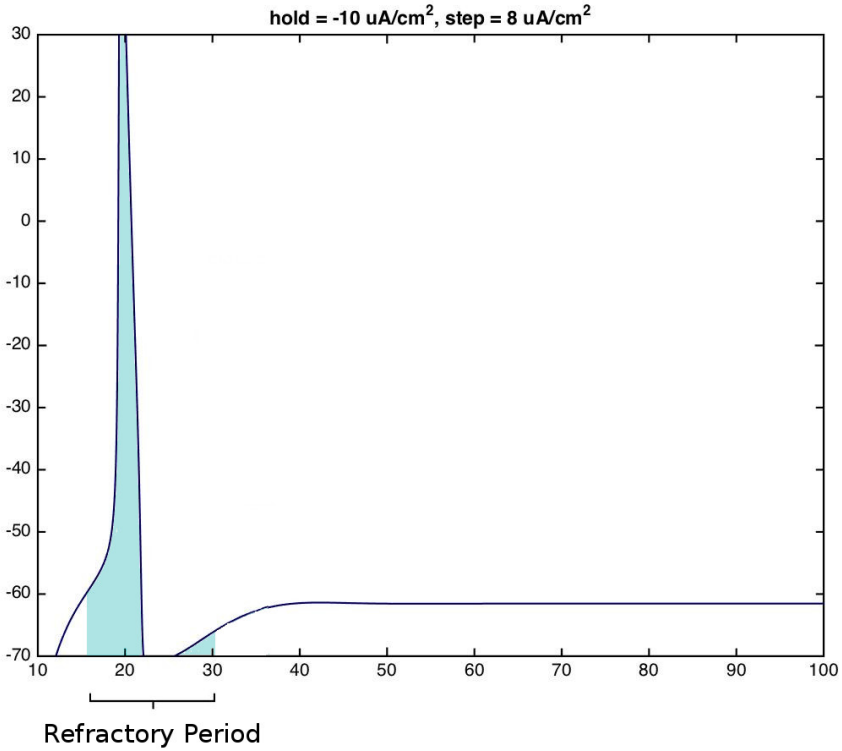
December 4, 2014

# HH Model Step Current Response



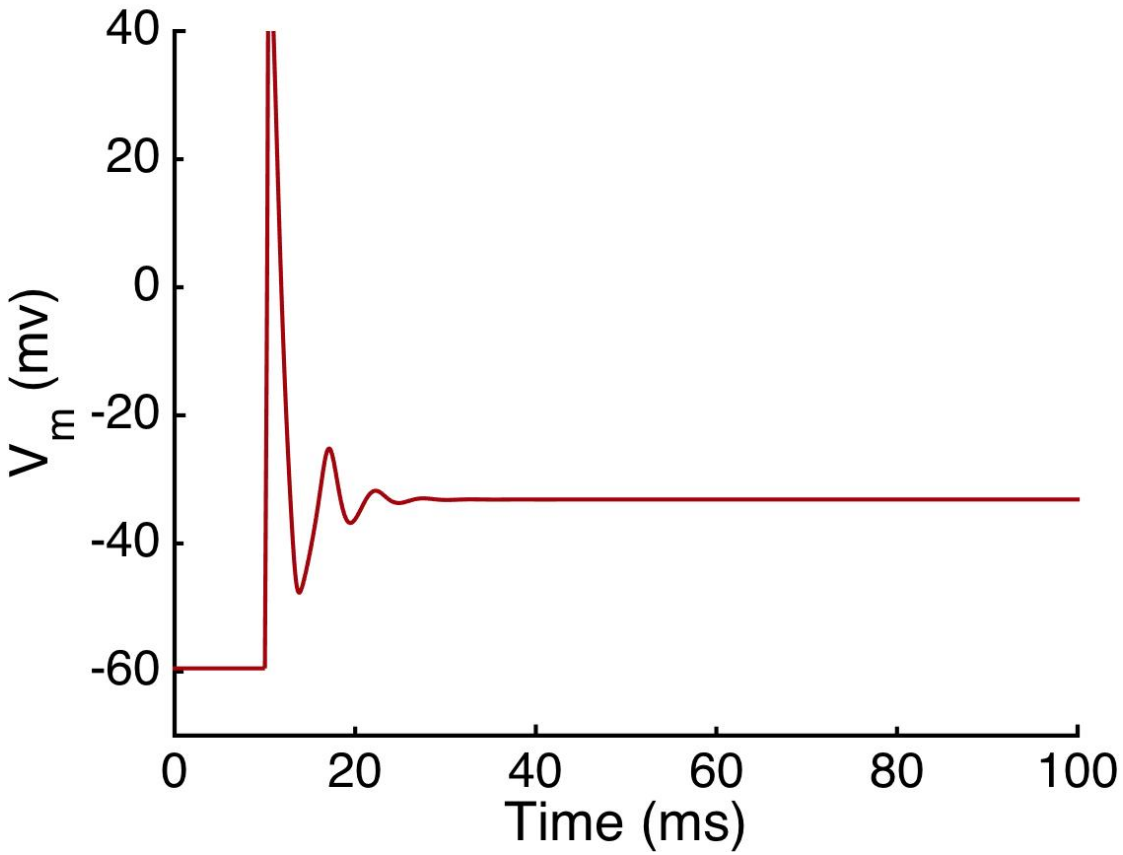

Step Current Stimulation Phase diagram

# Applications: Refractory Period



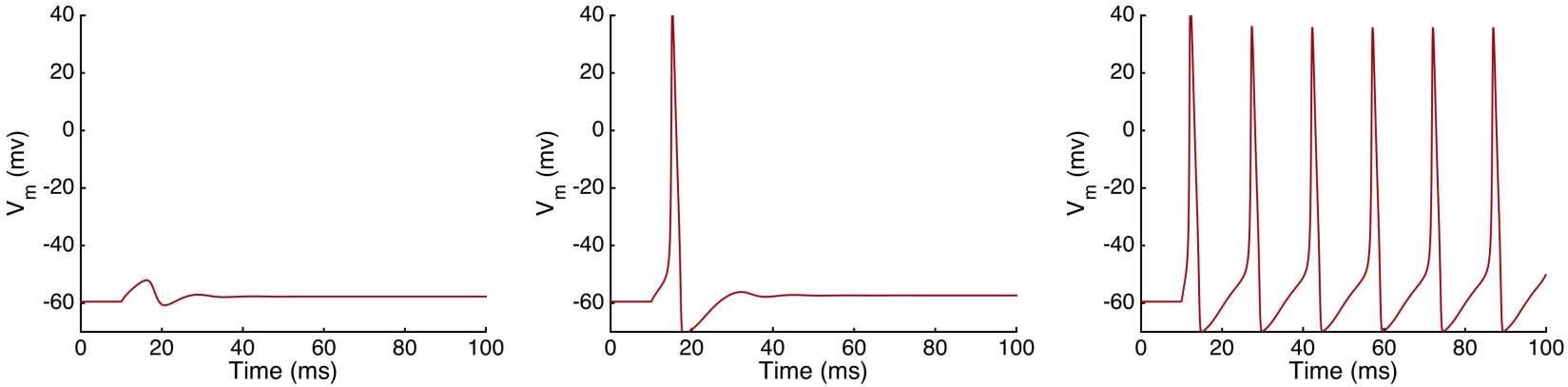

Reducing the Refractory Period can lead to faster reflexes.

# Applications: Neuron Inhibition



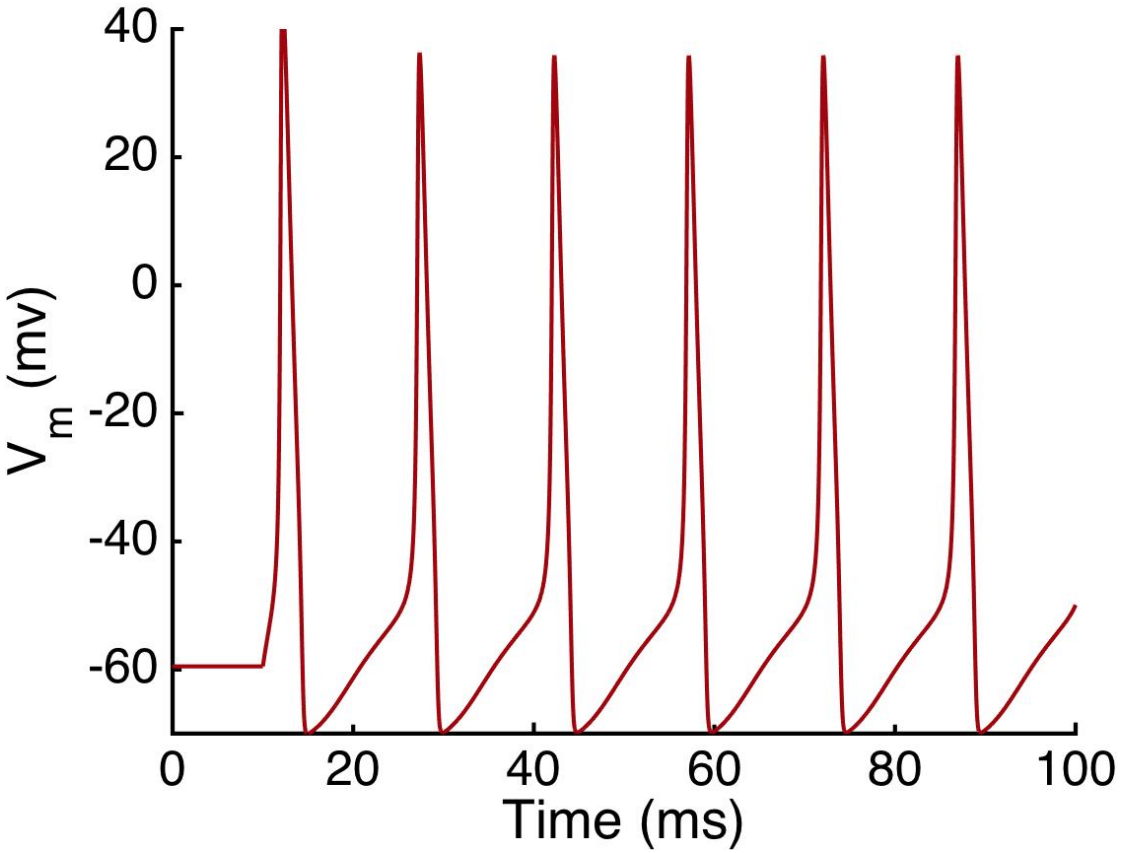

High current fully damps neuron response

# Simulation Response Regions



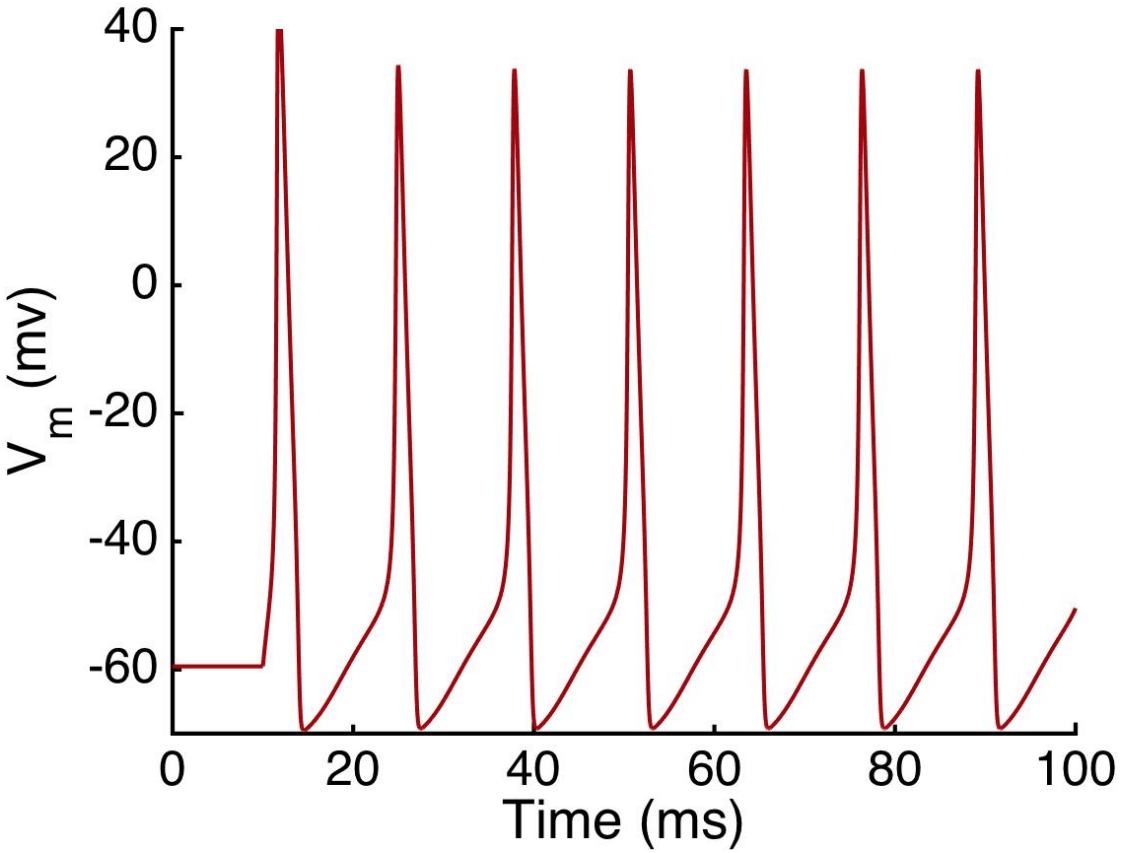

Response in the *Ringing*, *Single AP* and *AP Train* regions

# HH Model Action Train



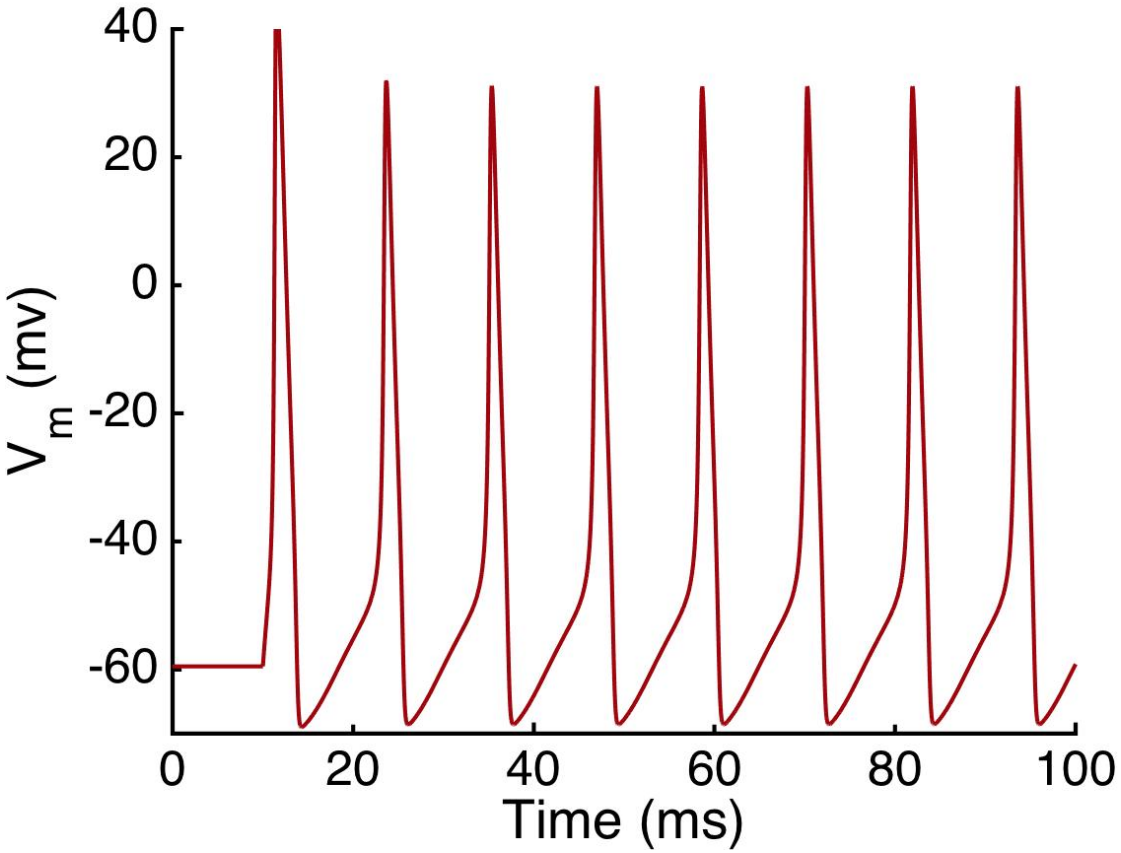

Stepping to 10 $\mu A/cm^2$

# HH Model Action Train



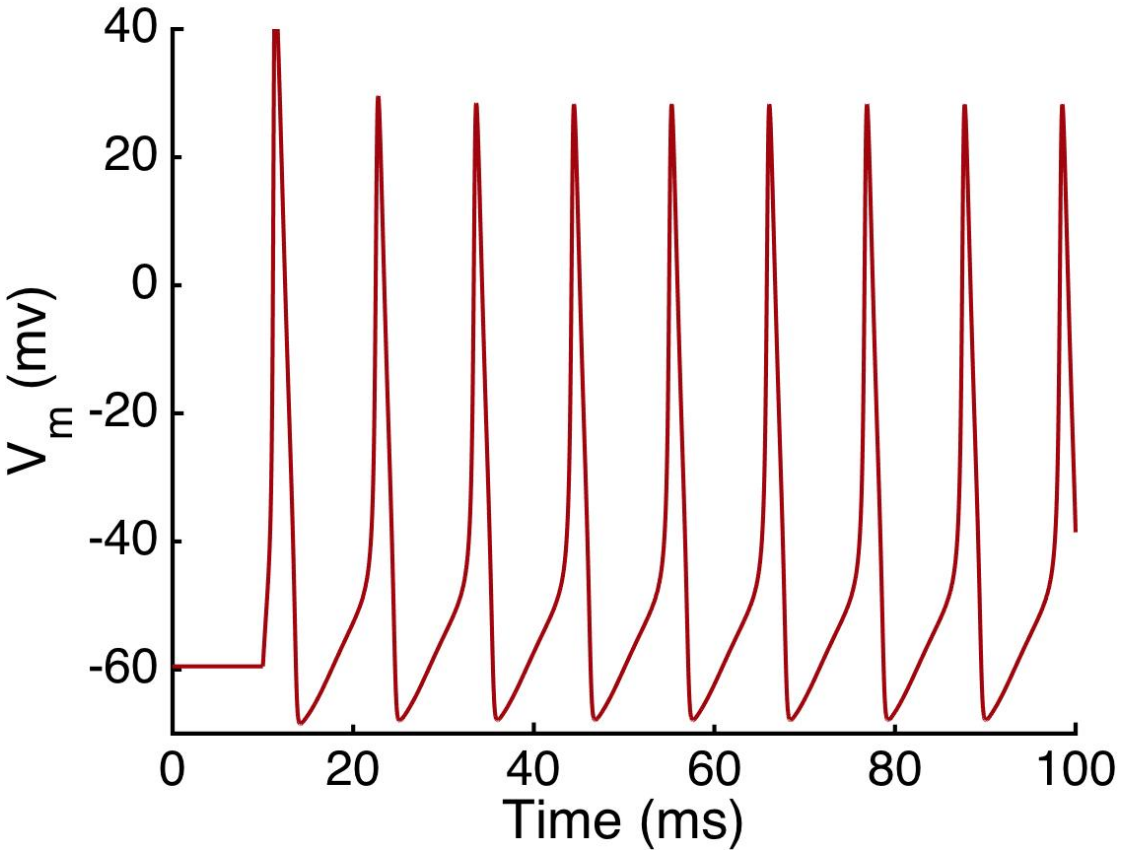

Stepping to 15 $\mu A/cm^2$

# HH Model Action Train



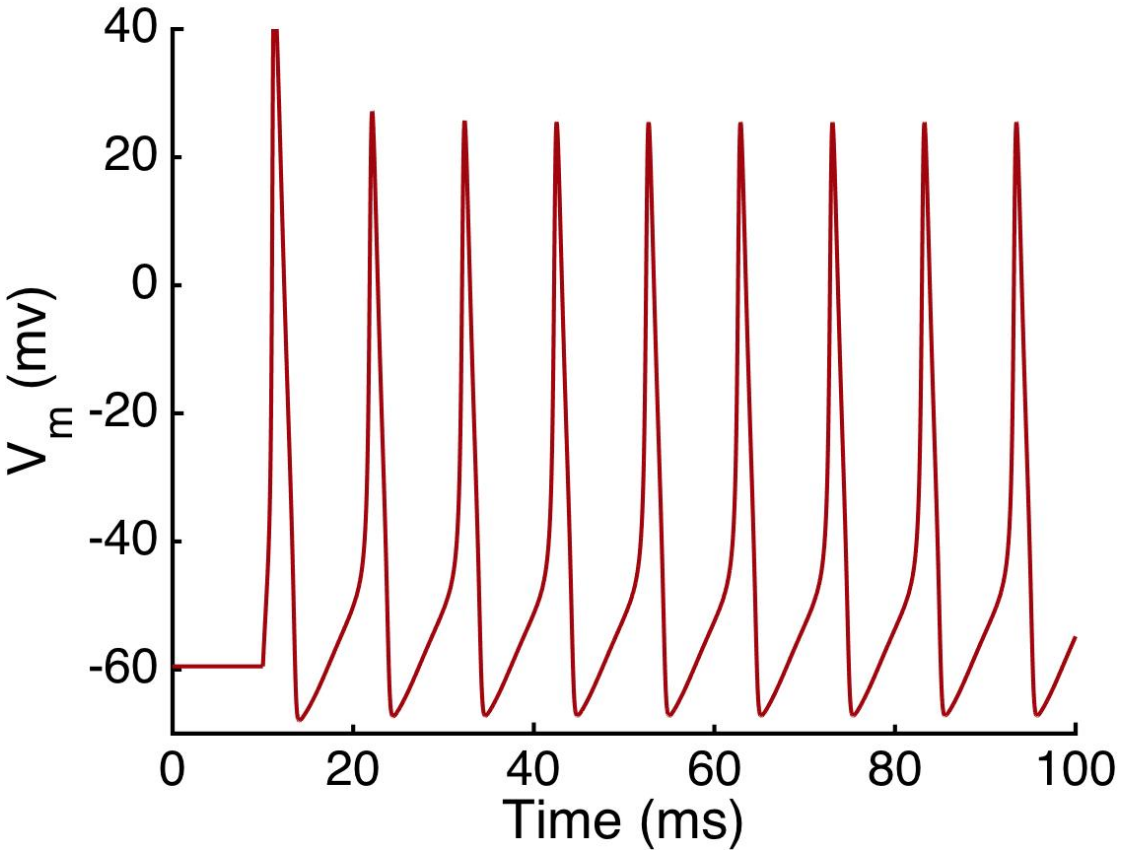

Stepping to 20 $\mu A/cm^2$

# HH Model Action Train



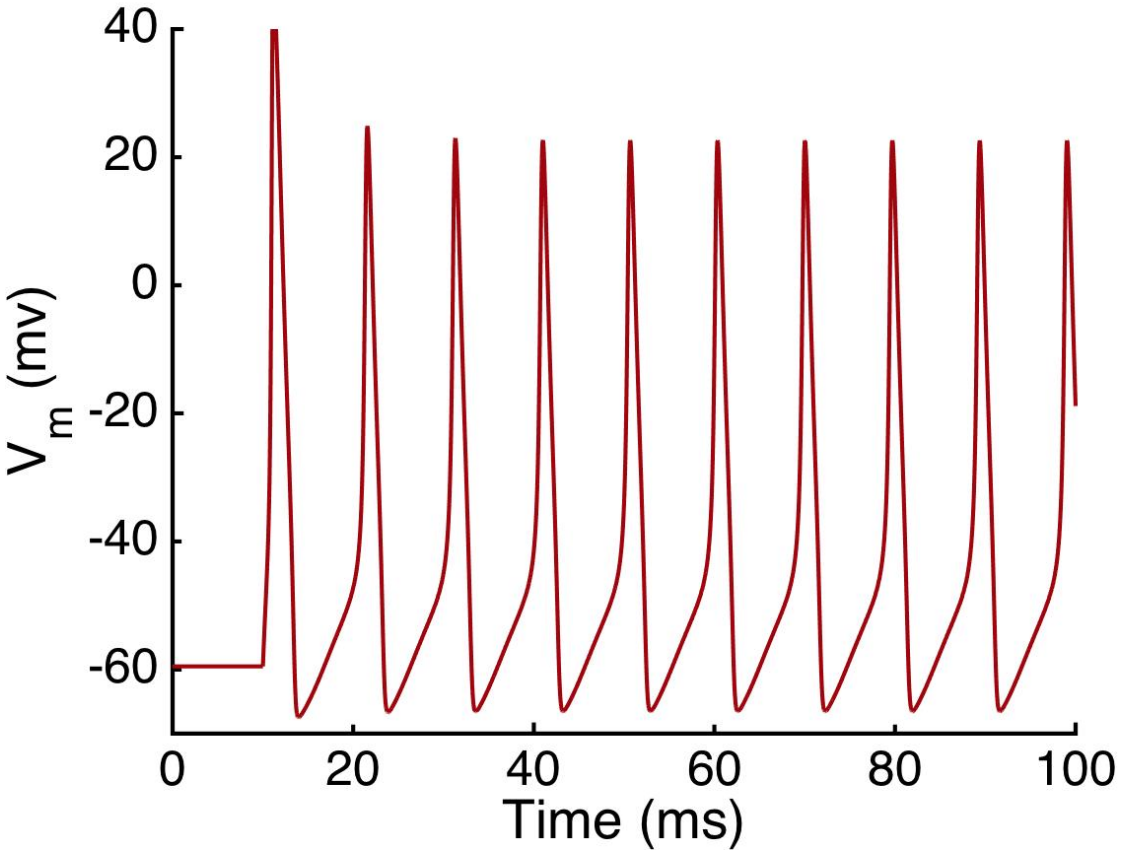

Stepping to 25 $\mu A/cm^2$

# HH Model Action Train



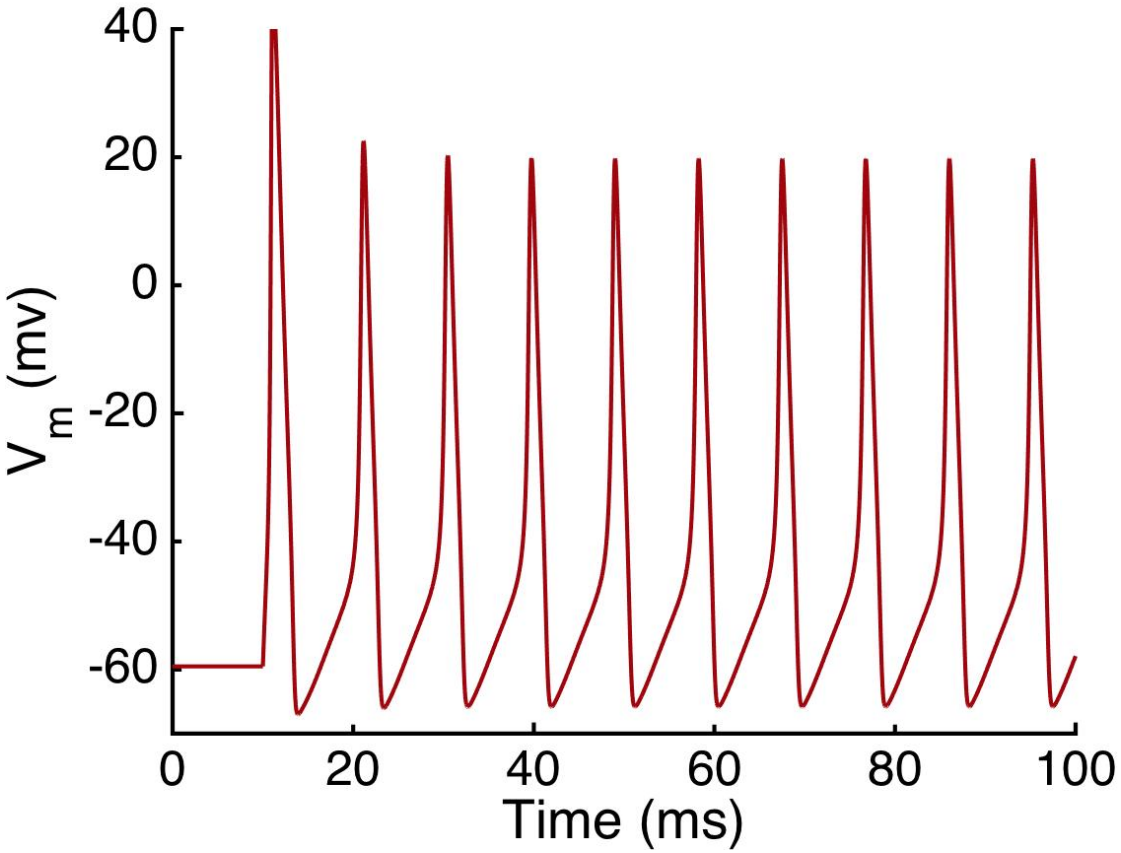

Stepping to 30 $\mu A/cm^2$

# HH Model Action Train



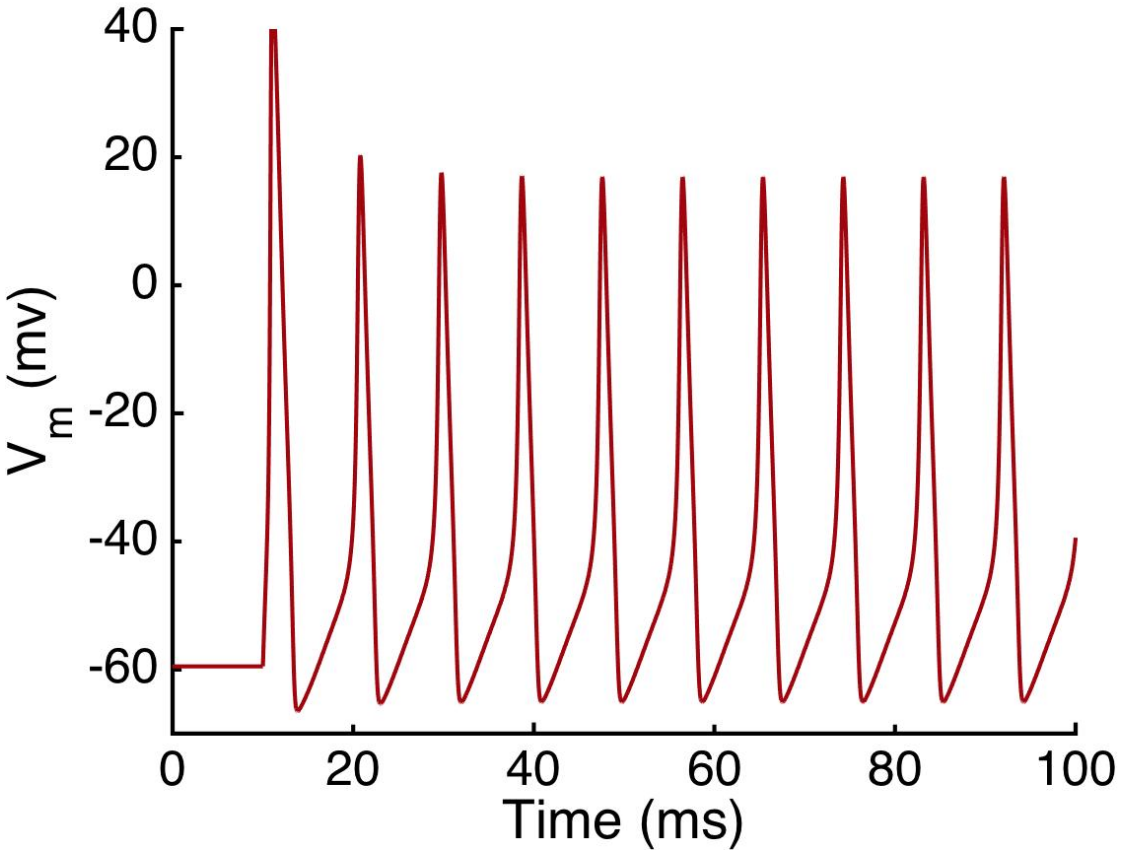

Stepping to 35 $\mu A/cm^2$

# HH Model Action Train



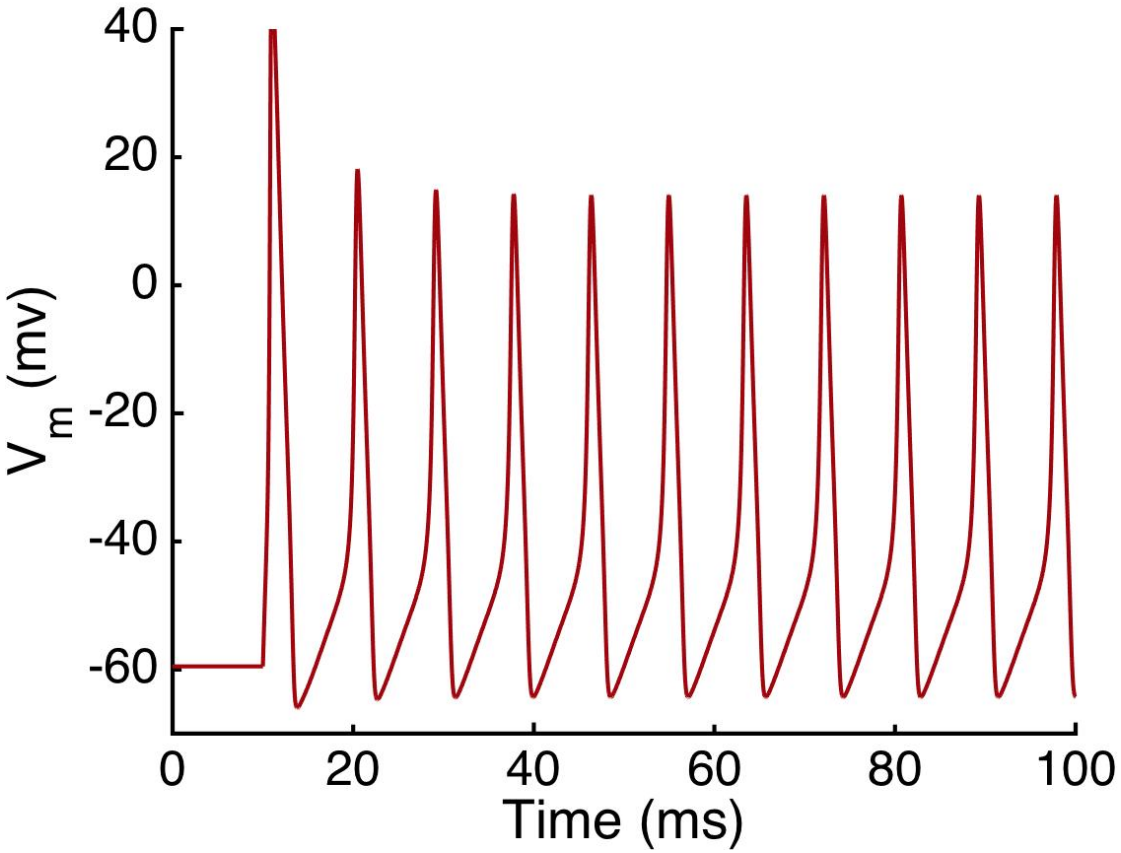

Stepping to 40 $\mu A/cm^2$

# HH Model Action Train



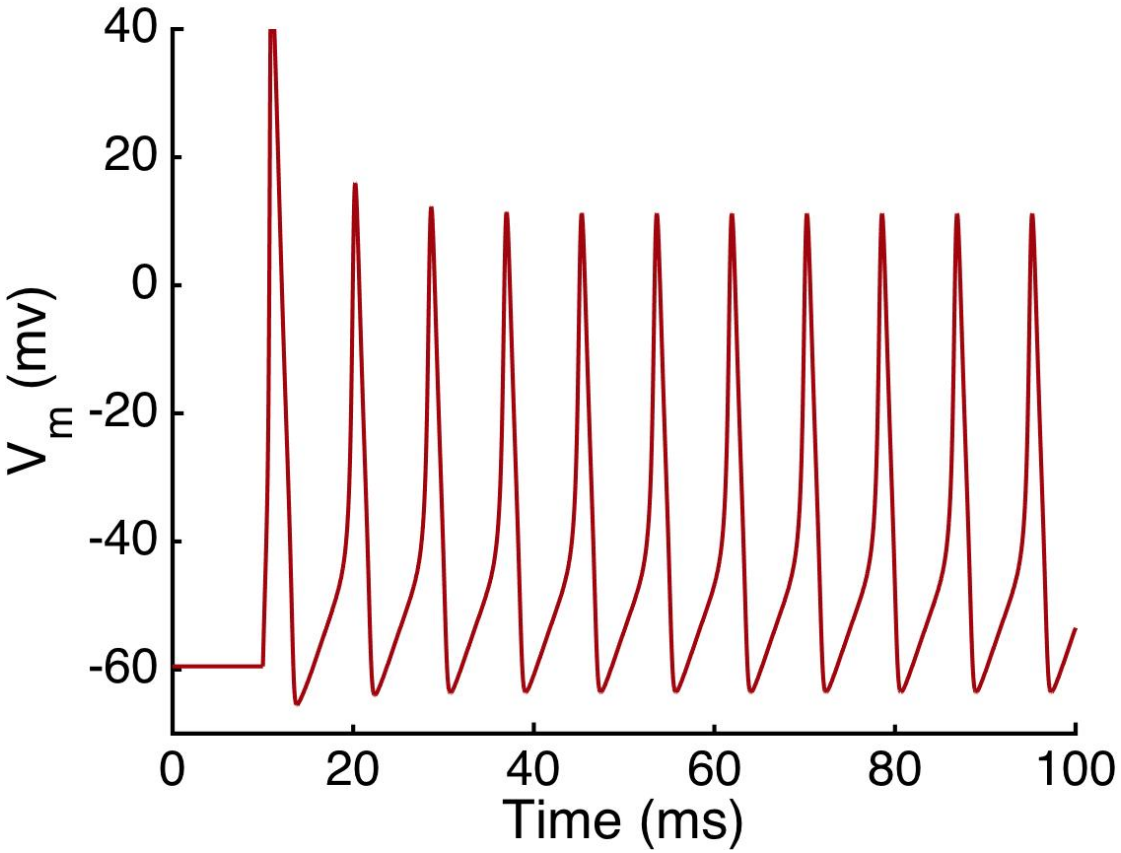

Stepping to 45 $\mu A/cm^2$

# HH Model Action Train



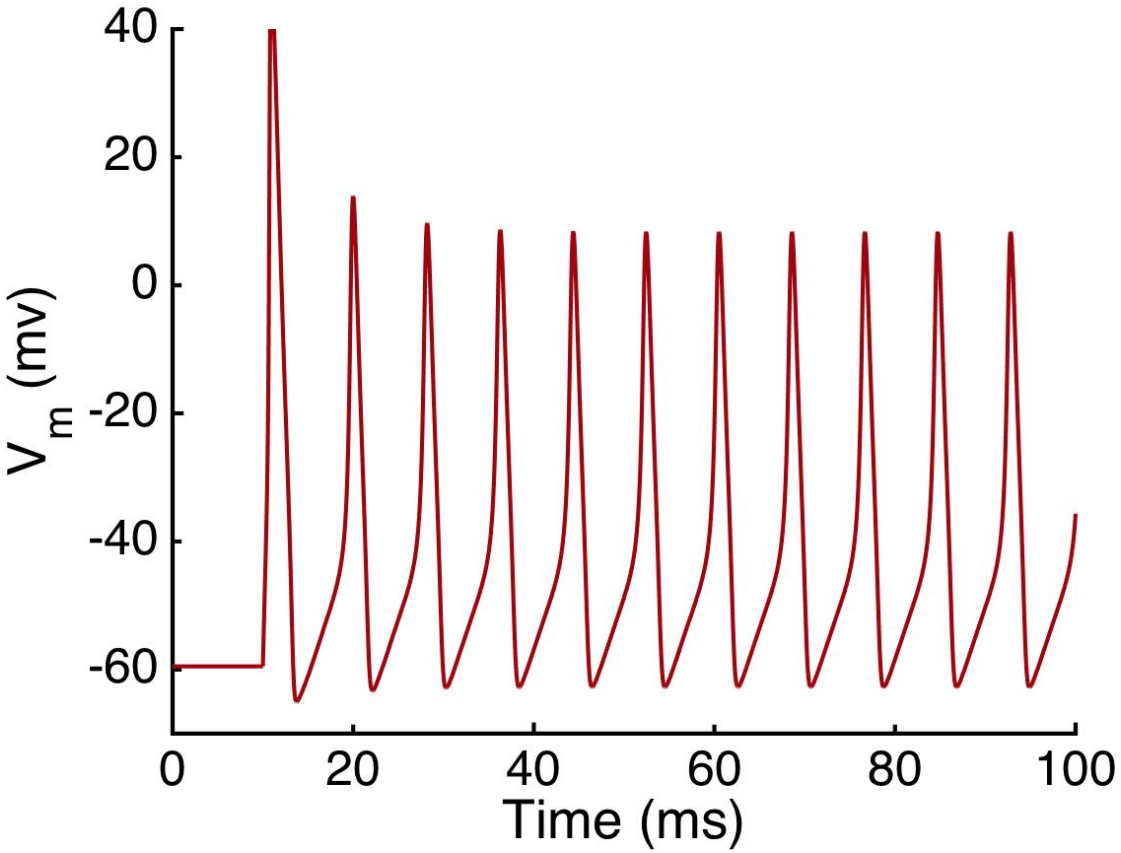

Stepping to 50 $\mu A/cm^2$

# HH Model Action Train



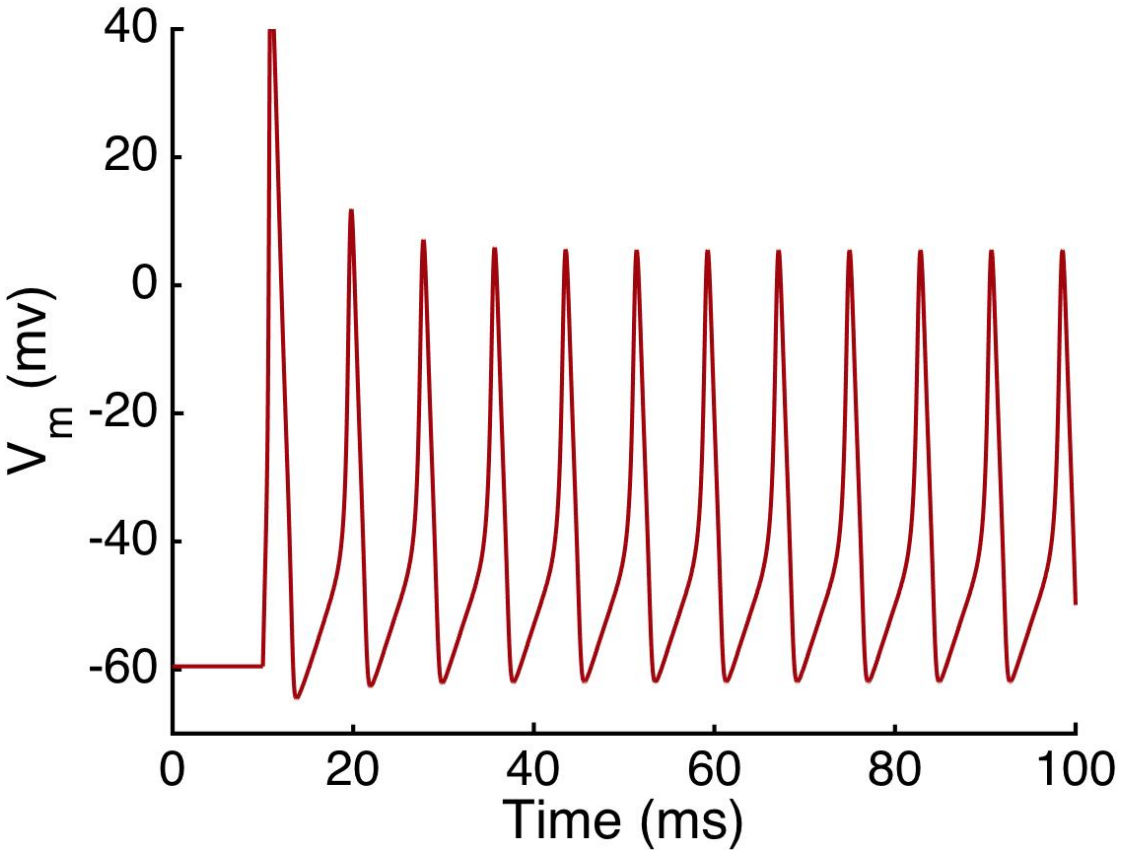

Stepping to 55 $\mu A/cm^2$

# HH Model Action Train



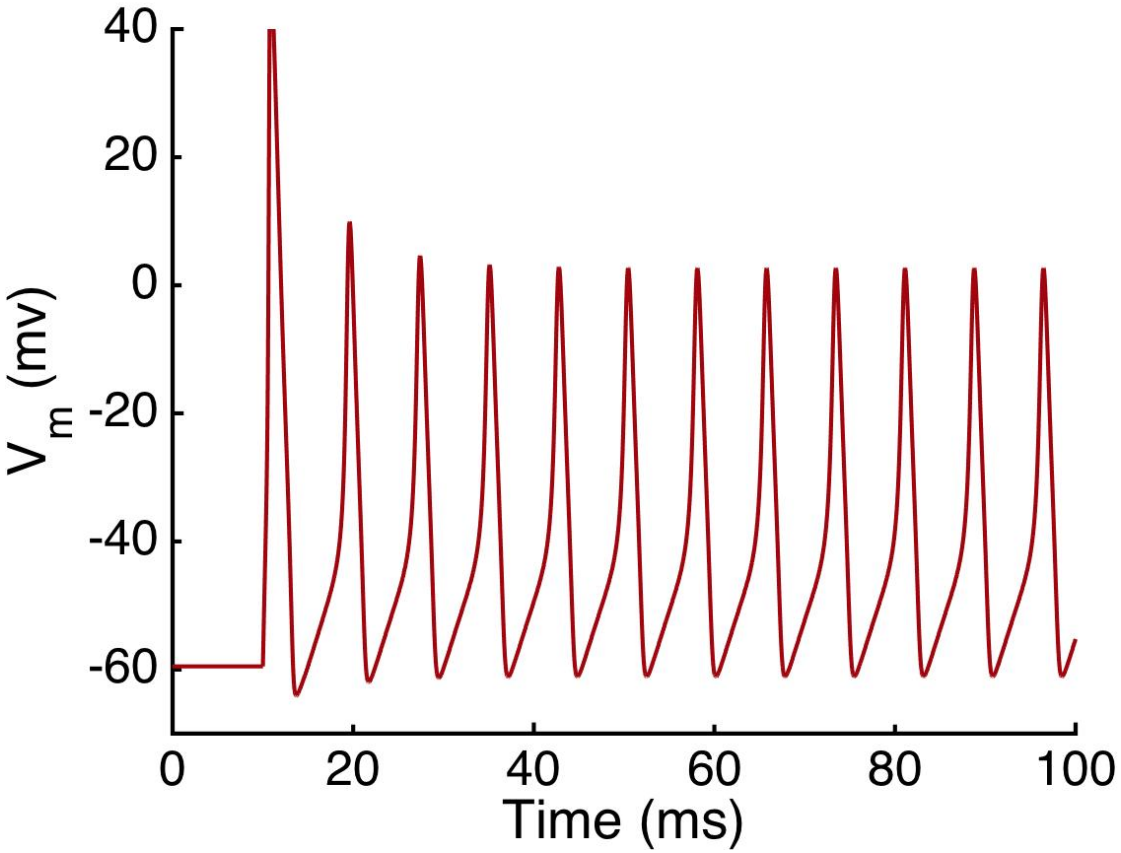

Stepping to 60 $\mu A/cm^2$

# HH Model Action Train



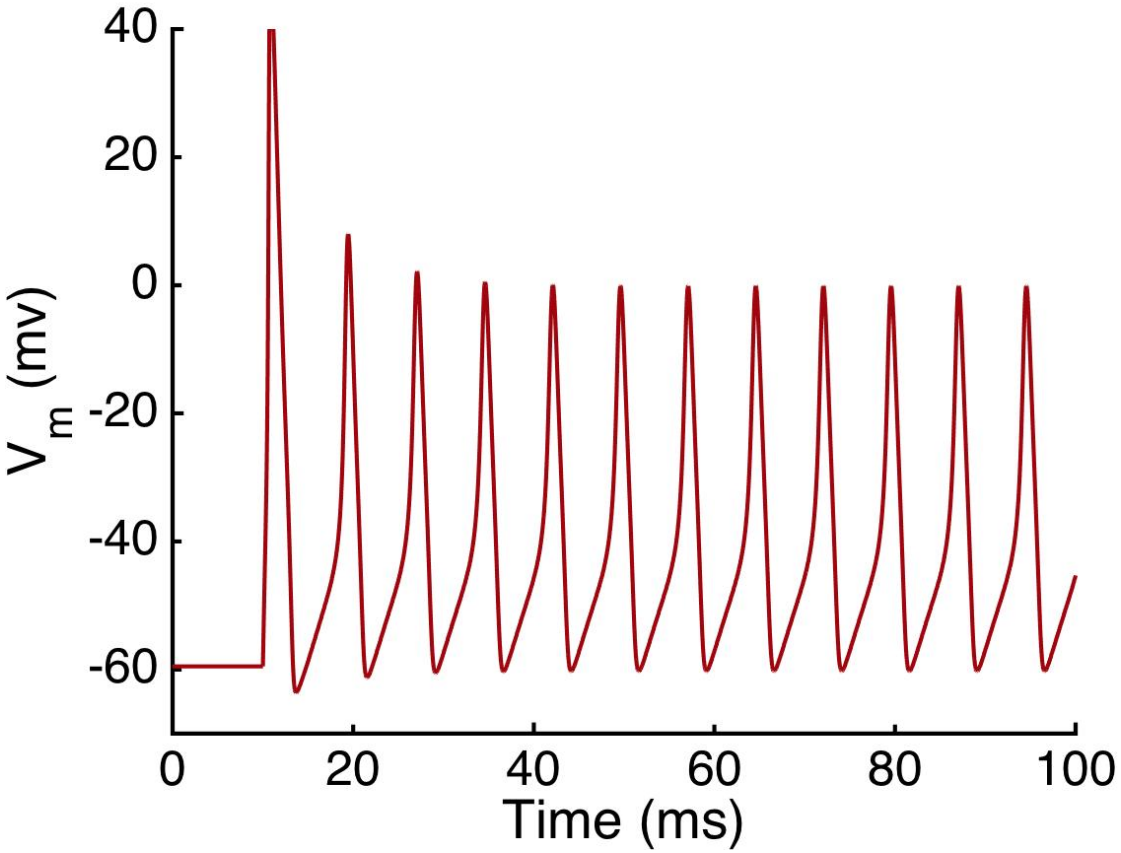

Stepping to 65 $\mu A/cm^2$

# HH Model Action Train



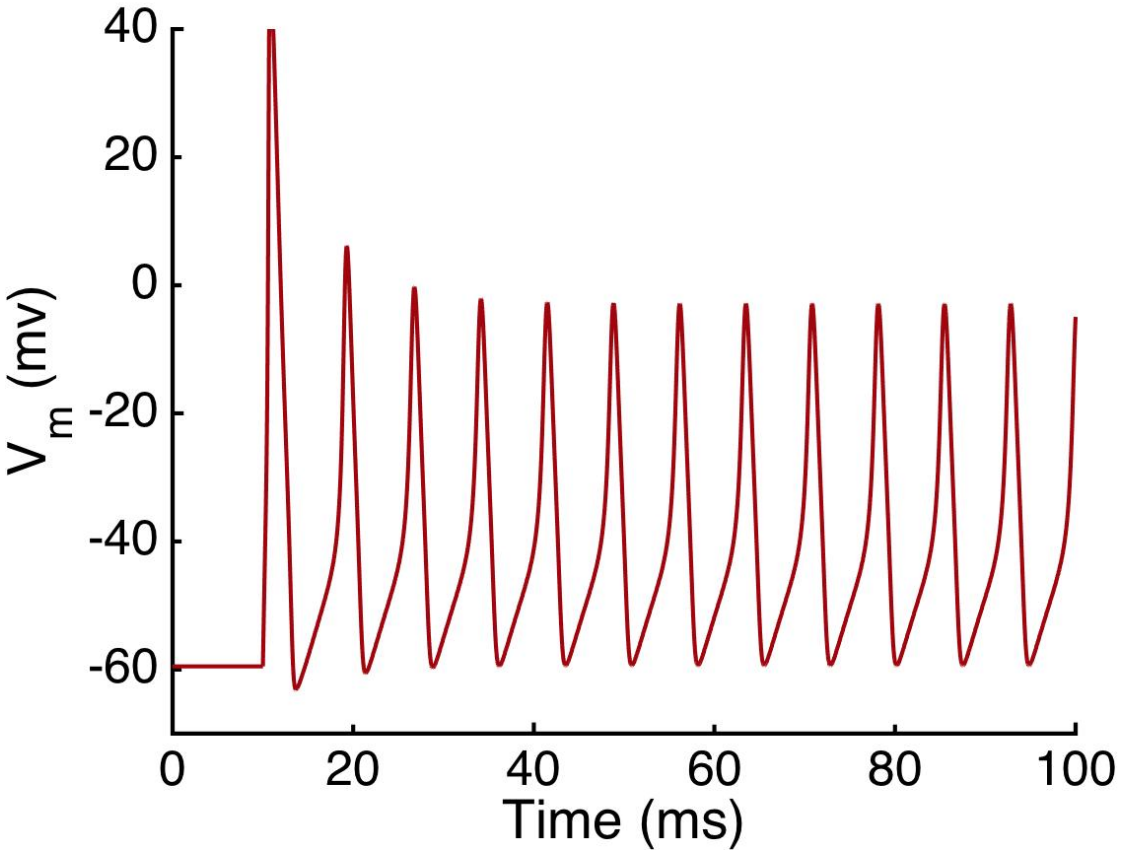

Stepping to 70 $\mu A/cm^2$

# HH Model Action Train



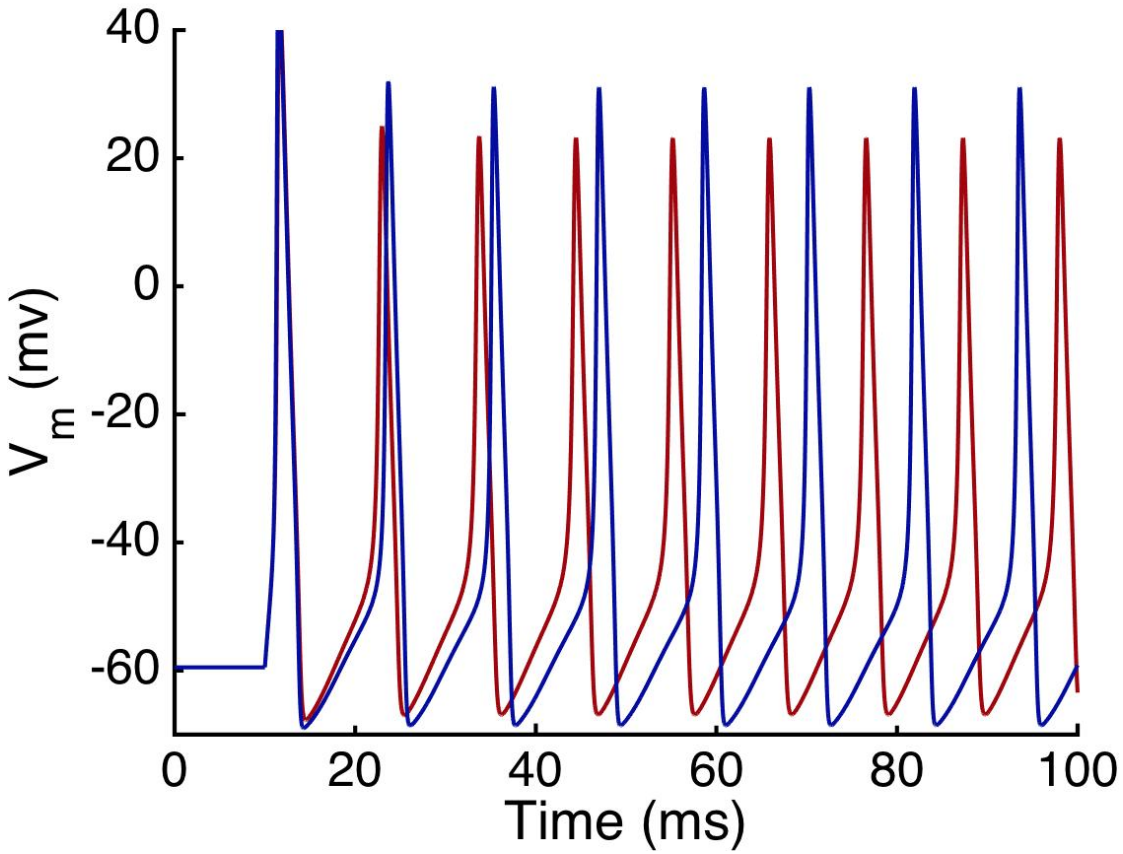

Stepping to 75 $\mu A/cm^2$

# HH Model Action Train



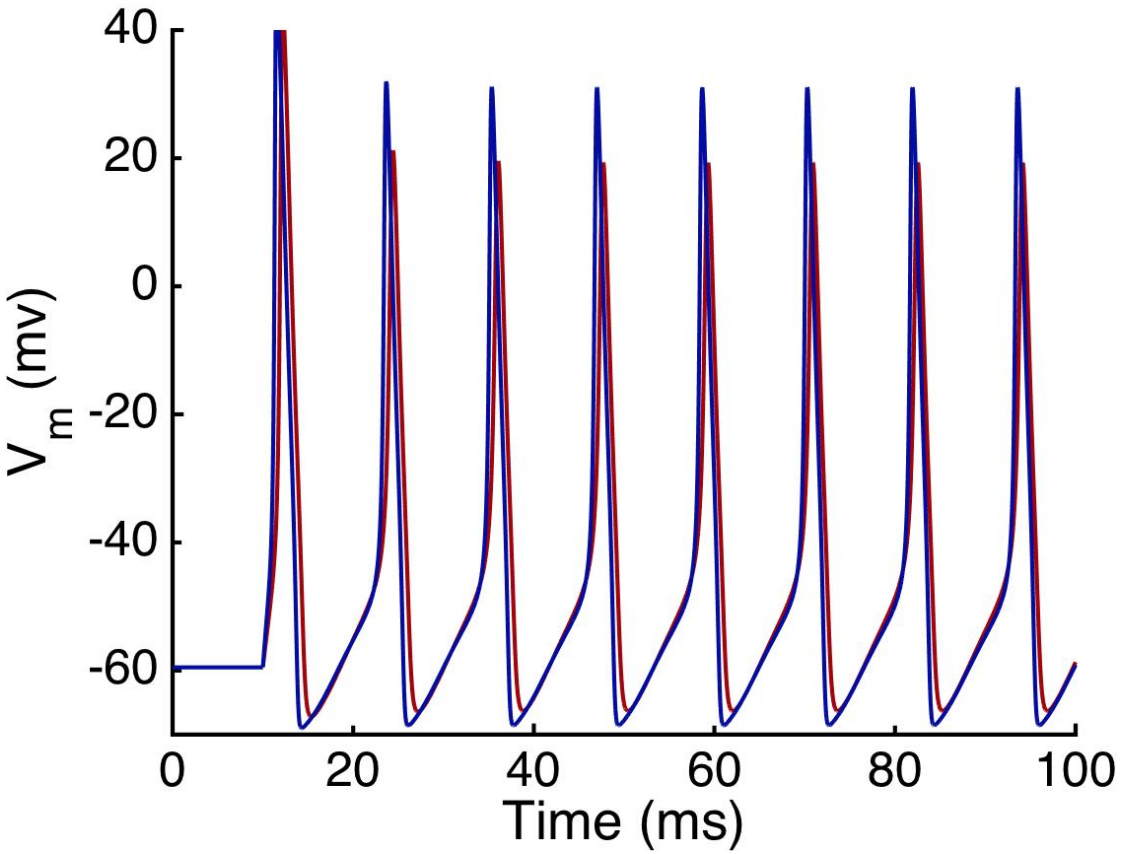

Stepping to 80 $\mu A/cm^2$

# Naive Mechanism



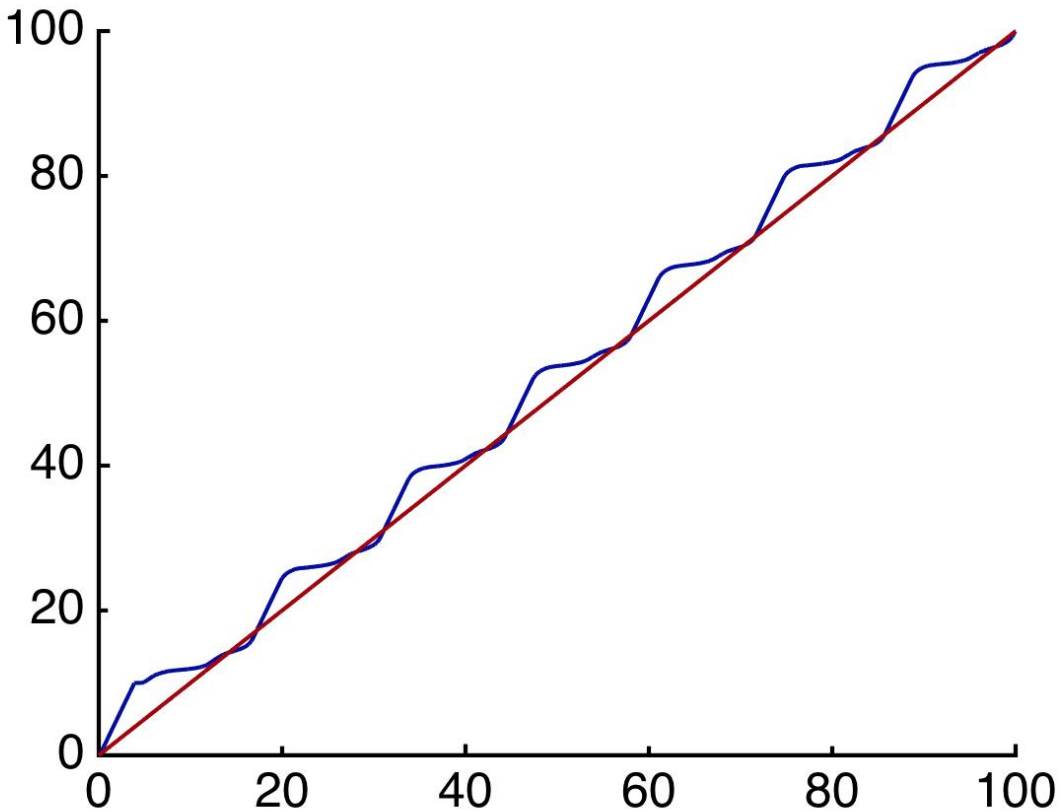

Equal ratio of current to capacitance

# Mechanism



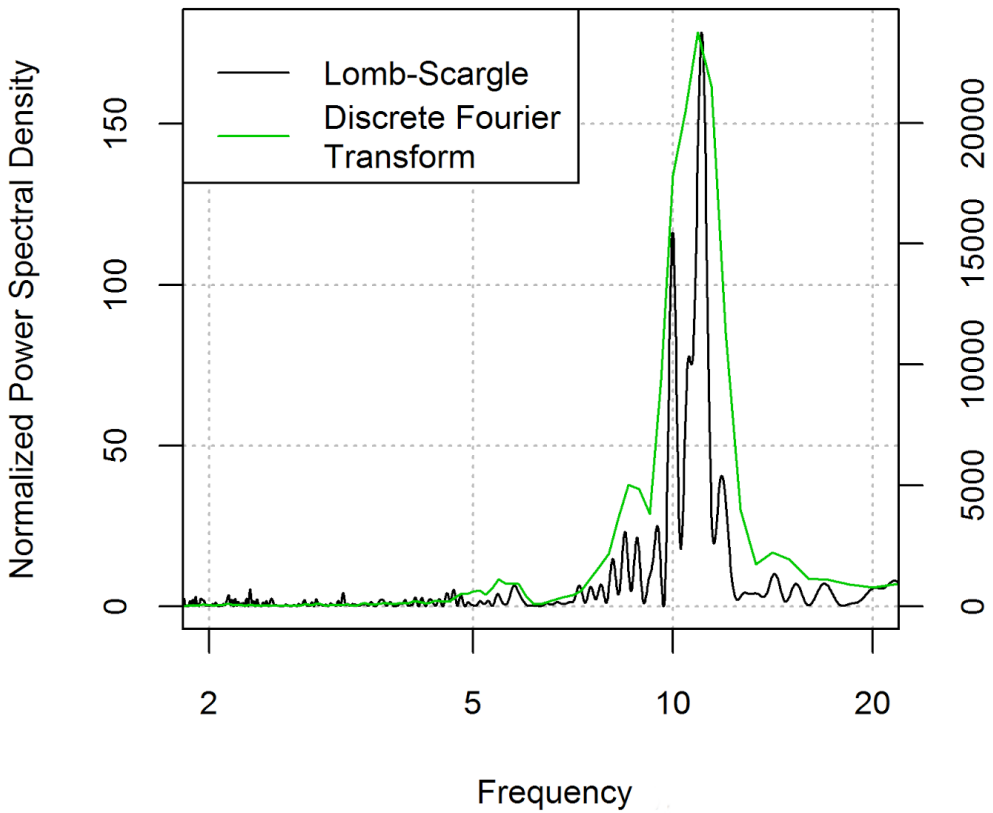

Unequal ratio of current to capacitance

# Fourier Transform insufficient: Inconsistent Time Intervals



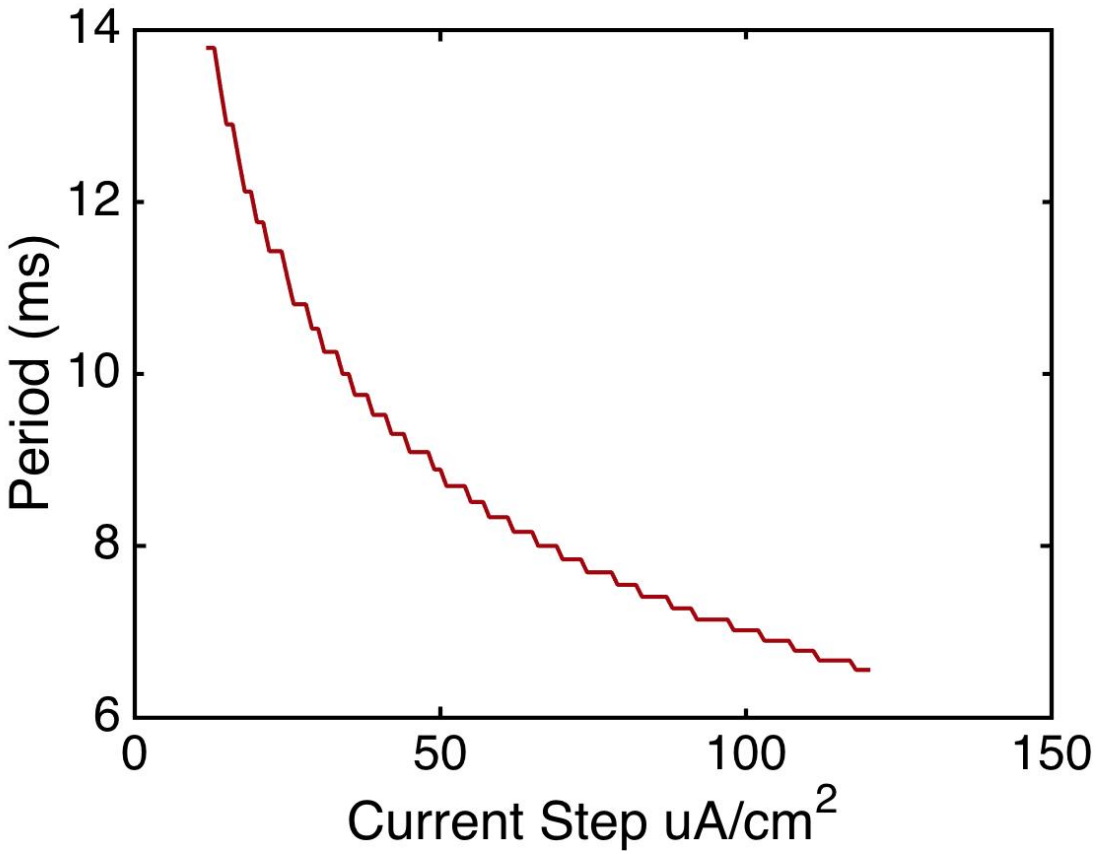

FFT insufficient, need a better Spectral Analysis Method

# Least-squares spectral analysis



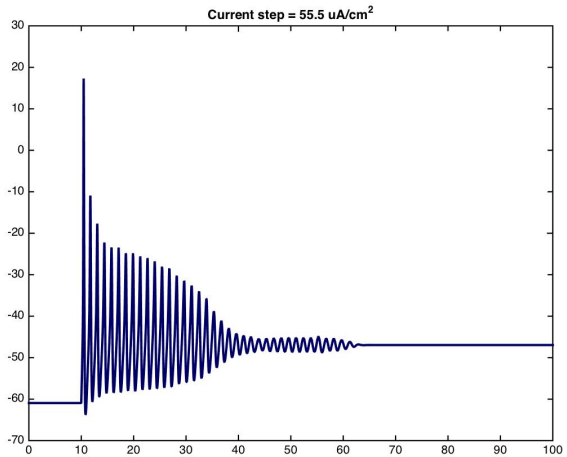

The Lomb-Scargle Periodogram works with variable intervals.

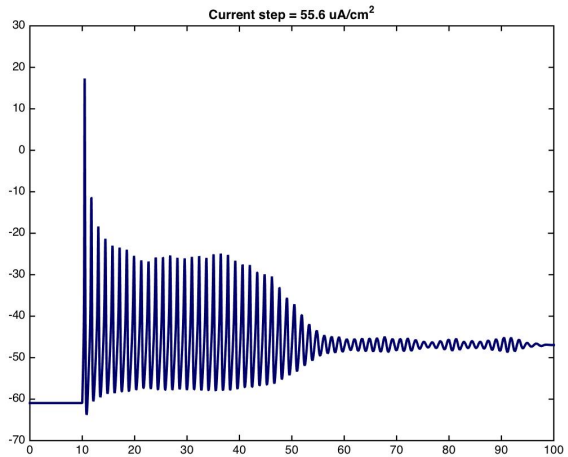
# Train period over increasing input step




Nonlinearity shows complexity of behavior

# Anomalies with precision approximation




Incorrect behavior due to low precision

# Conclusion

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

# 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.