

Step Current Response of the HH Model

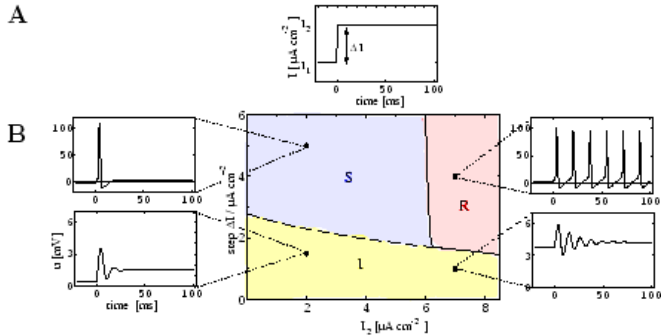
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HH Model Step Current Response



Step Current Stimulation Phase diagram

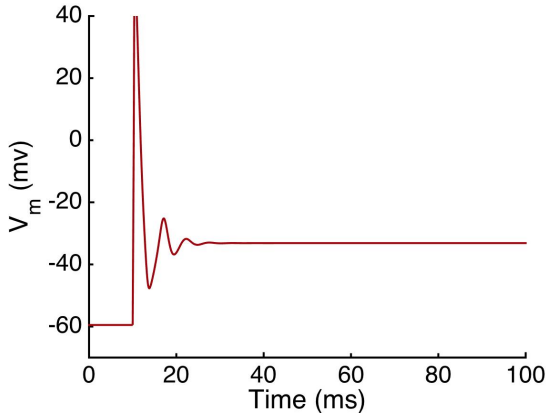
Hypothesis

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

$$f \propto J$$

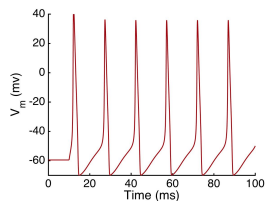
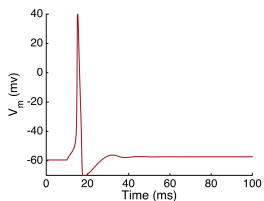
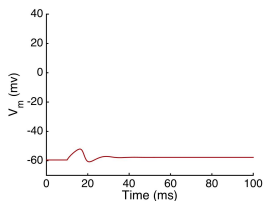
The train frequency is proportional to the current density

Applications: Neuron Inhibition



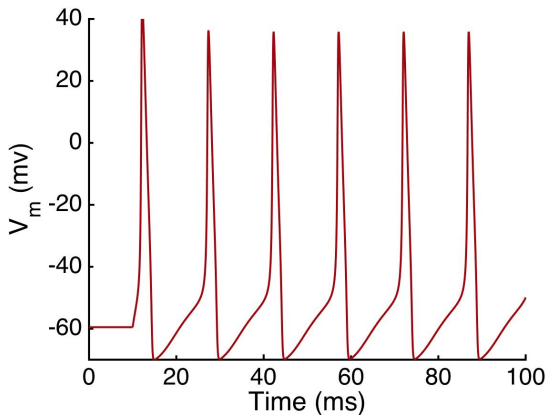
High current fully damps neuron response

Simulation Response Regions



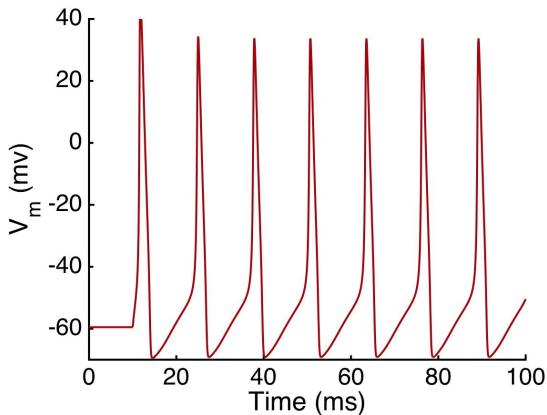
Response in the *Ringing*, *Single AP* and *AP Train* regions

HH Model Action Train



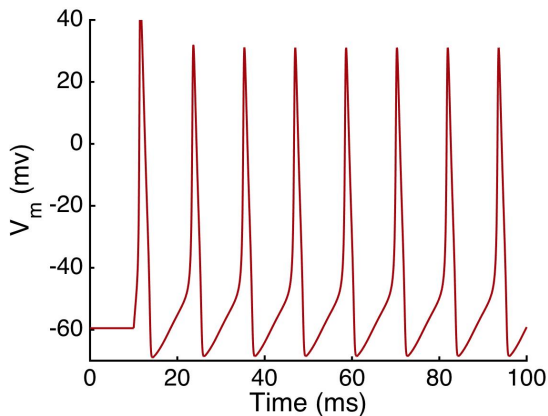
Stepping to $10 \mu A/cm^2$

HH Model Action Train

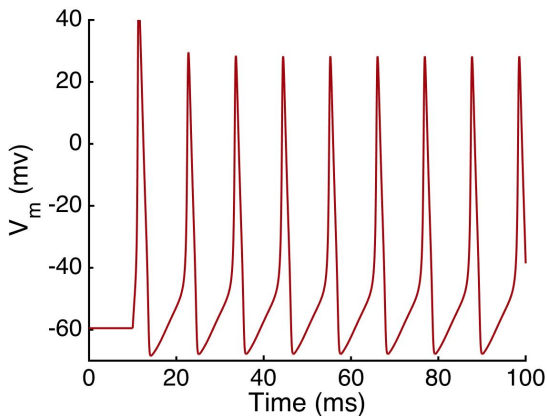


Stepping to 15 $\mu A/cm^2$

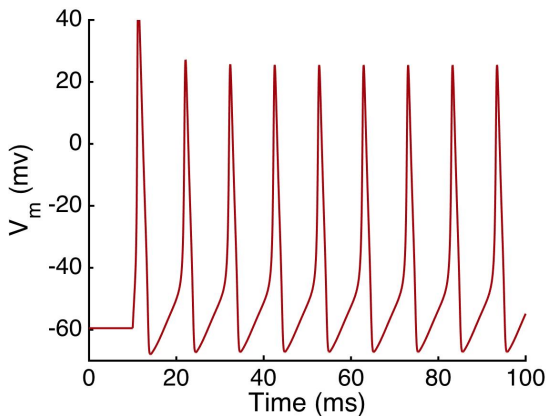
HH Model Action Train



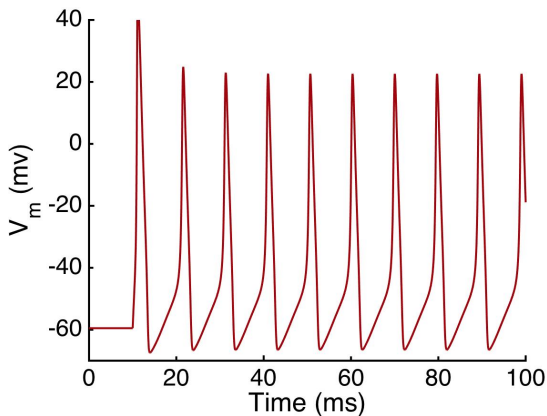
HH Model Action Train



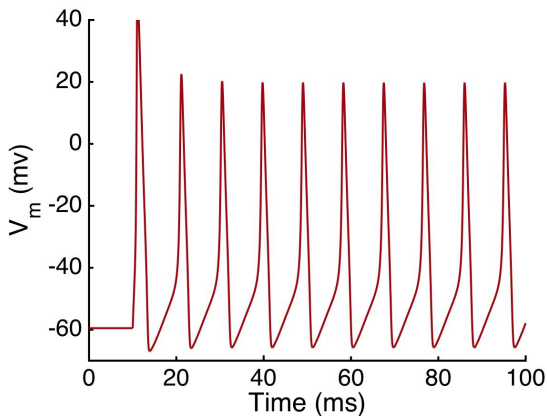
HH Model Action Train



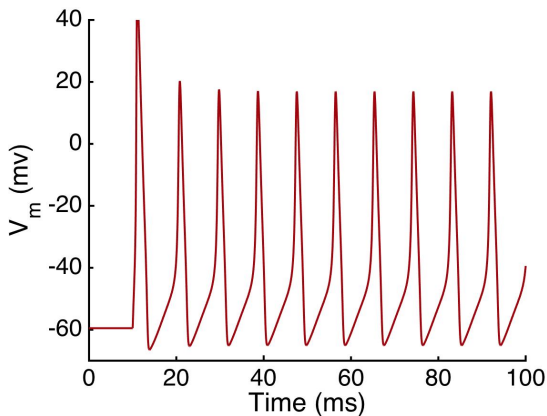
HH Model Action Train



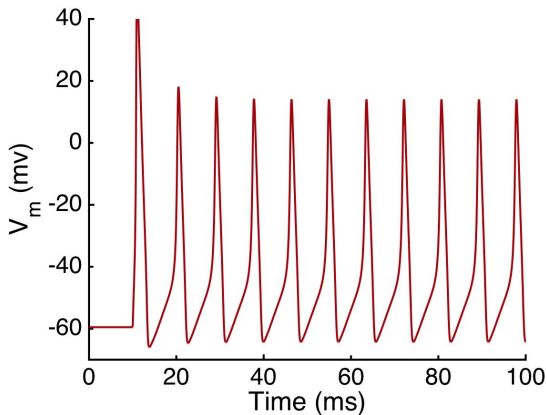
HH Model Action Train



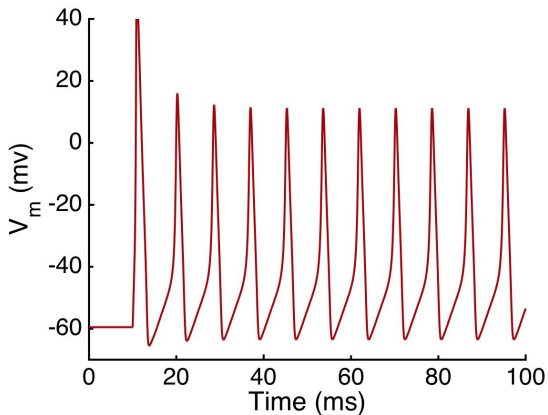
HH Model Action Train



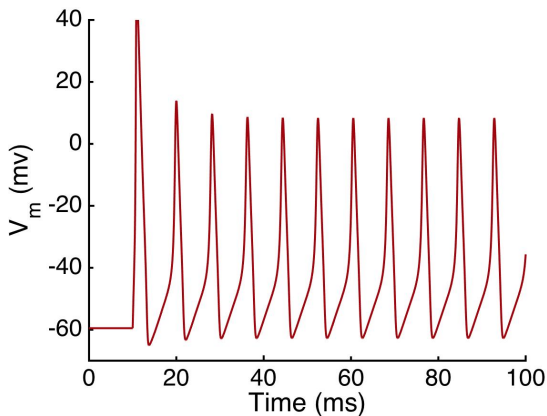
HH Model Action Train



HH Model Action Train

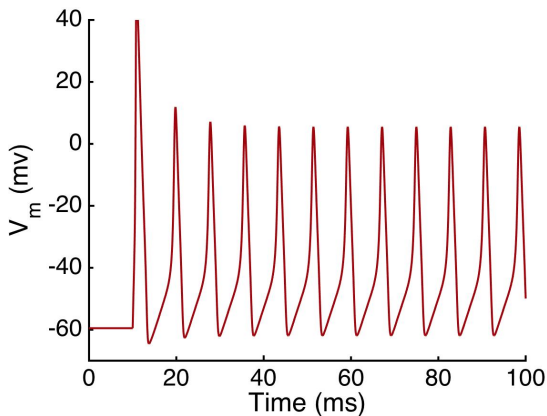


HH Model Action Train

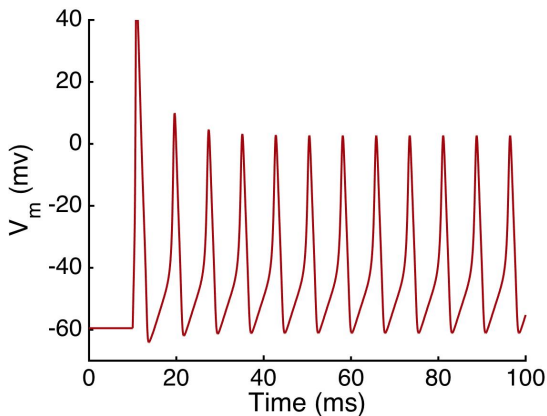


Stepping to $60 \mu A/cm^2$

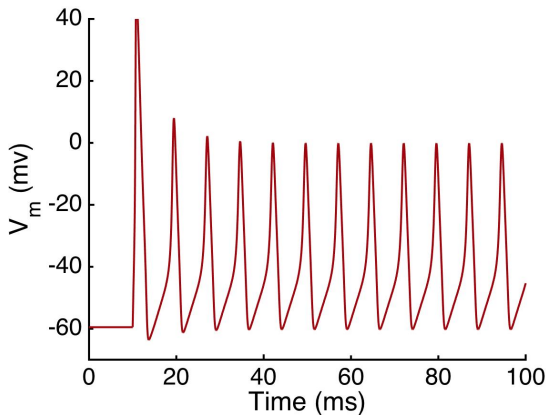
HH Model Action Train



HH Model Action Train

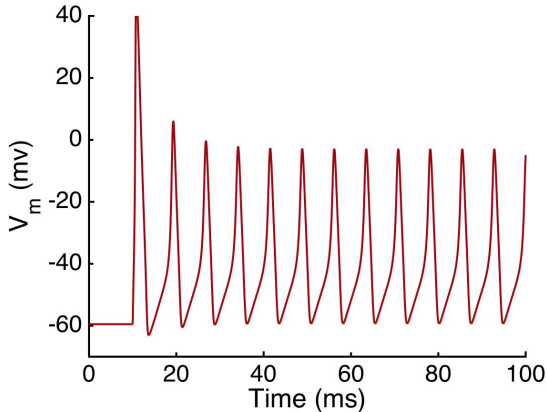


HH Model Action Train

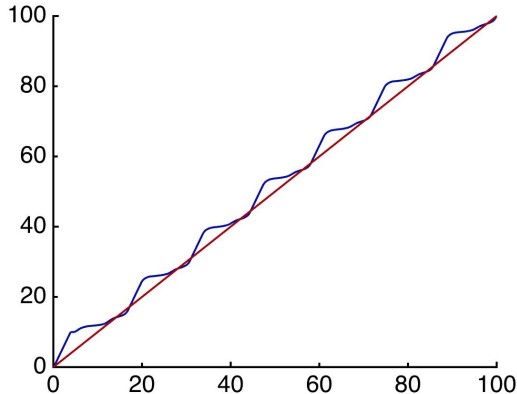


Stepping to $75 \mu A/cm^2$

HH Model Action Train

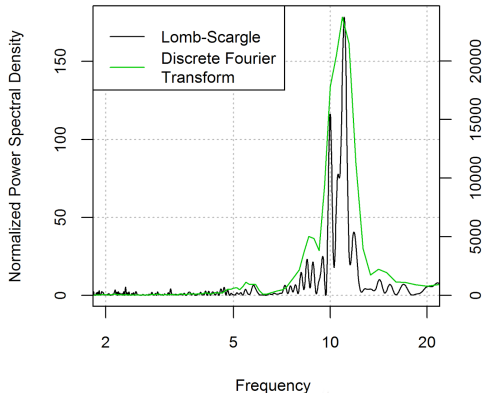


Fourier Transform Insufficient: Inconsistent Time Intervals



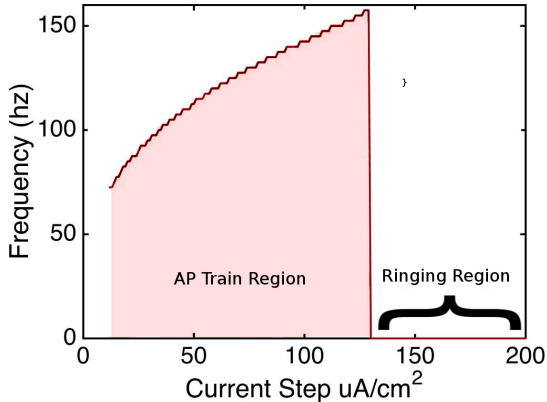
FFT insufficient, need a better Spectral Analysis Method

Least-Squares Spectral Analysis



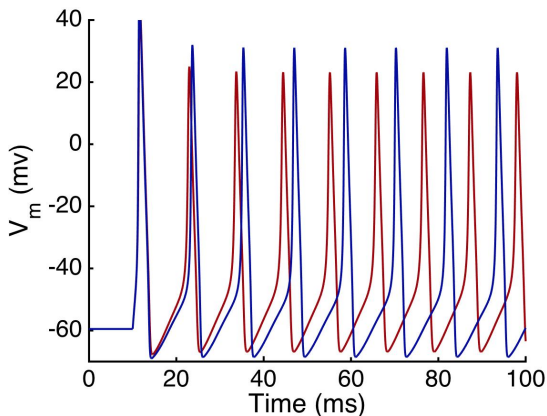
The Lomb-Scargle Periodogram works with variable intervals.

Graphing the Train Frequency



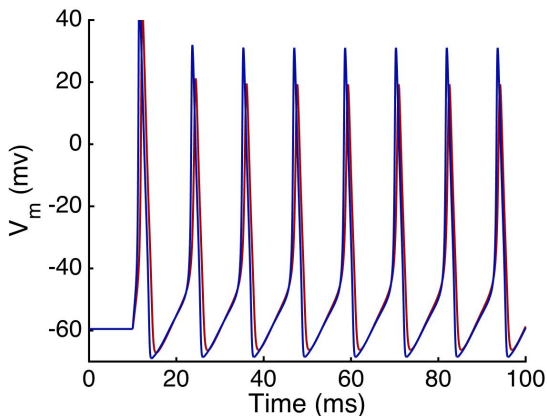
Nonlinearity shows complexity of behavior

Naive Mechanism



Equal ratio of current to capacitance

Mechanism



Unequal ratio of current to capacitance

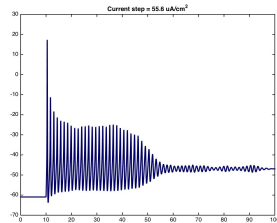
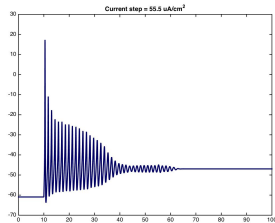
Conclusion

- 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 (backup slide)



Incorrect behavior due to low precision