Step Current Response of the HH Model

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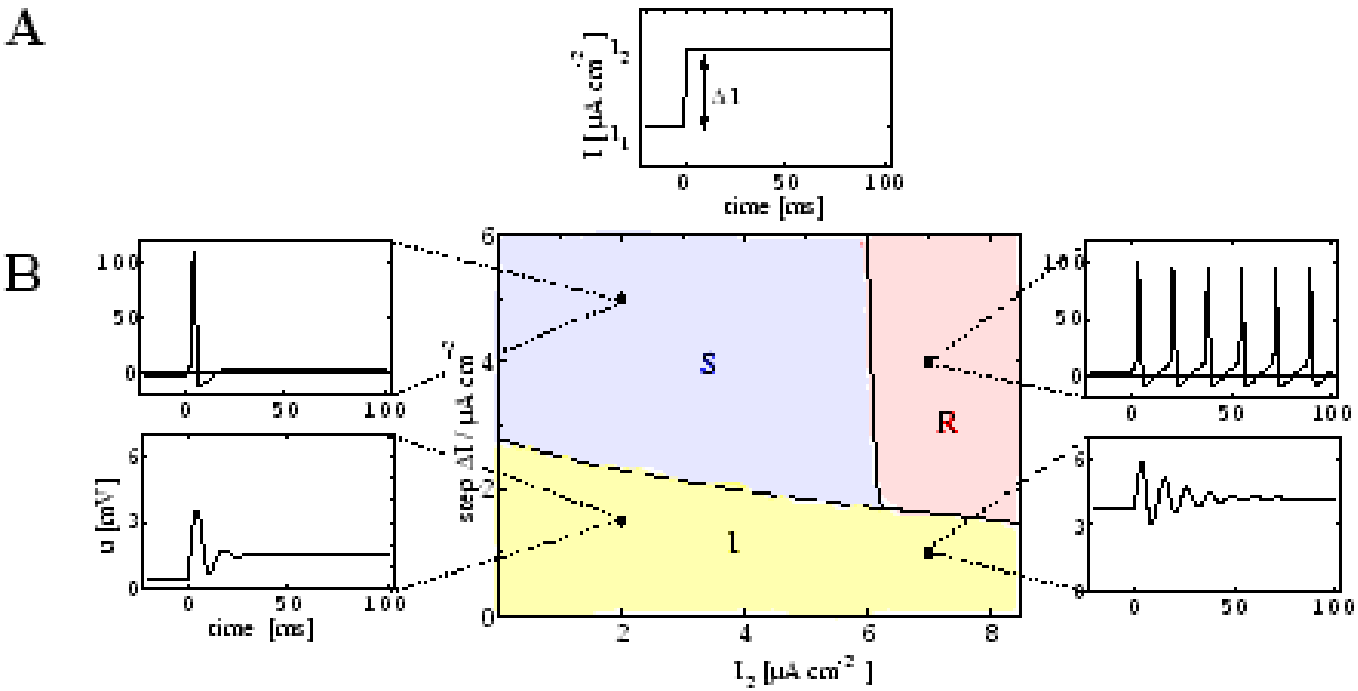
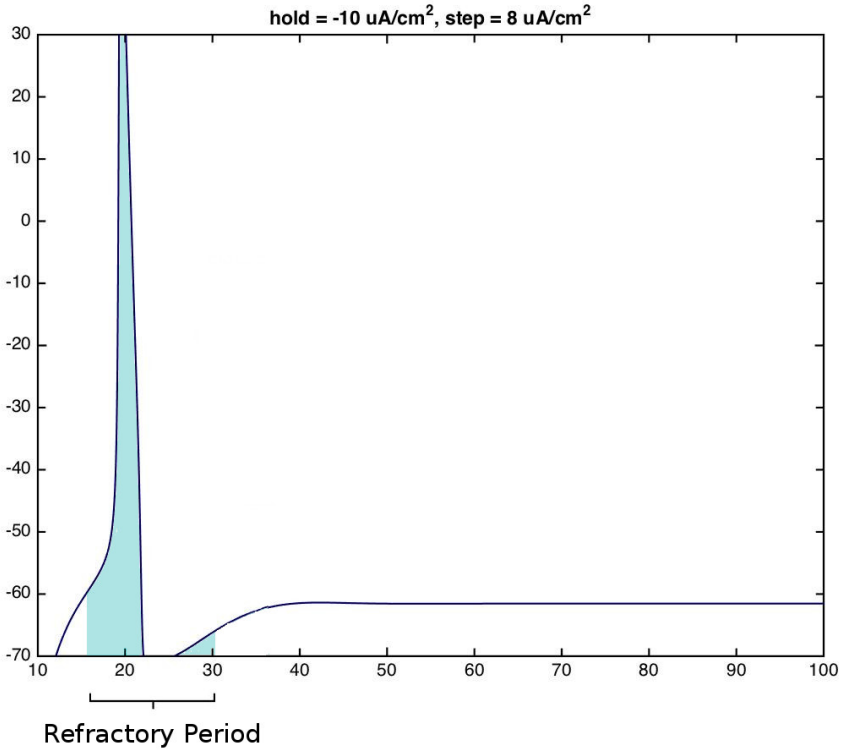
HH Model Step Current Response

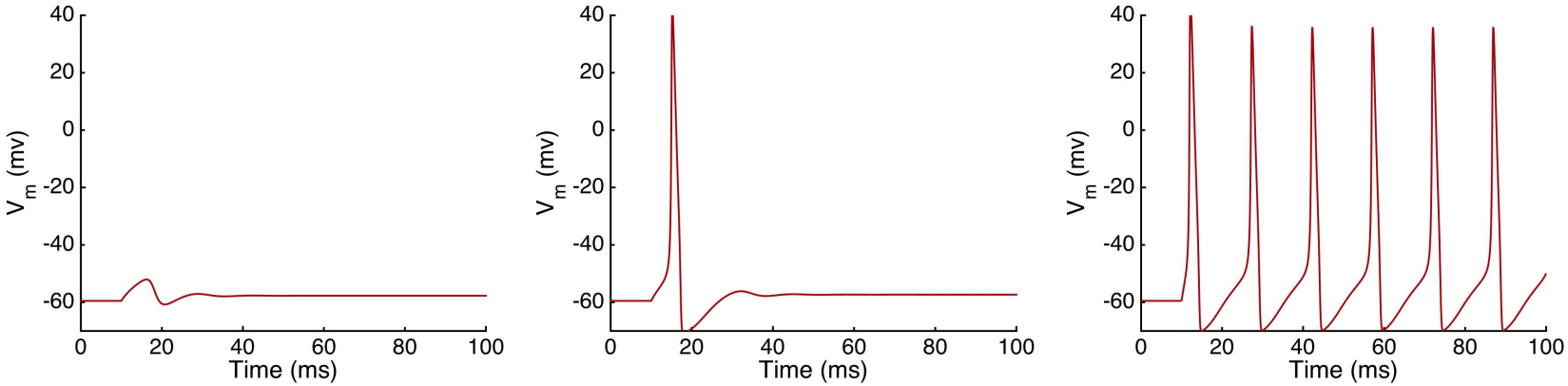


Step Current Stimulation Phase diagram

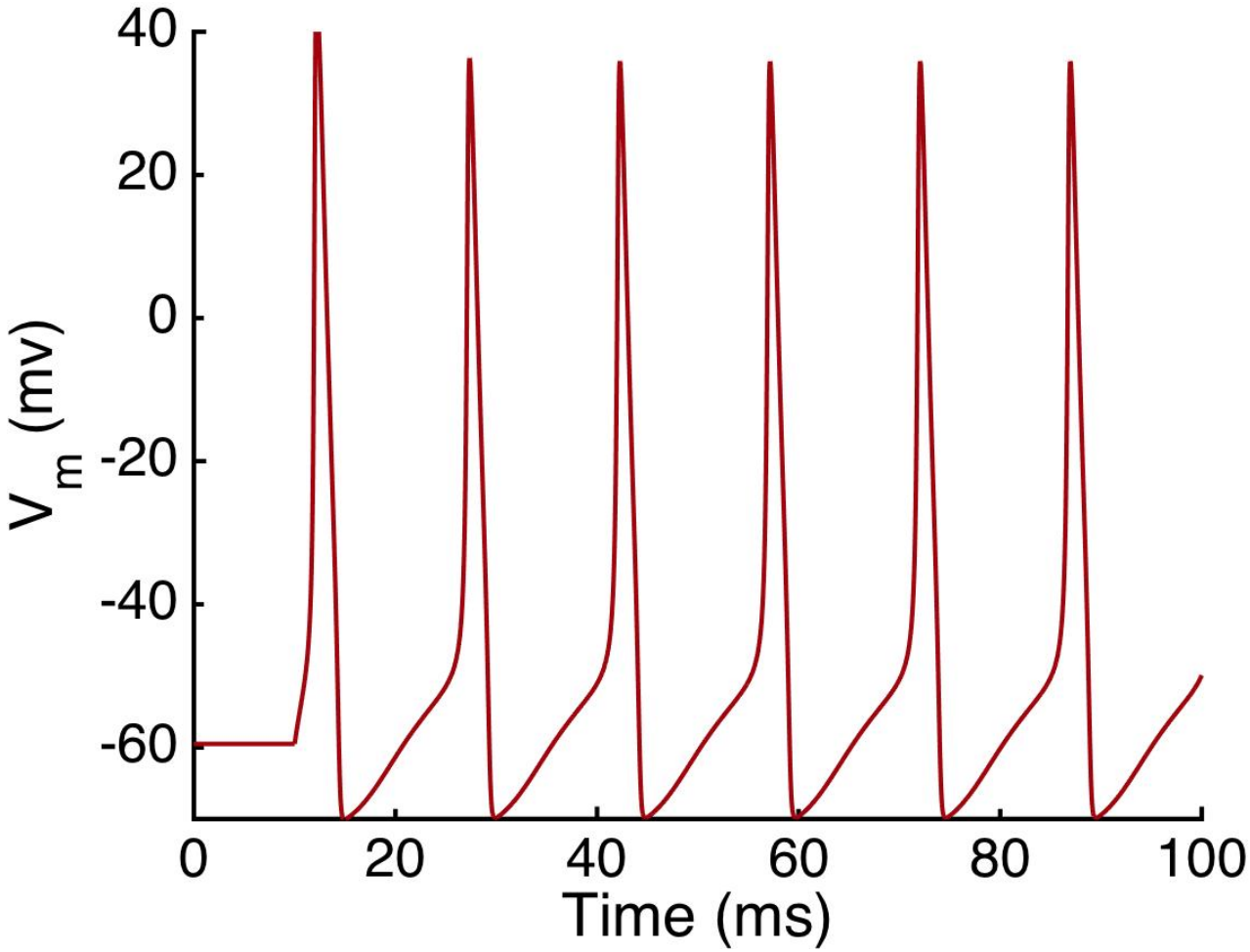
Applications: Refractory Period



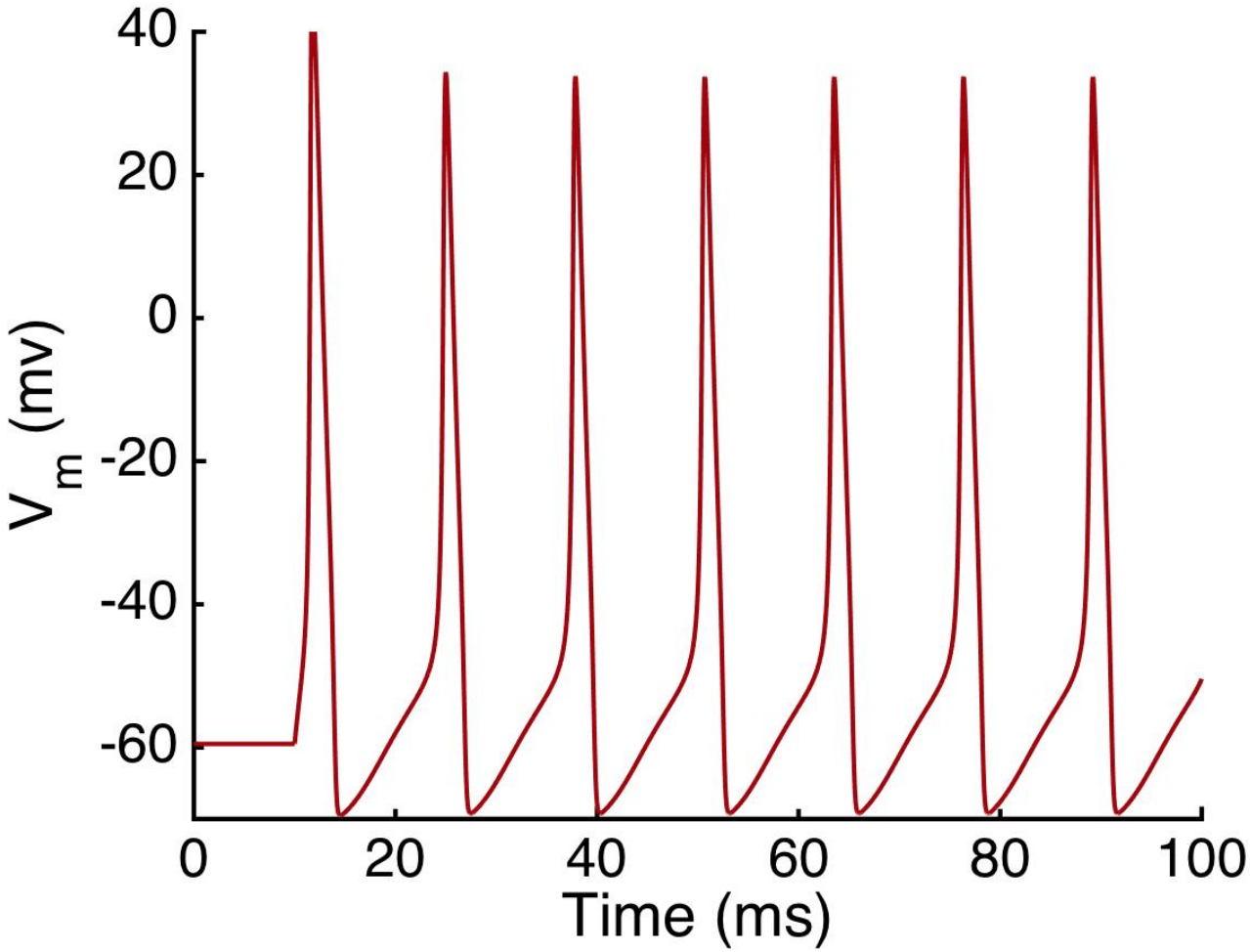
Reducing the Refractory Period can lead to faster reflexes.



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



HH Model's step current response starting at 0 $\mu A/cm^2$



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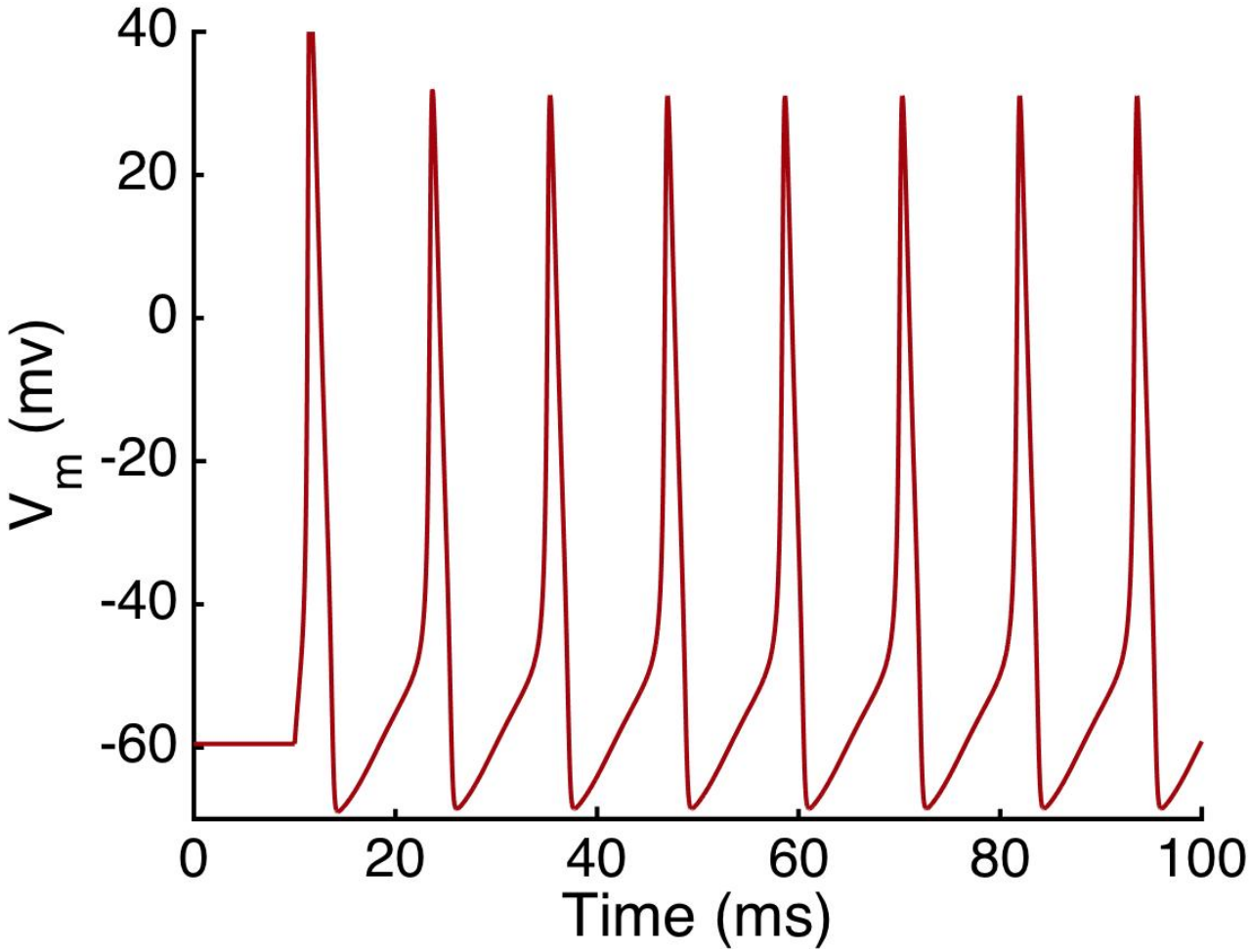

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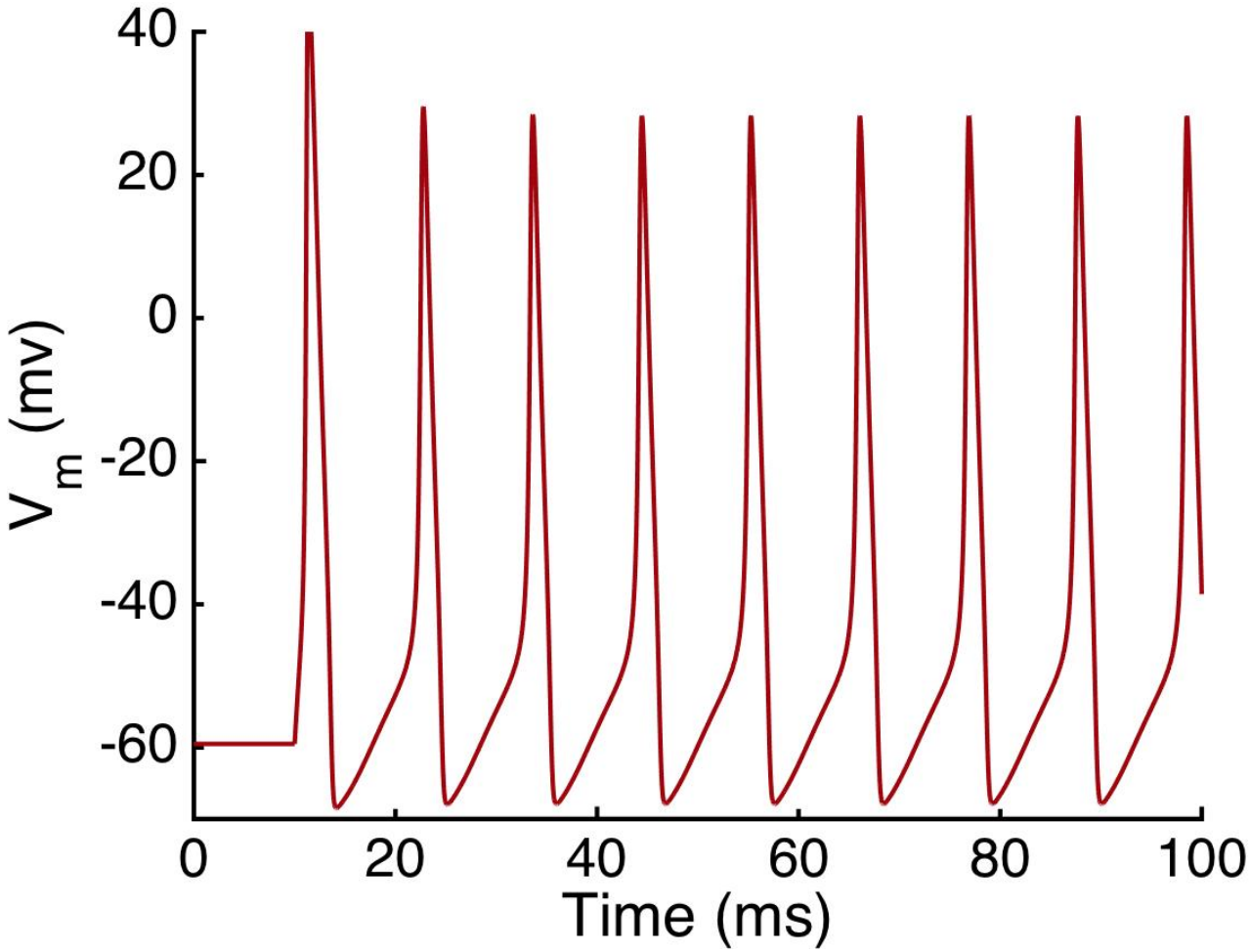

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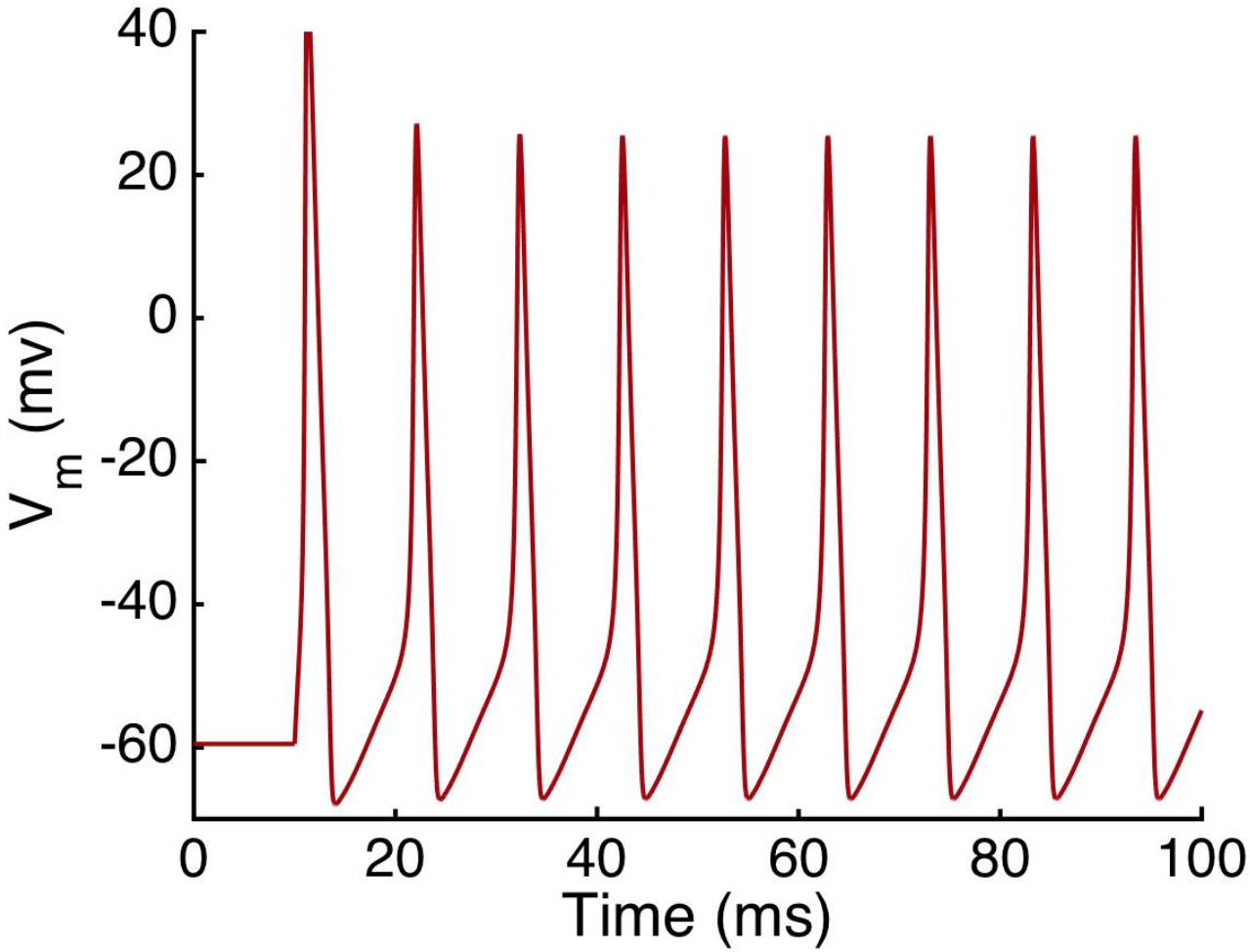

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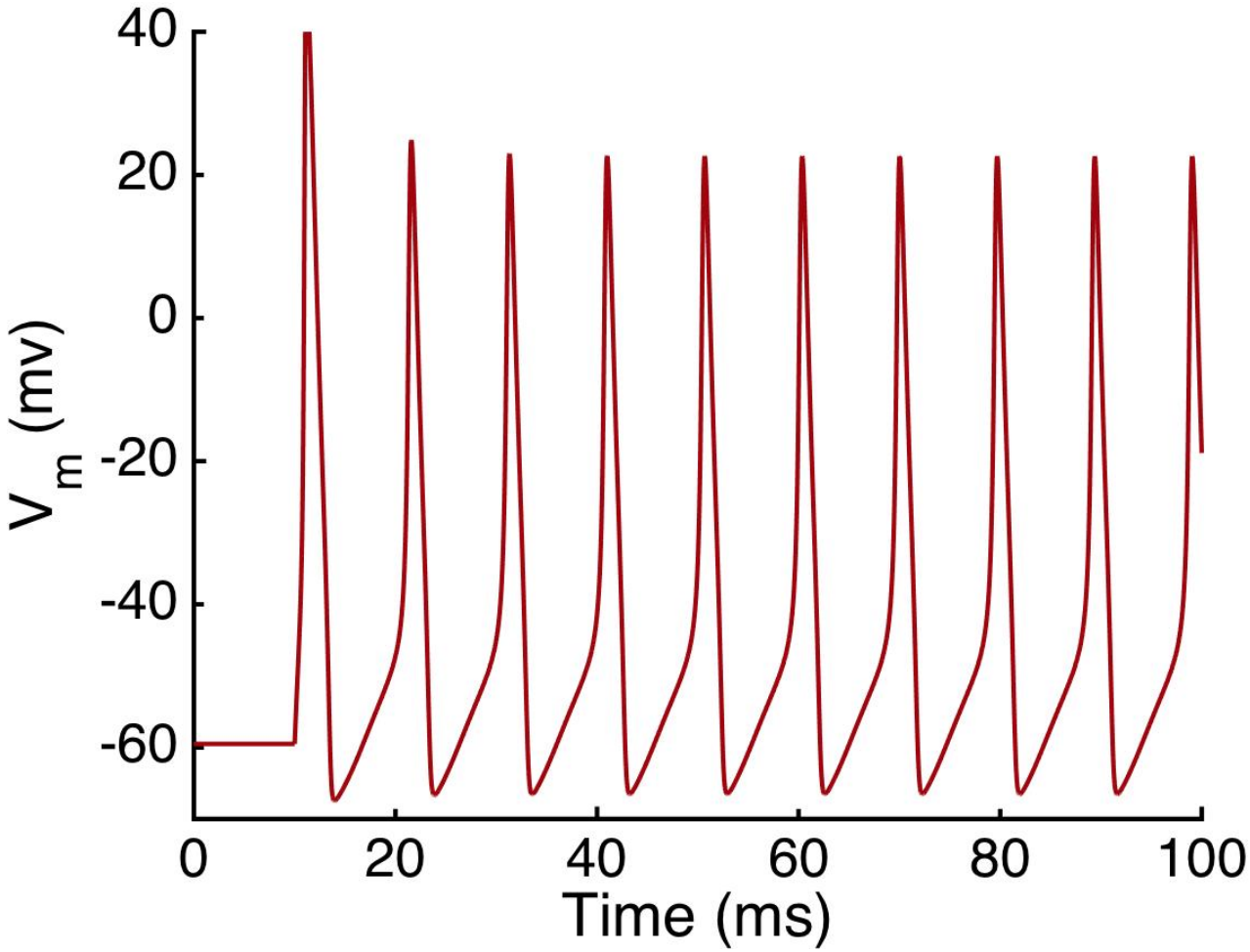

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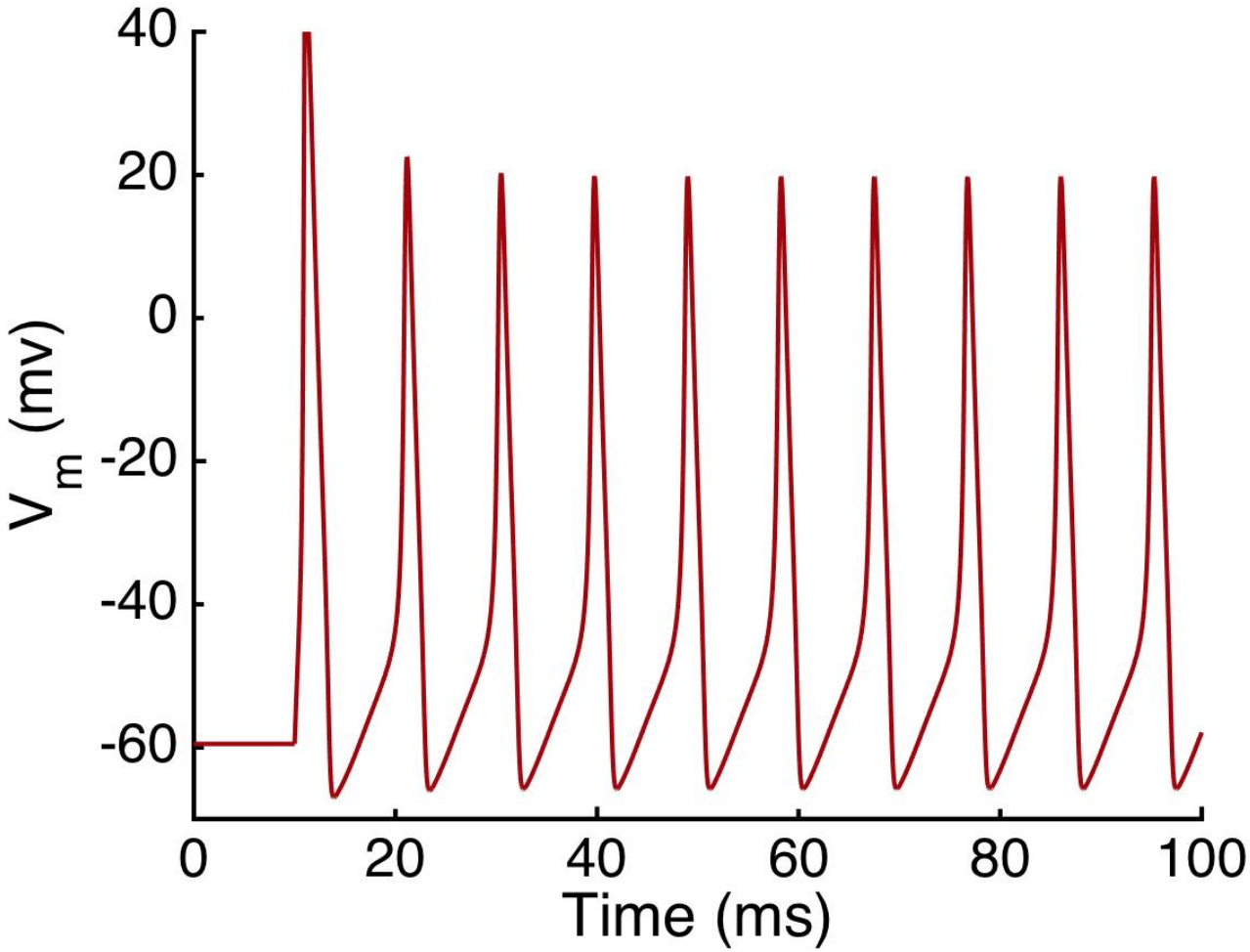

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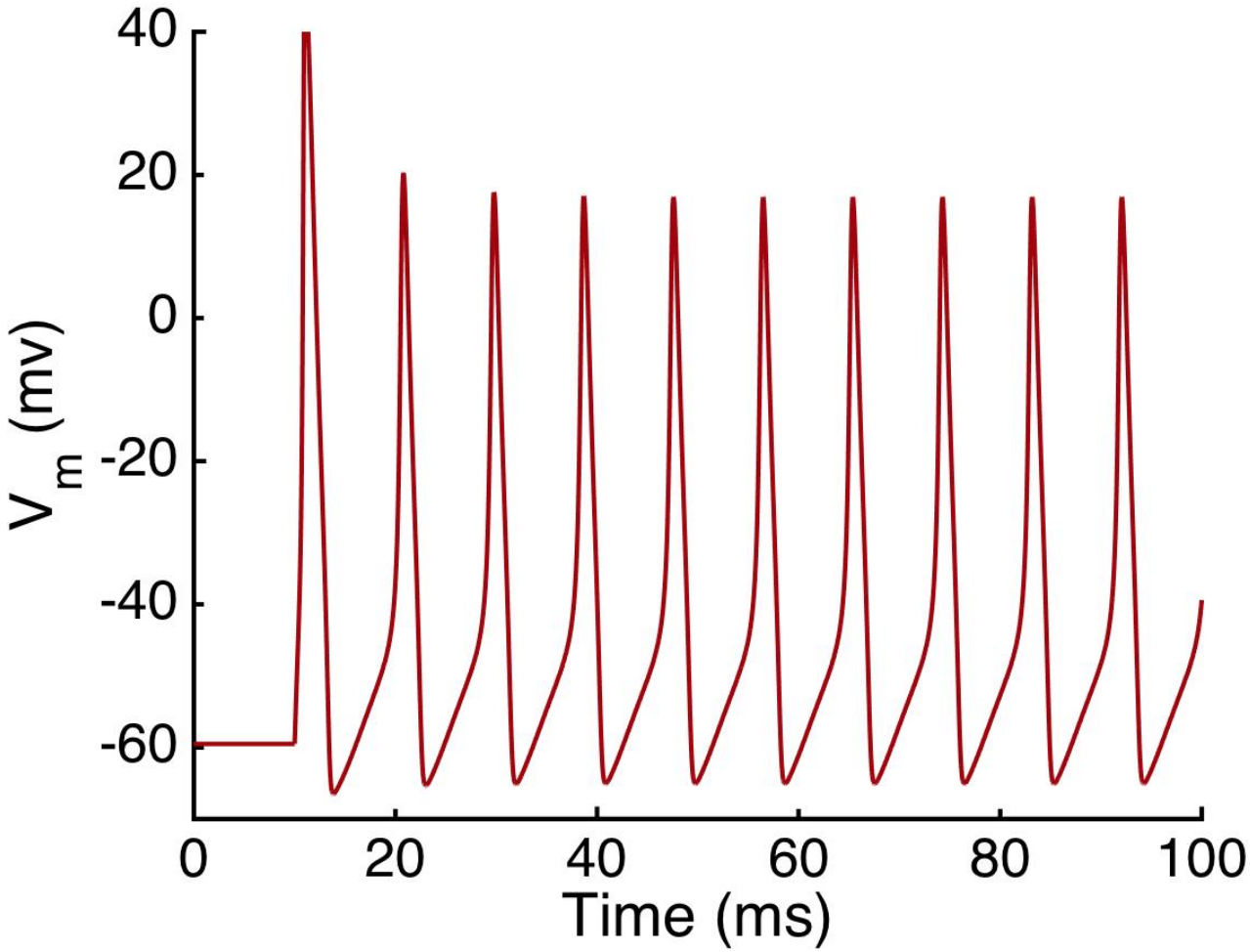

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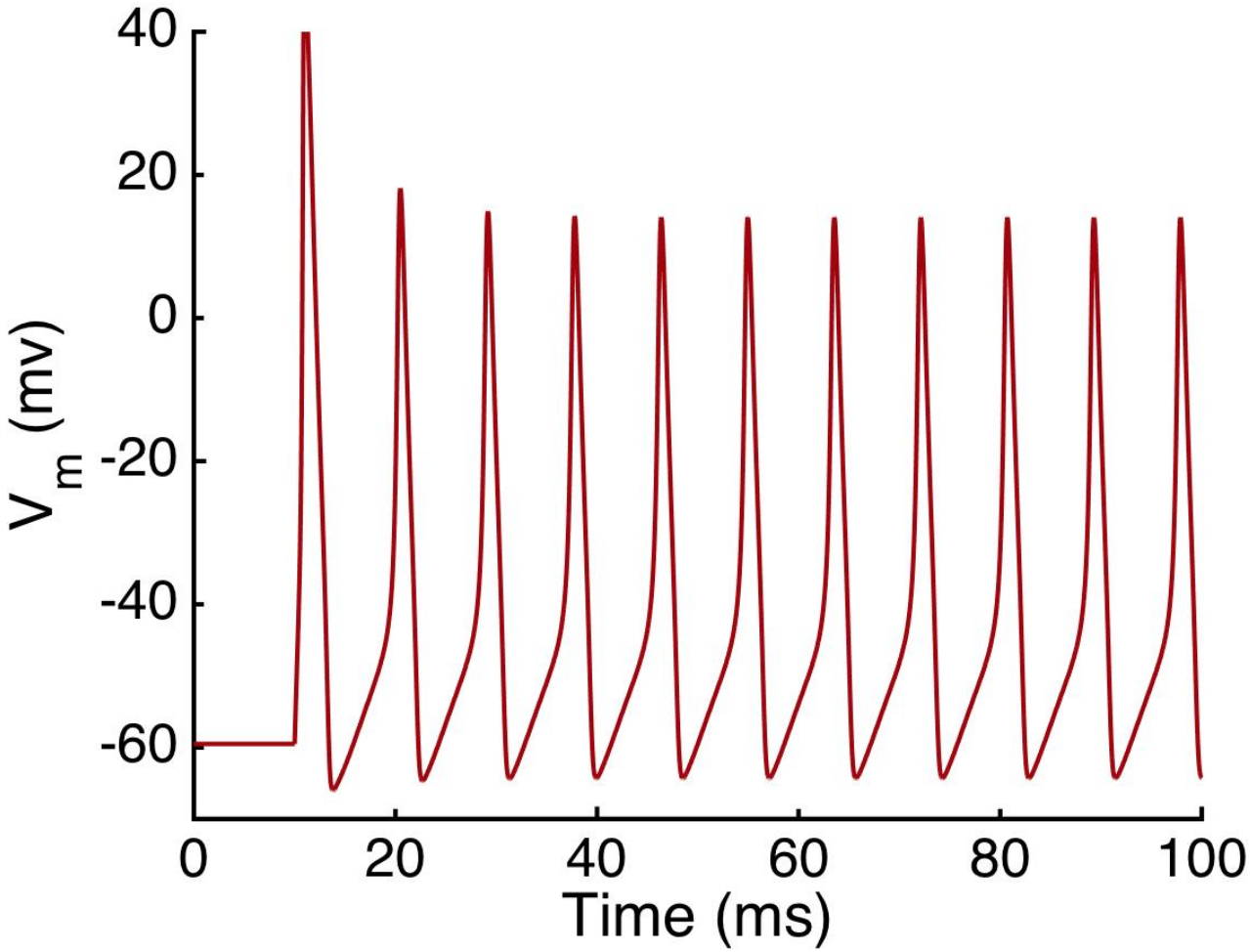

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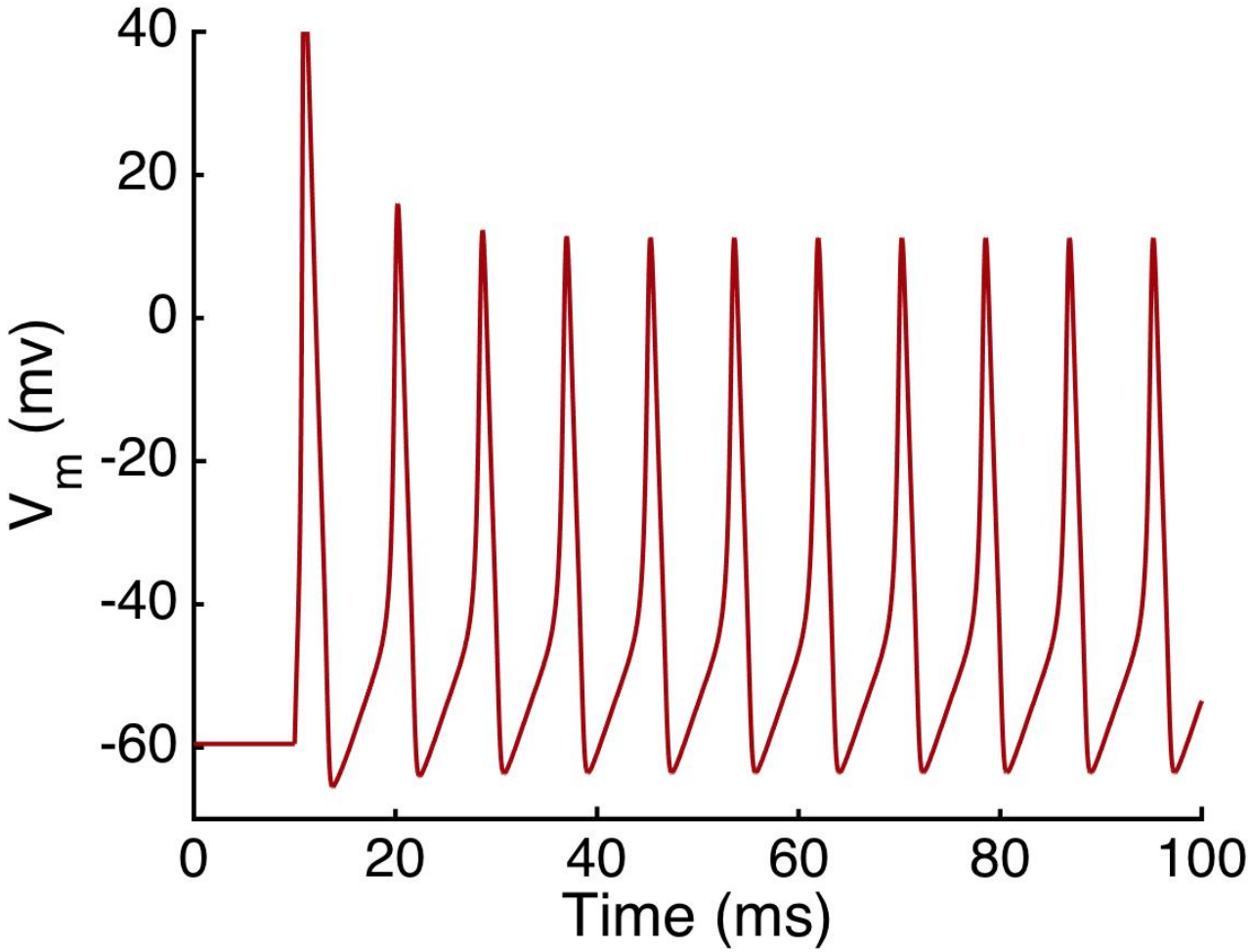

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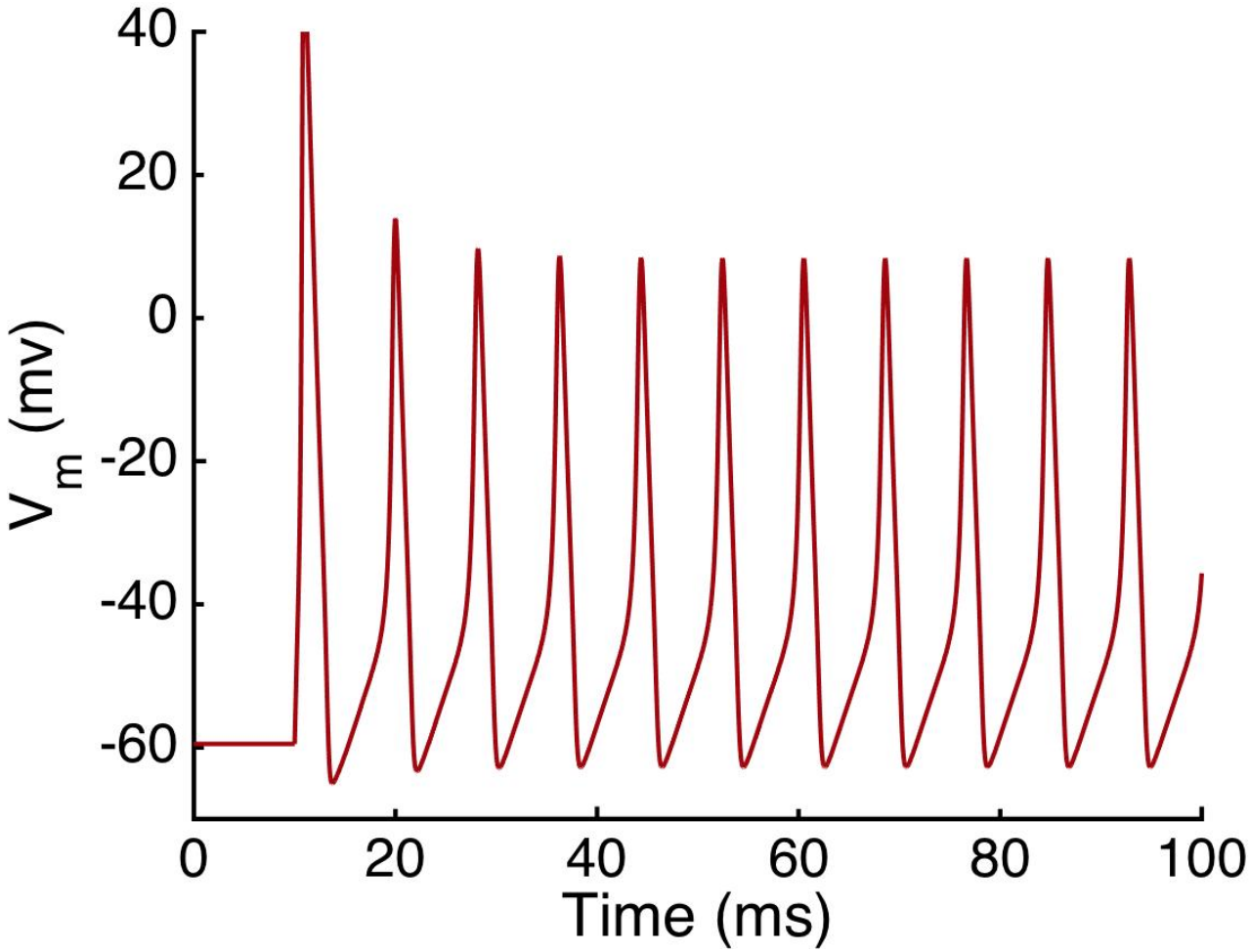

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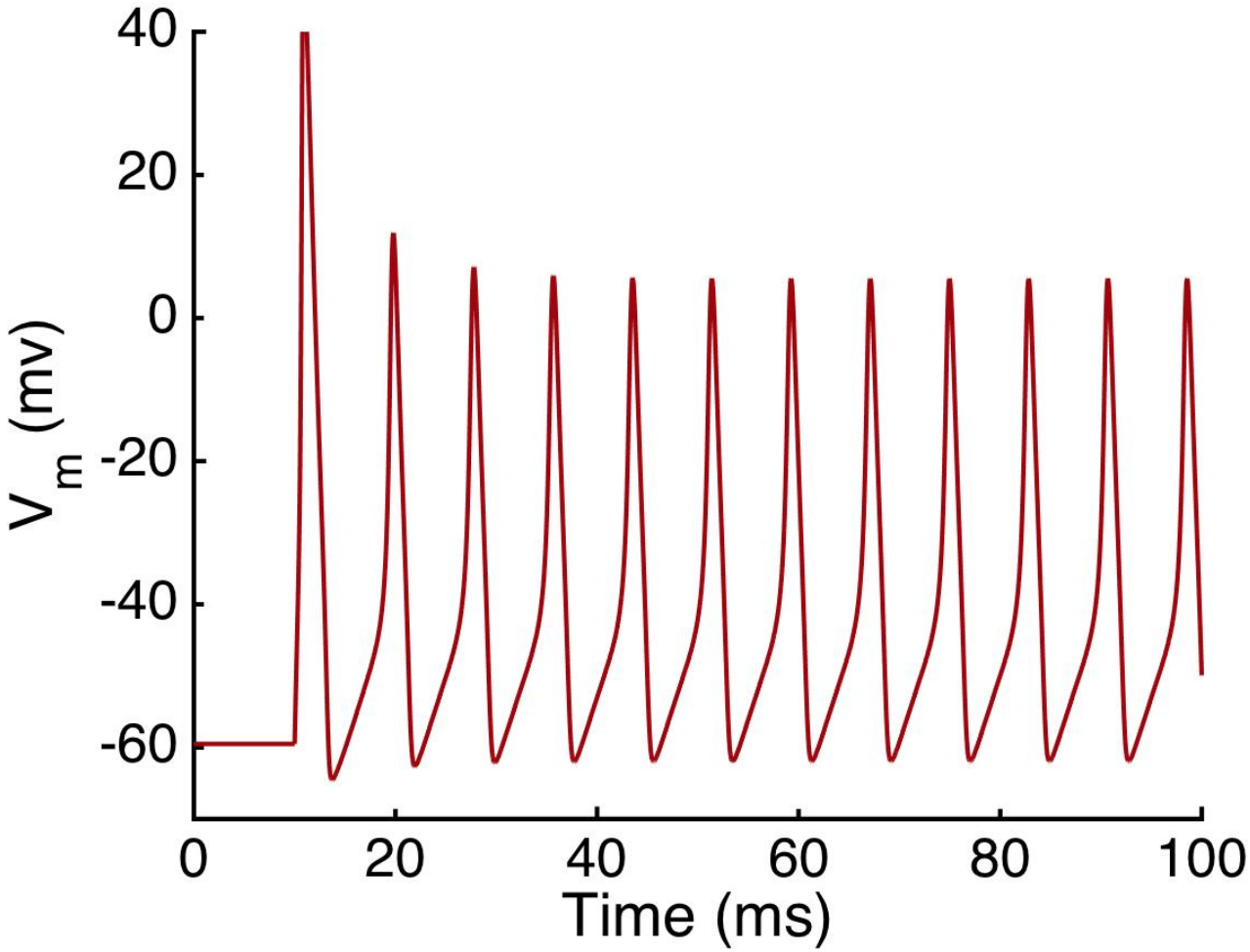

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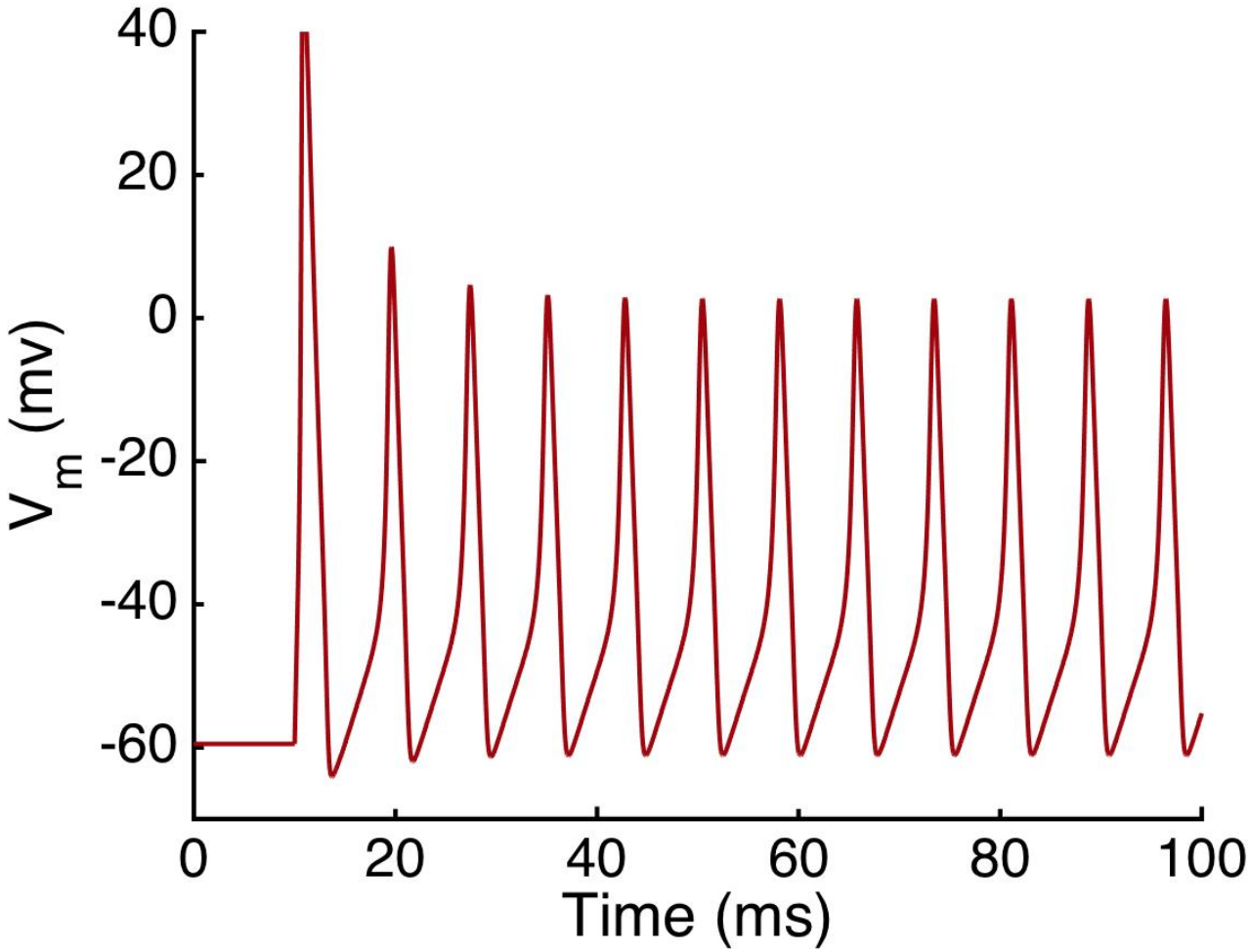

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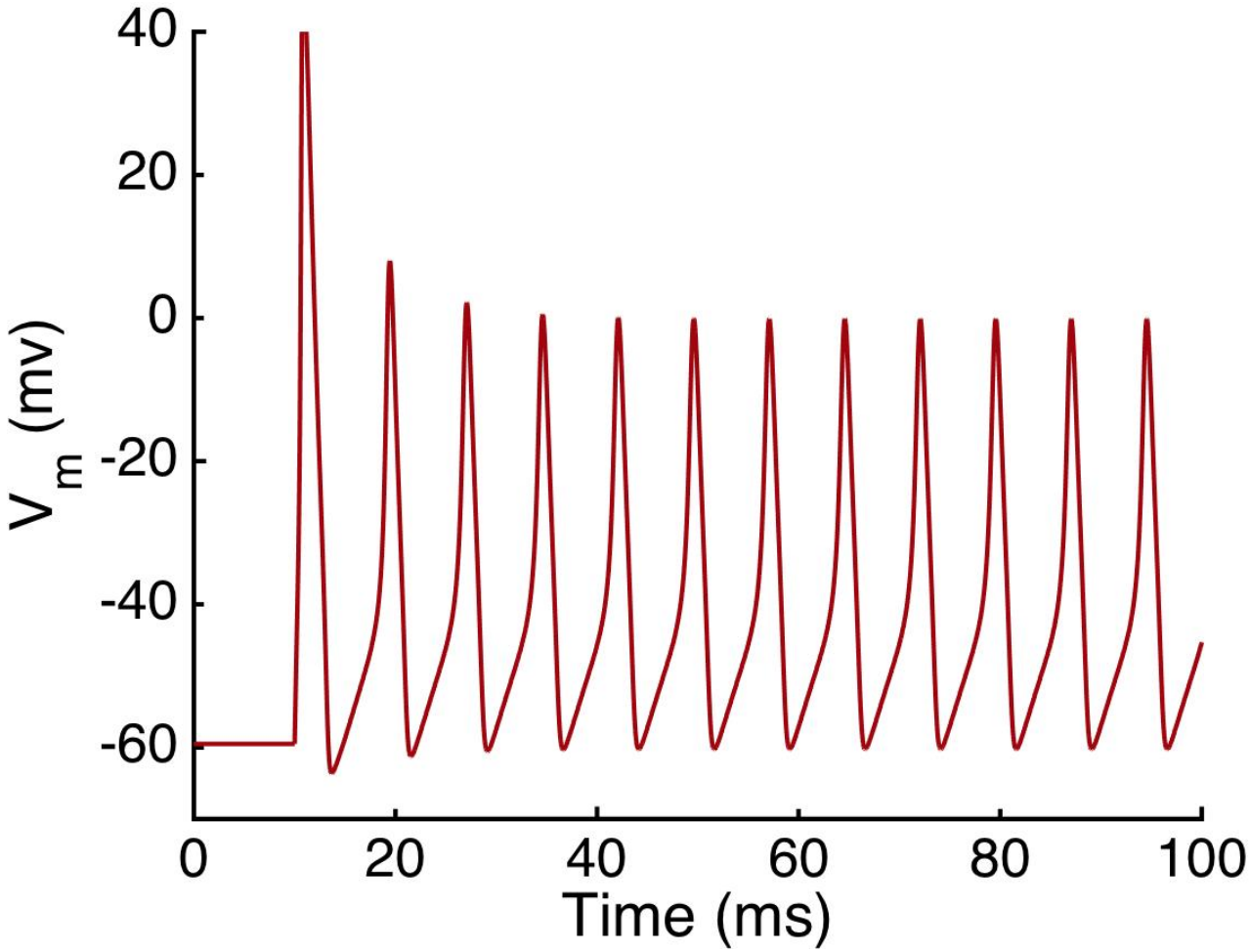

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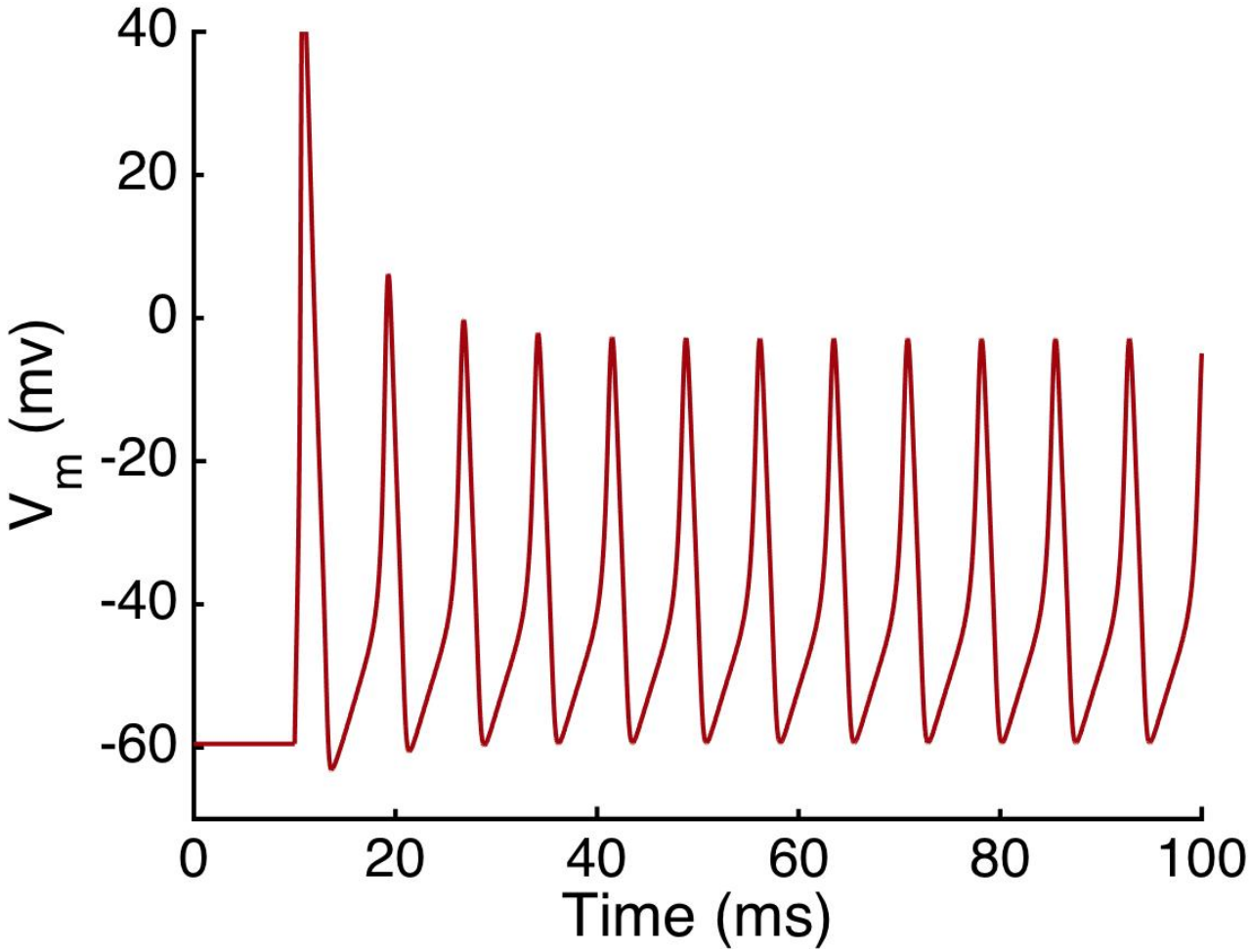

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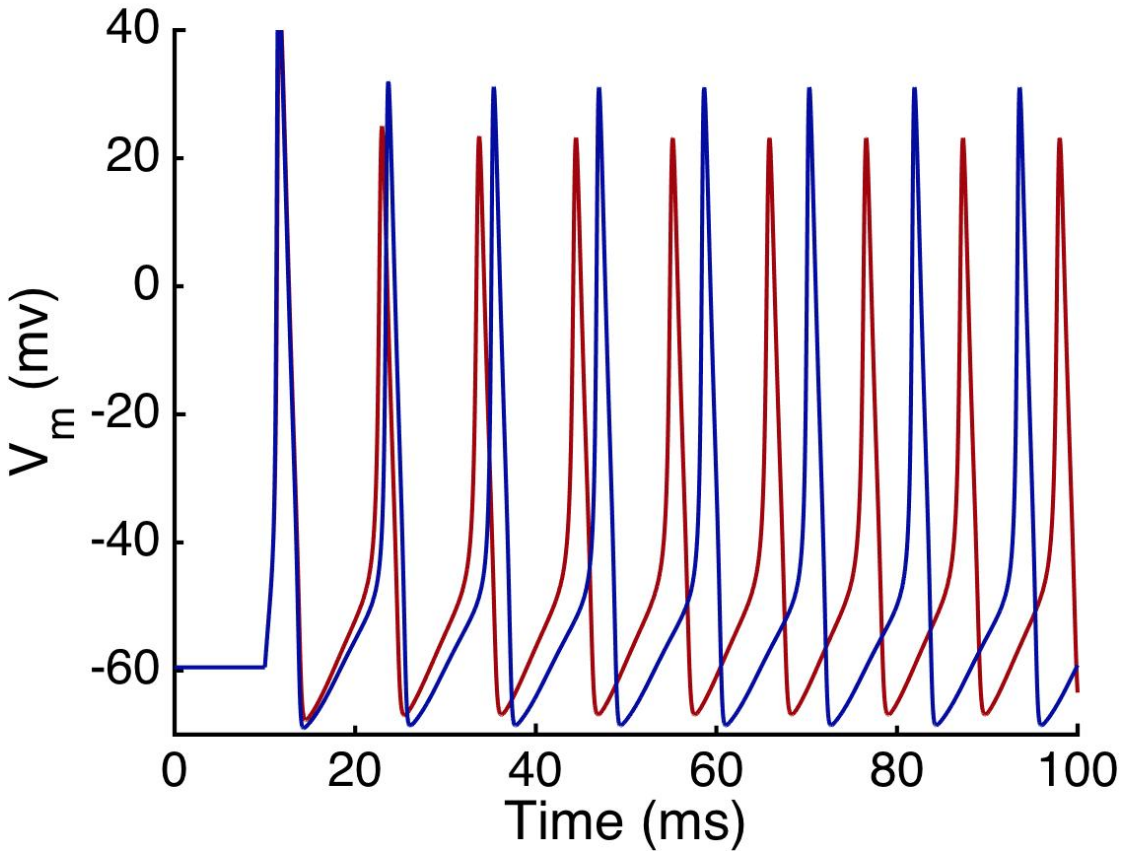
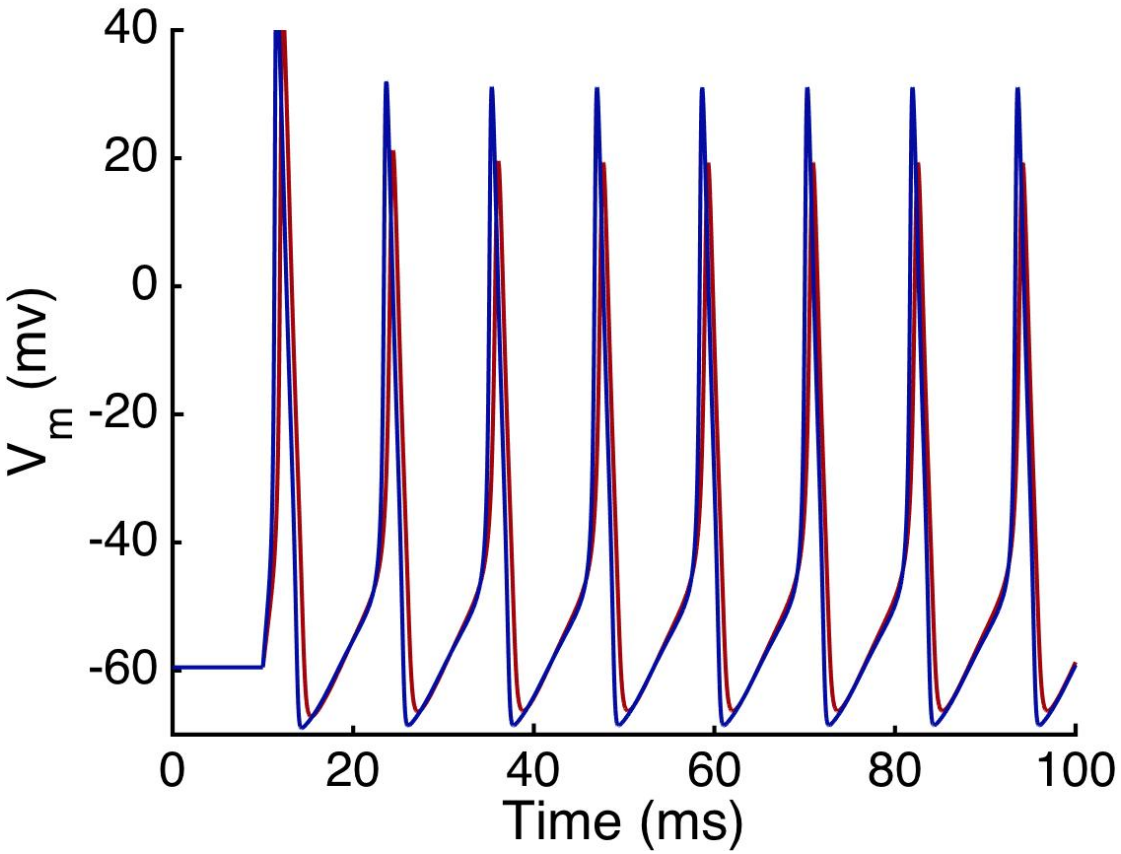
Naive Mechanism



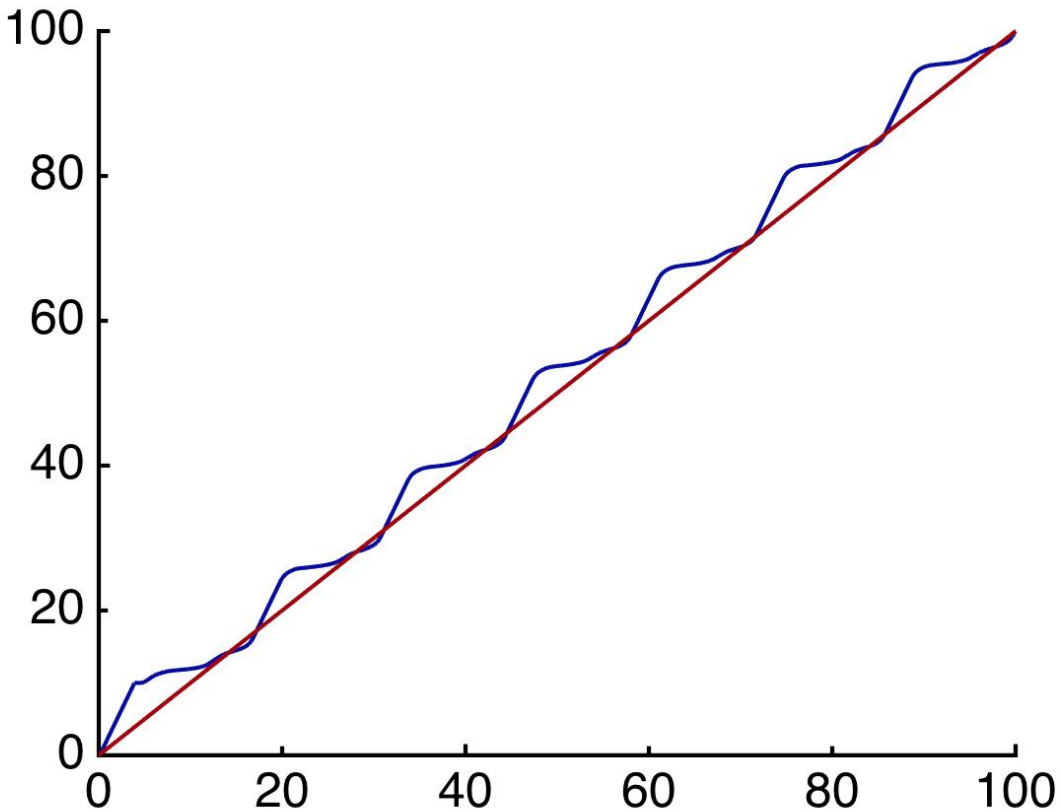
Equal ratio of current to capacitance

Mechanism



Unequal ratio of current to capacitance

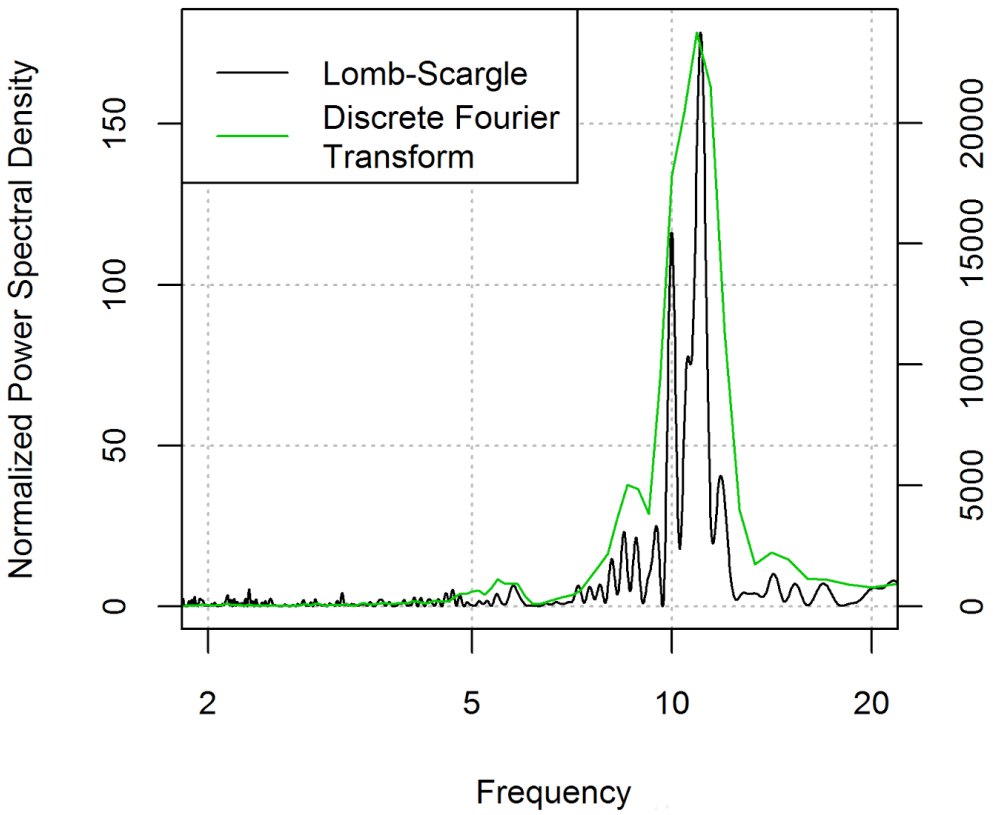
Fourier Transform insufficient: Inconsistent Time Intervals



FFT insufficient,

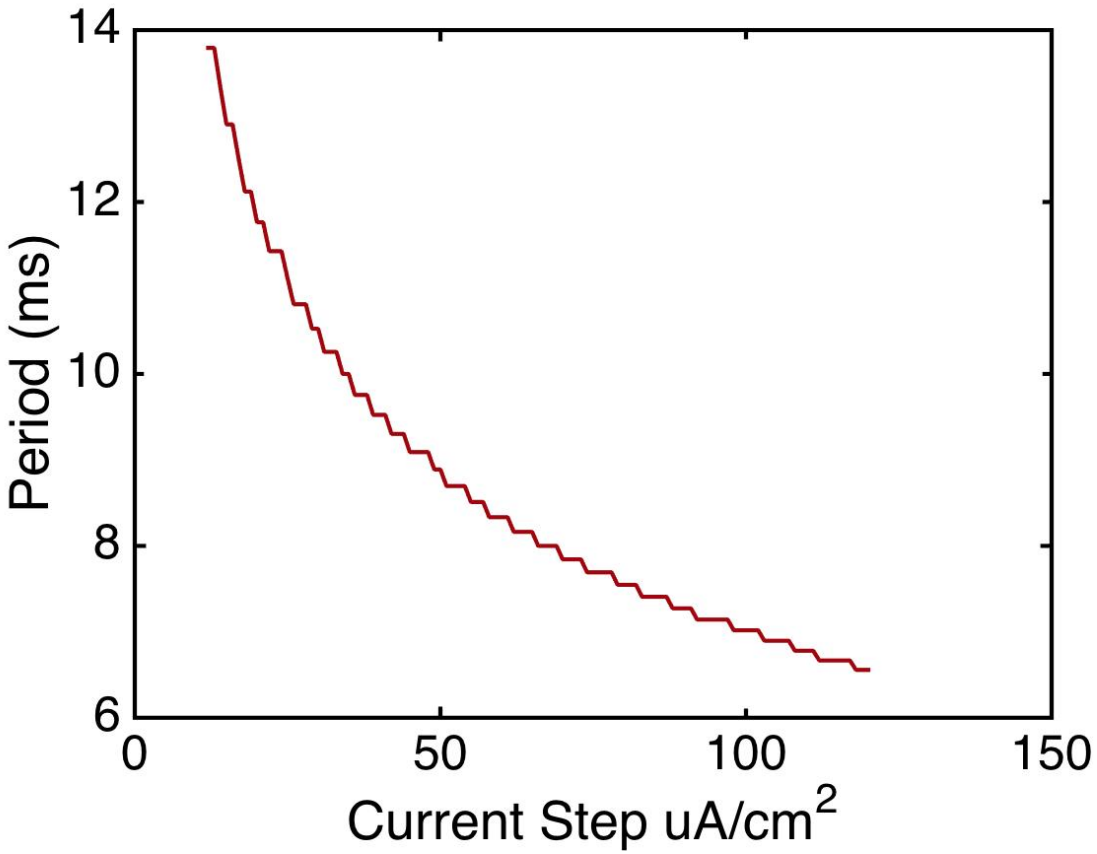
need a better Spectral Analysis Method

Least-squares spectral analysis



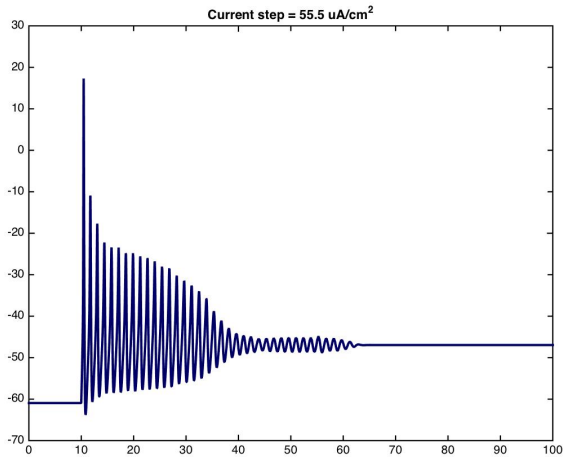
The Lomb-Scargle Periodogram works with variable intervals.

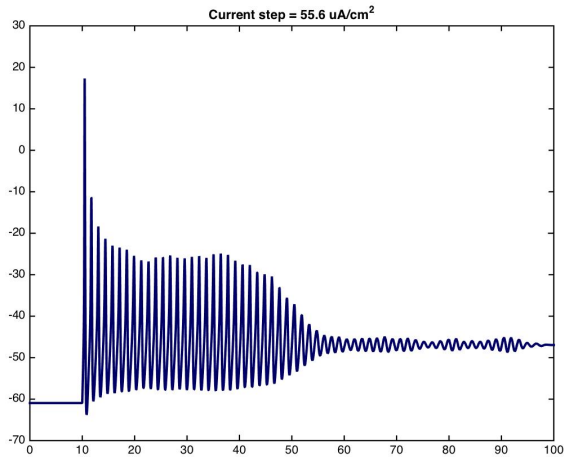
Train period over increasing input step



Nonlinearity shows complexity of behavior

Issues with precision approximation





Incorrect behavior due to low precision

Opportunities for Future Research

1. Experiment with decreasing the refactory period by changing the membrane capacitance.
2. Isolate neurons by disabling parts of the axon with train potentials.
3. Study isolated neuron responces.

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.