Modeling Delay in Axon Circuit

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TCPS # 4: Undergraduate Research Activities in Mathematical and Computational Biology

Math Fest

August 7, 2015

Outline

I. CAM and CSUMS Programs and Participants
II. Hodgkin-Huxley Equations
III. Delay
IV. Numerical Experiments

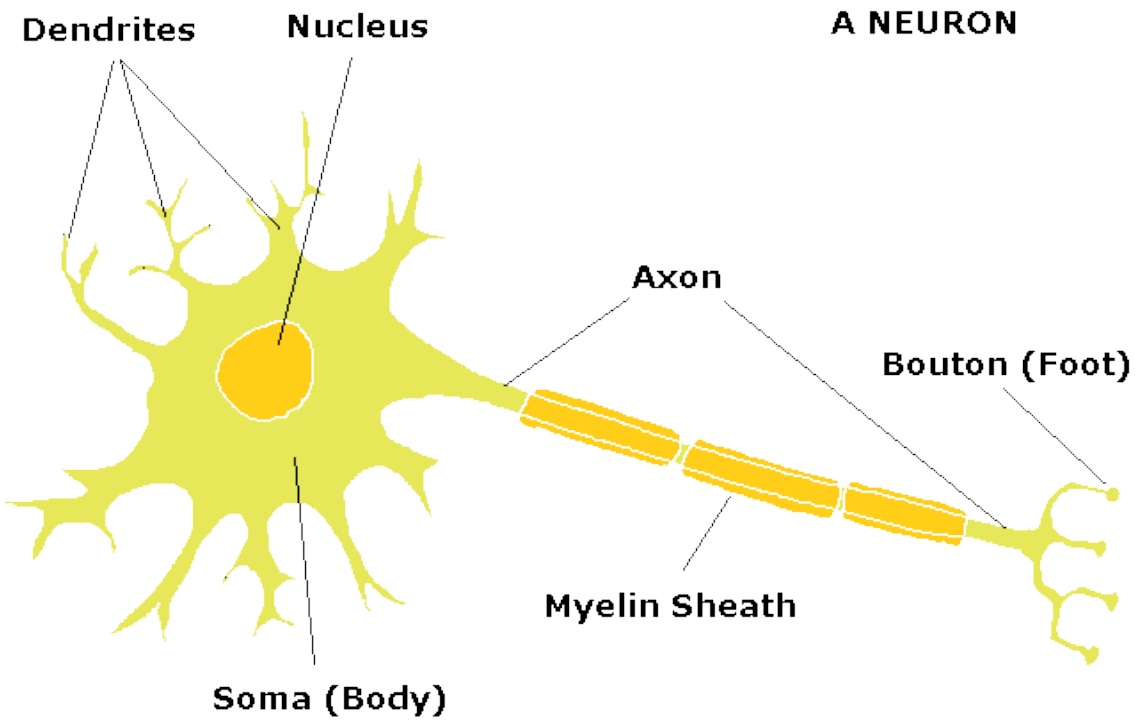
1. Center for Applied Mathematics,
University of St. Thomas
2. Computational Science Training for Undergraduates in the Mathematical Sciences (CSUMS)
National Science Foundation (Grant DMS-0802959)
University of St. Thomas, Augsburg College, Macalester College

Students:
Sean Ewen,
Ann Motl,
Dee Buford-Prioleau,
Natasha Wright

Faculty Mentors:
Misha Shvartsman
Pavel Bělík
Dwight Nelson

Neurons

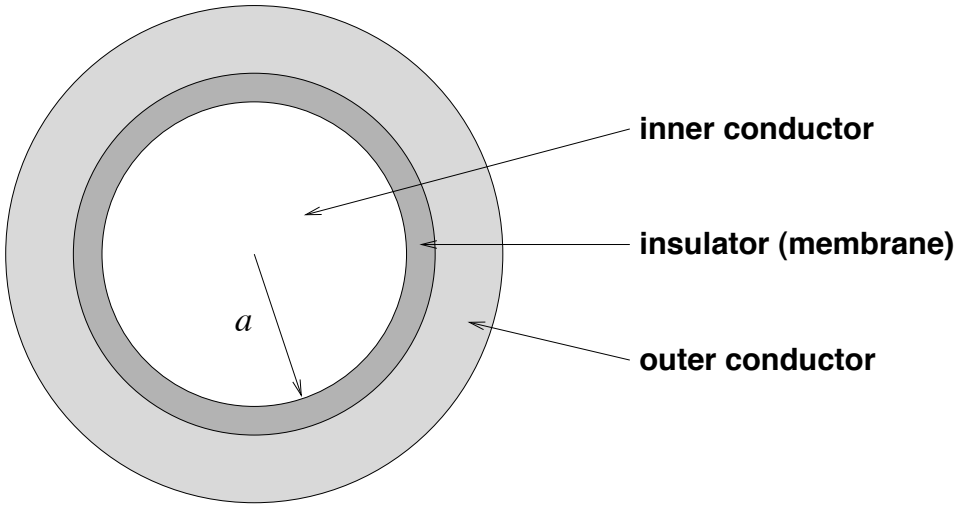
Neurons do most of the work related to transmission of signals inside the brain.



Charlie Rose Brain Series

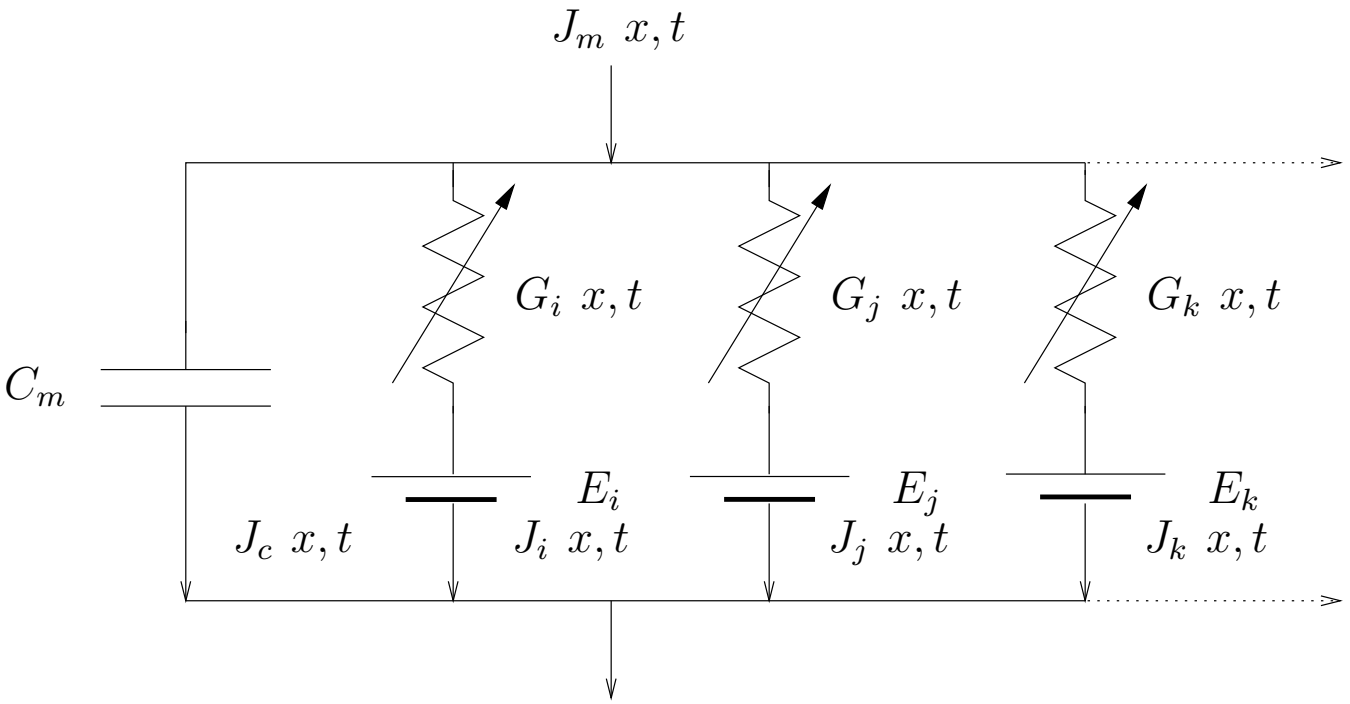
Gerald D. Fischbach, Simons Foundation

Action Potential



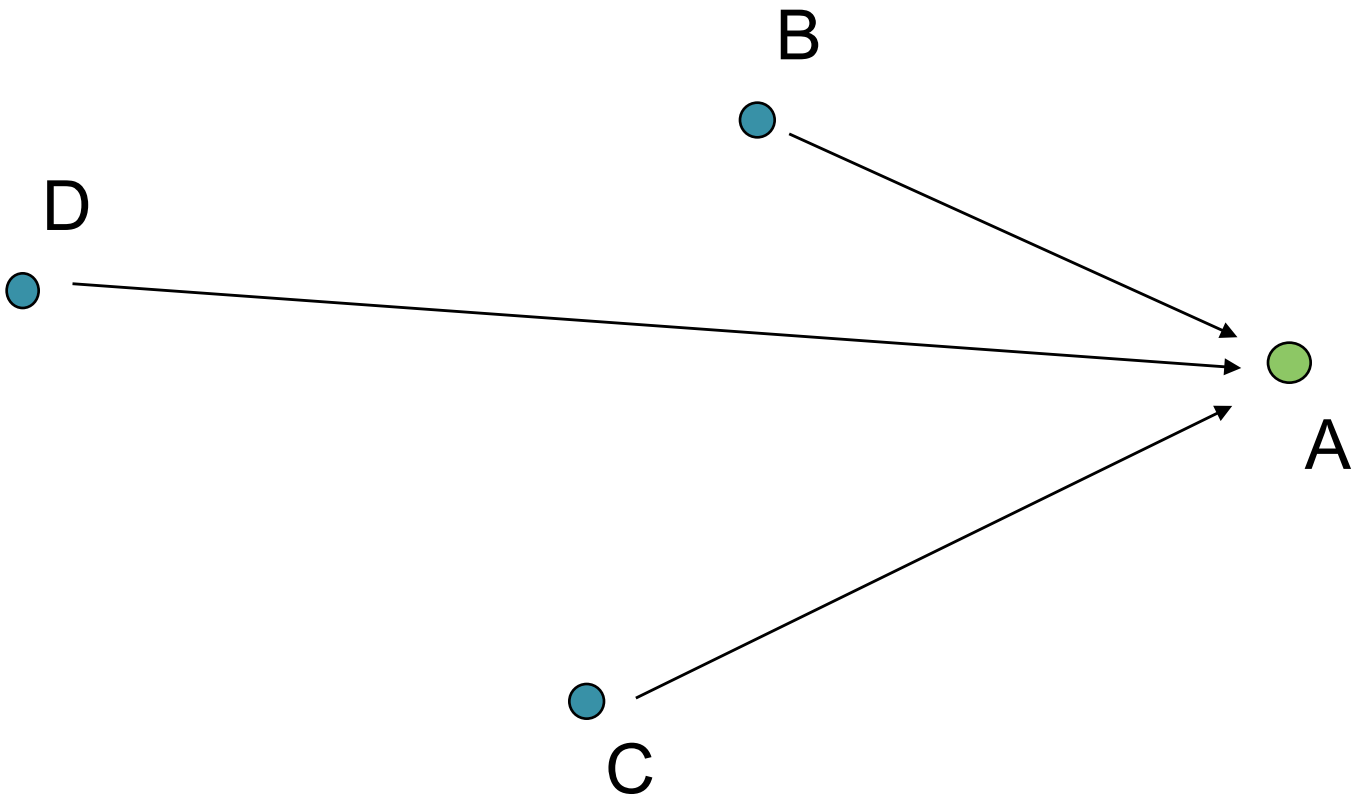
$$\frac{1}{2\pi a r_i}\frac{\partial^2 V_m}{\partial x^2} = C_m\frac{\partial V_m}{\partial t} + \sum_k (V_m - E_k)G_k(x,t,V_m) - J_{ei}(x,t)$$

intracellular

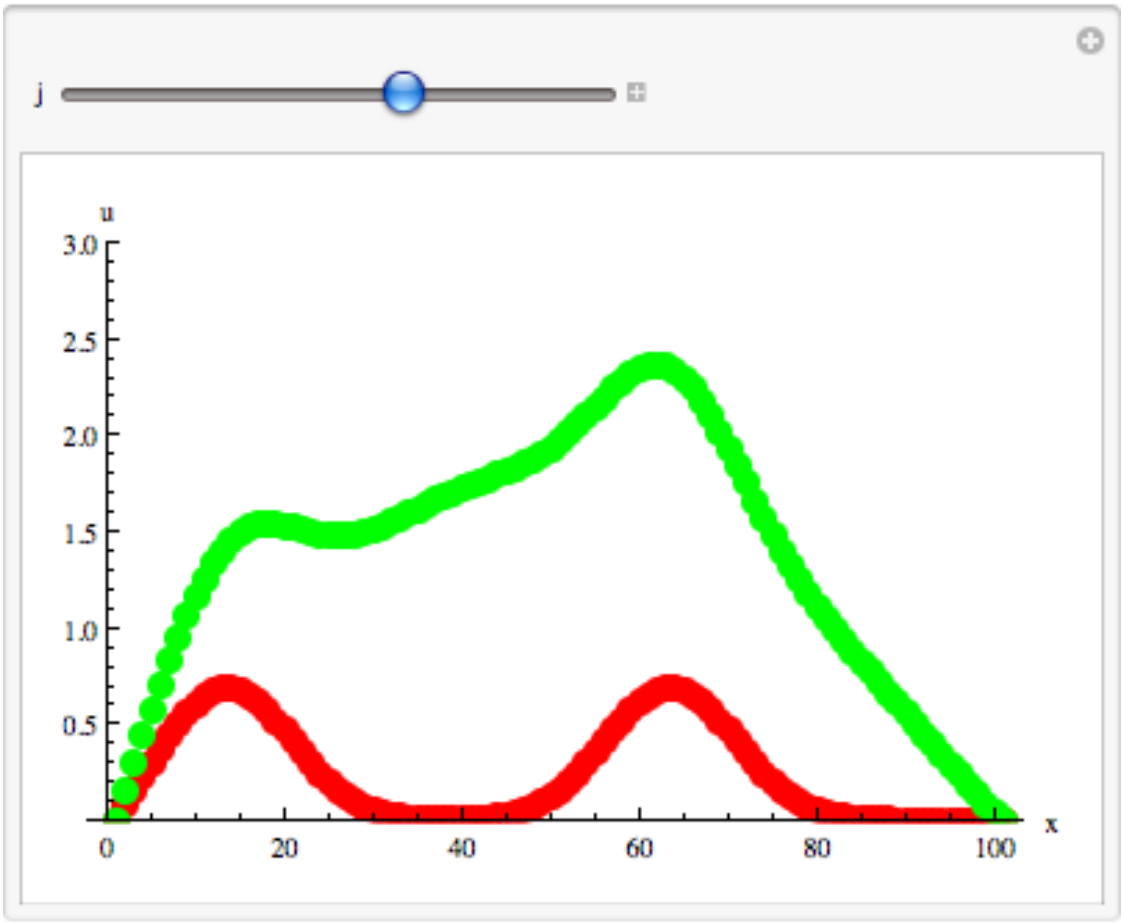


extracellular

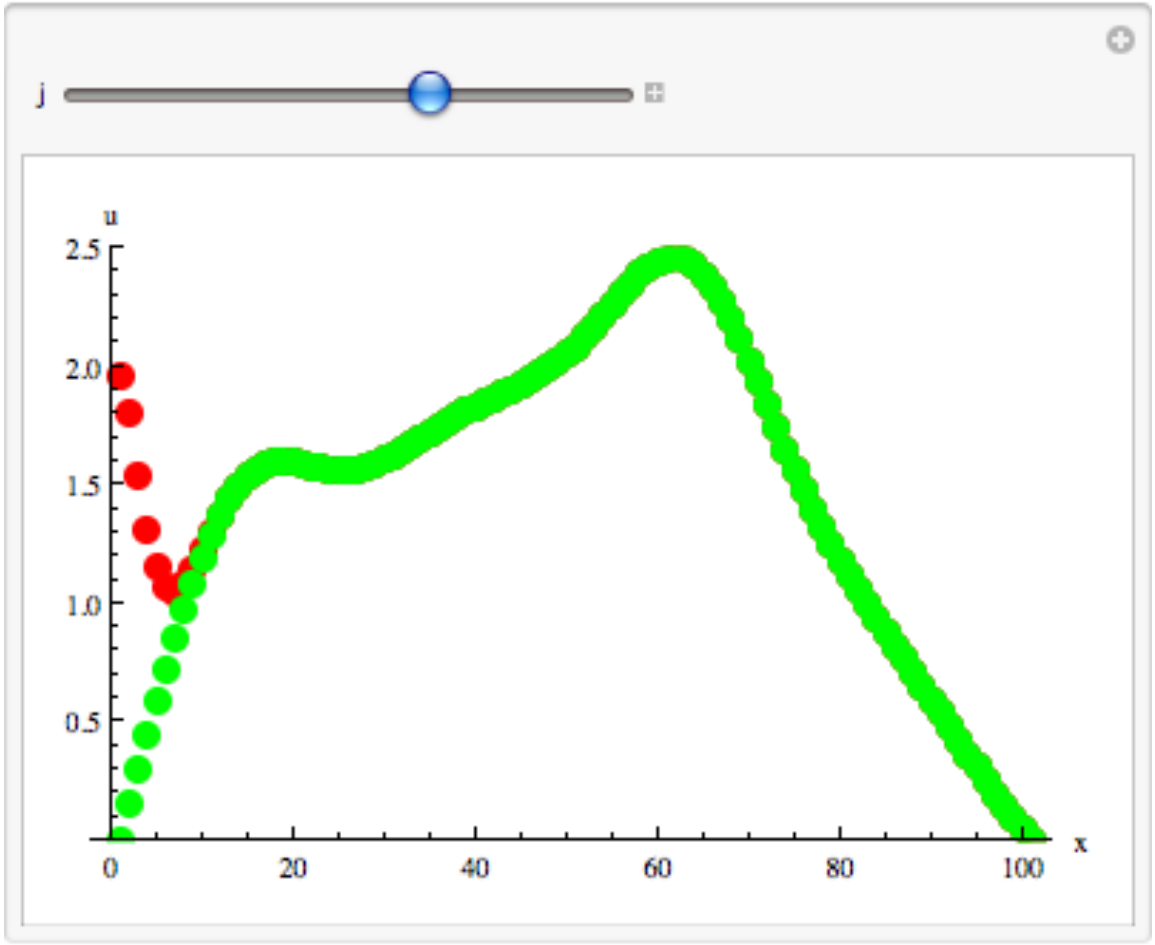
Conduction Delay



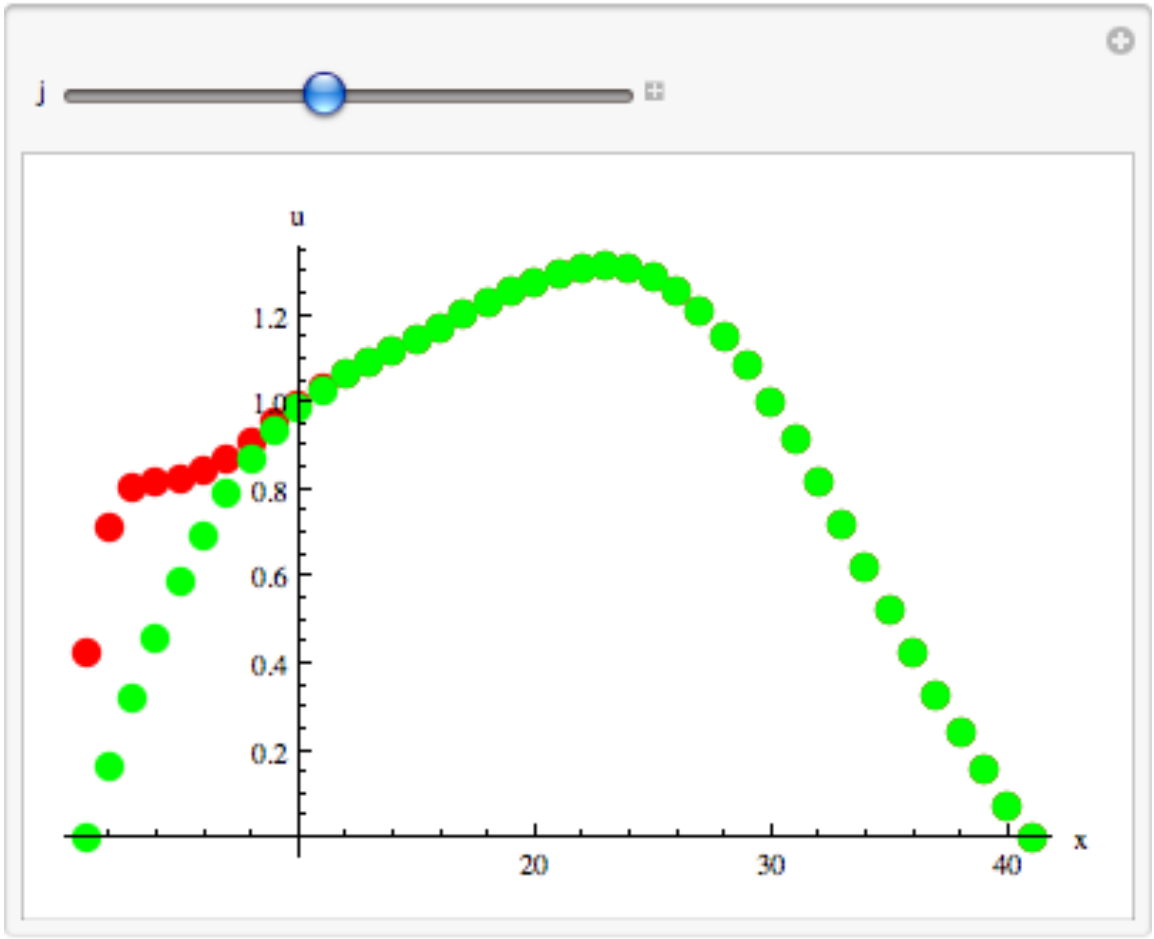
Passive without PDE delay
G = 0 (Red) vs G < 0



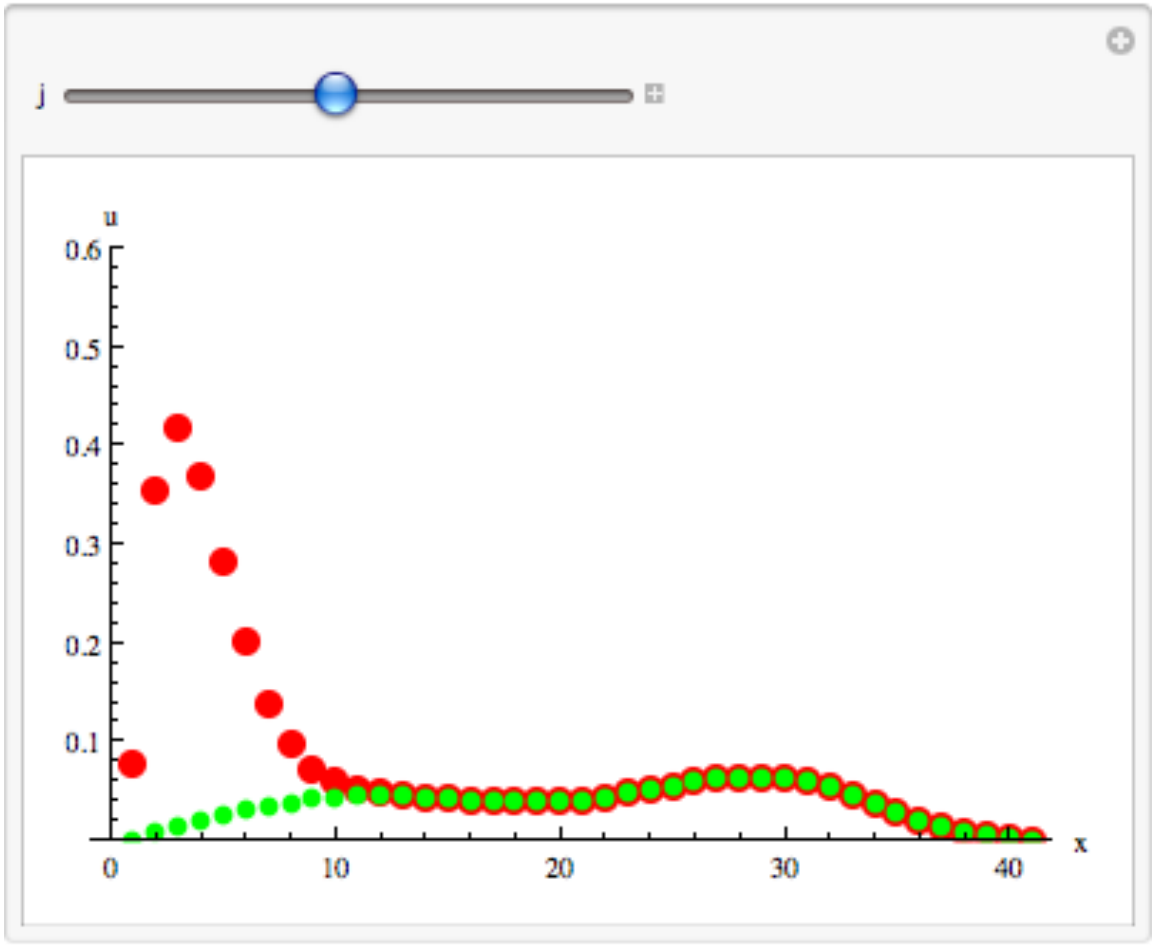
Passive without PDE delay
STDP (Red) vs No STDP



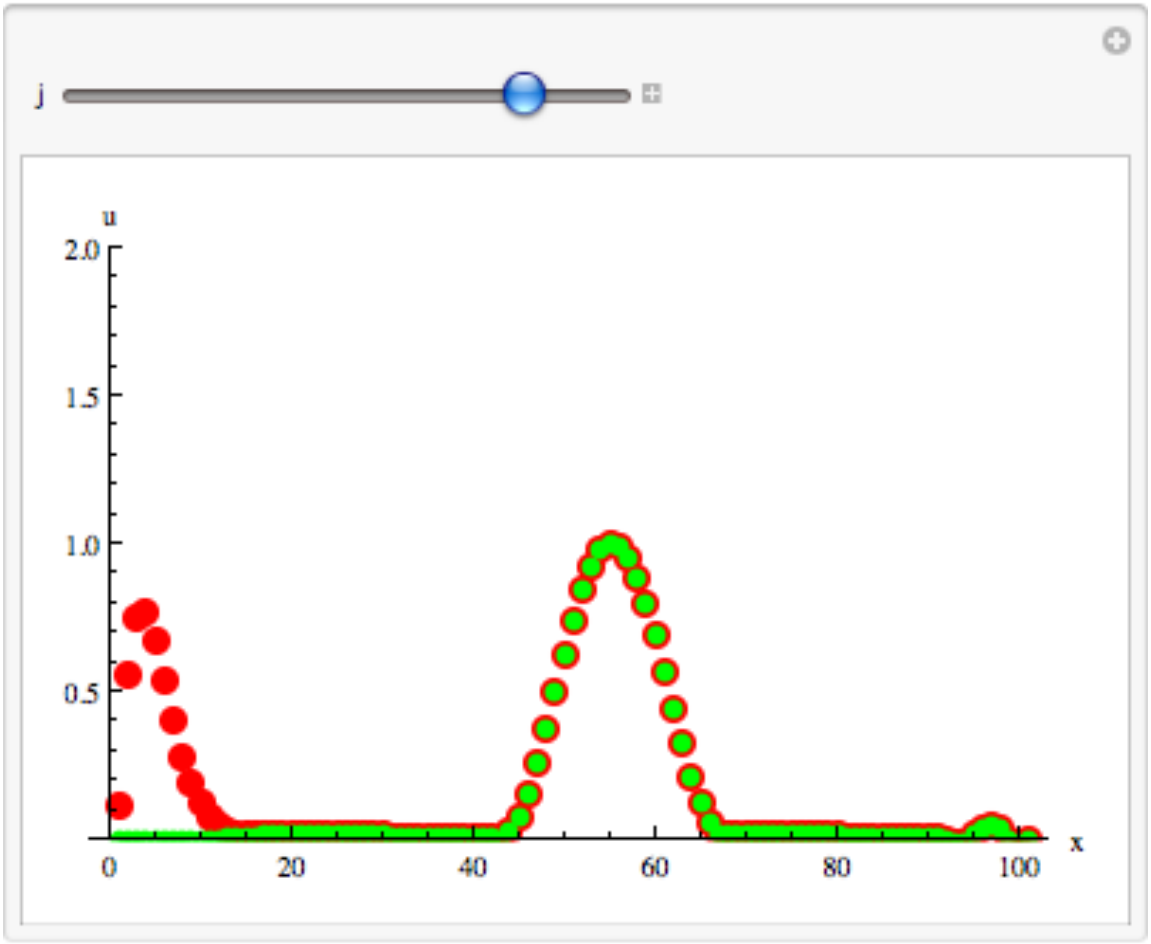
Passive without PDE delay
Polychronization (Red) vs No STDP



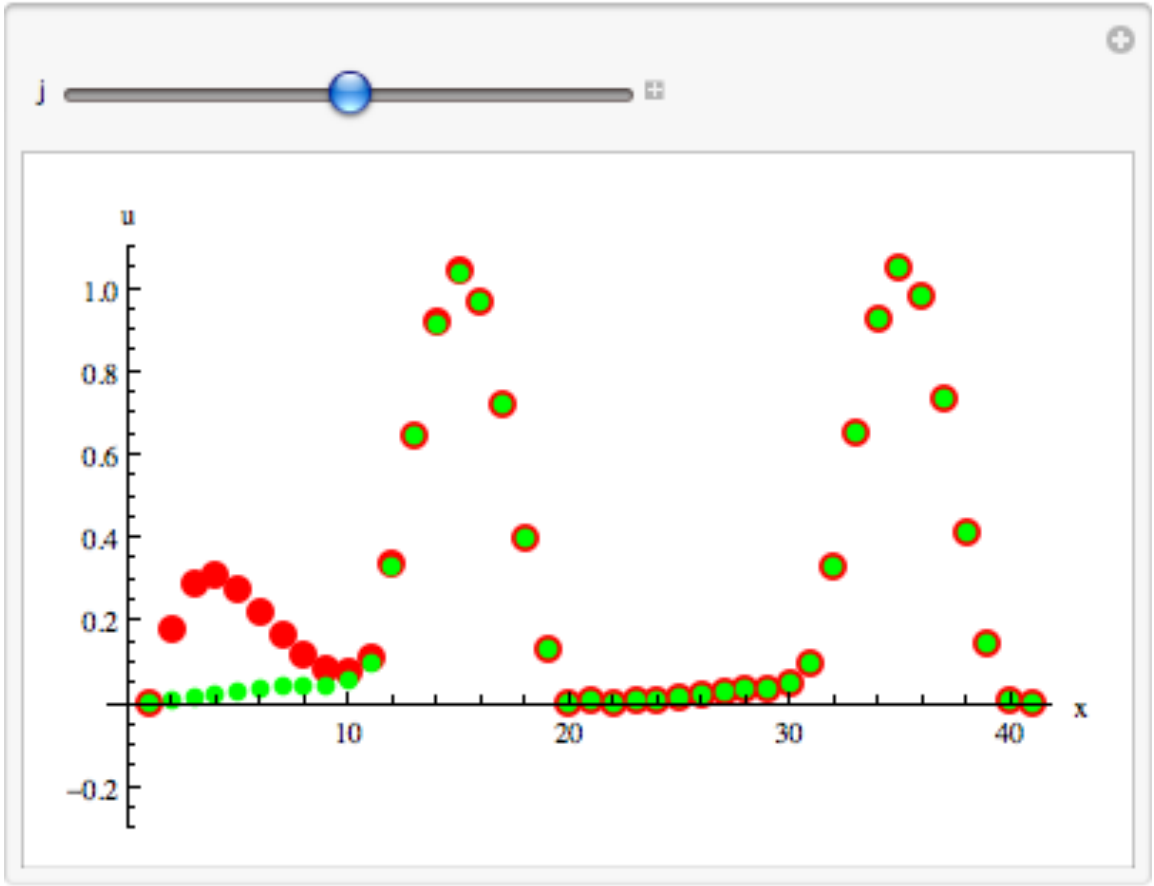
Propagating without PDE delay
Polychronization (Red) vs No STDP



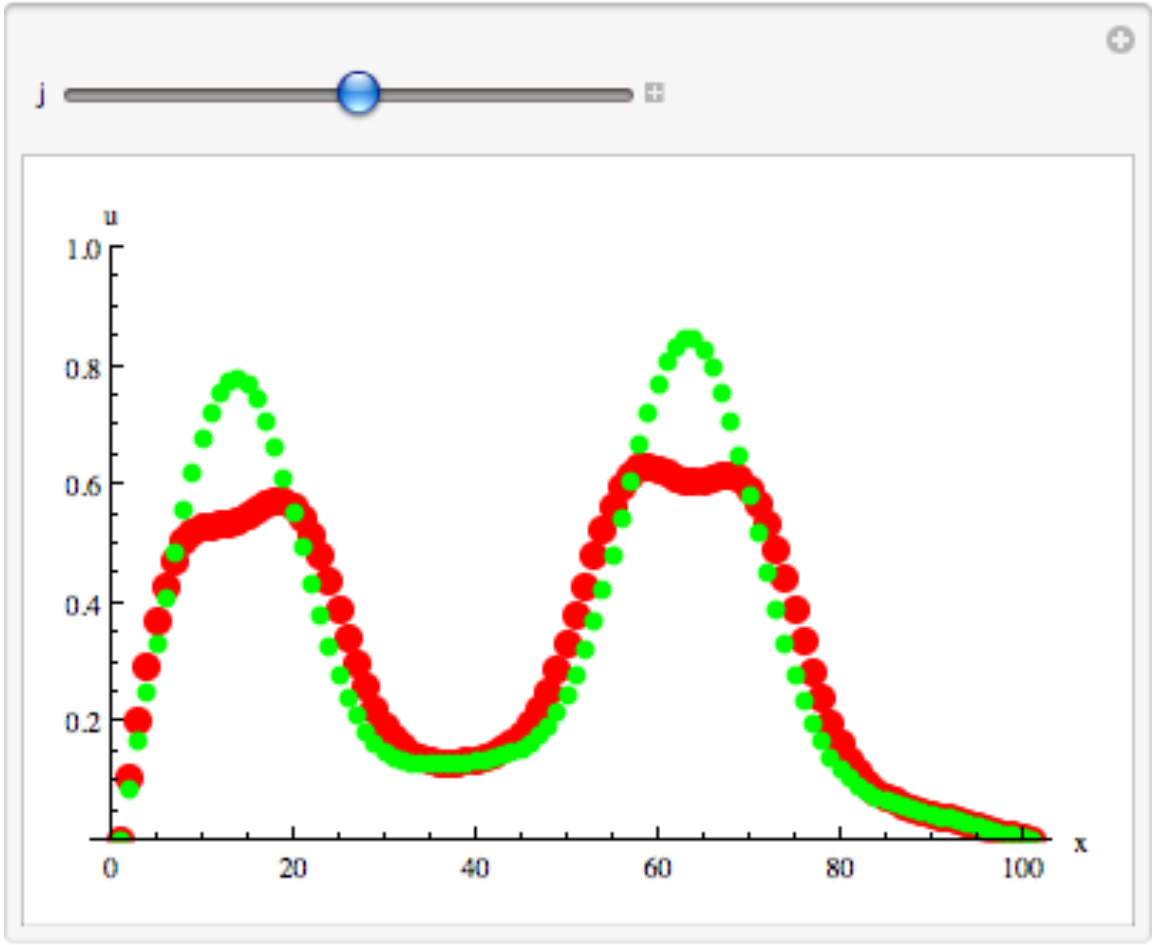
Propagating with PDE delay
STDP (Red) vs No STDP



Propagating with PDE delay
Polychronization (Red) vs No STDP



Passive Cable
PDE delay (Red) No PDE Delay



Propagating Potential
PDE delay (Red) vs No PDE Delay