Math 430 and Math 635: Analytical and Computational Neuroscience
Fall 2001, Prof. V. Booth
Homework 6, Due Wednesday, Oct 21, 2001

Download the XPP file `2ml_1synapse.ode` from the course website. This is a model of 2 Morris-Lecar neurons with 1 synapse from Cell 1 to Cell 2. The applied current in Cell 1, $i1 = 100$ μA/cm^2, is set so that Cell 1 spikes repetitively, while the applied current in Cell 2, $i2 = 60$, is lower and Cell 2 has a stable equilibrium solution. The synapse from Cell 1 to Cell 2 is excitatory with maximal conductance g_{syn}. Run XPP with this file. After integrating, click "Graphic Stuff" and "Add curve" to plot $v2$ along with $v1$ in the window. Make sure to put a number > 0 for the "Color" option so that you can differentiate $v2$ from $v1$ (Color=0 plots a white curve). Also, after the first integration, remember to integrate clicking "Initial Conds" and "Last" so that there are no transient effects on your numerical solution because of initial conditions.

1. The default value for g_{syn} is 1 mS/cm^2. With this value for g_{syn}, Cell 2 spikes with every Cell 1 spike but the spike timing is not synchronized. Cell 2 fires after Cell 1. For what values of g_{syn} is spiking in the two cells synchronized?

2. What is the minimum value of g_{syn} so that Cell 2 fires a full action potential ($v2$ increasing above 0 mV) with every Cell 1 action potential? What happens for g_{syn} values lower than this value? Why?

3. To help understand the "Why?" in Problem 2, change the ϕ value in the Cell 2 to $phi2 = 0.01$ and set $g_{syn} = 2$. Changing $phi2$ makes Cell 2 fire wider spikes at a low frequency. When you integrate, you should see Cell 2 firing an action potential with every other Cell 1 spike. Explain why this is happening by analyzing the solution in the Cell 2 phase plane ($w2$ vs. $v2$). You can plot nullclines for Cell 2 in this phase plane but remember that the position of the nullclines depends on s the synaptic gating variable. For the nullcline computation, XPP uses the value for s that appears in the Initial Conditions window. Change this value for s and when you re-draw the nullclines, the $v2$-nullcline will shift. After understanding why Cell 2 doesn't fire with every Cell 1 spike in this case, answer the "Why?" in Problem 2.