Neuronal Dynamics

Professor Wulfram Gerstner
Laboratory of Computational Neuroscience

Hodgkin-Huxley (HH) Neuron Model

Exercise 1: Numerical Integration of HH model of the Squid Axon

Download HH.py from the book's webpage. HH.py is a python module containing 4 main functions: HH_Step, HH_Ramp, HH_Sinus and HH_ForwardEuler. The later is a subroutine used by the first 3 to perform the numerical integration. With those, you can simulate a step current, a ramp current or a sinusoidal current injected in the squid axon. The specific formulas implemented are described on pages 32 and 33 of the book. Once you have started ipython -pylab in the directory containing HH.py, simply type:

```
>> import HH
```

to port HH.py onto your current session. Then you can simulate a step current in a Hodgkin-Huxley model by typing:

```
>> HH.HH_Step()
```

which should trigger a plot with three panels. To have information on the arguments of the function, simply type:

```
>> HH.HH_Step?
```

or open HH.py in any text editor.

1.1 What is the lowest step current amplitude for generating at least one spike? Hint: use binary search on I_{amp}, with a 0.1 μA resolution.

1.2 What is the lowest step current amplitude to generate repetitive firing?

1.3 What is the minimum current required to make a spike when the current is slowly increased (ramp current waveform) instead of being increased suddenly?

1.4 What is the current threshold for repetitive spiking if the density of sodium channels is increased by a factor of 1.5? (You need to change the maximum conductance of sodium channel.)

Hint: You can change the parameters of the model in the appropriate section of HH.py; use any text editor to save the change. To actualize the change you have saved, you must type in your current ipython workspace:

```
>> reload(HH)
```

1.5 Look at HH_Step(I_amp = -5) and HH_Step(I_amp = -1). What is happening here? To which gating variable do you attribute this rebound spike?