CS296.6: Numerical Models for Excitable Media (Spring 2007)

Hodgkin-Huxley Membrane Model

$$C_m \frac{dV_m}{dt} = -\bar{g}_{Na} m^3 h \,(V_m - E_{Na}) - \bar{g}_K n^4 \,(V_m - E_K) - g_{leak} \,(V_m - E_{leak}), \tag{1}$$

$$\frac{dm}{dt} = (1-m)\,\alpha_m(V_m) - m\,\beta_m(V_m), \tag{2}$$

$$\frac{dh}{dt} = (1-h)\,\alpha_h(V_m) - h\,\beta_h(V_m), \tag{3}$$

$$\frac{dn}{dt} = (1-n)\,\alpha_n(V_m) - n\,\beta_n(V_m), \tag{4}$$

with rate functions

$$\alpha_m(V_m) = 0.1 \frac{25 - V_m}{\exp\left(\frac{25 - V_m}{10}\right) - 1}, \tag{5}$$

$$\beta_m(V_m) = 4 \exp\left(-\frac{V_m}{18}\right); \tag{6}$$

$$\alpha_h(V_m) = 0.07 \exp\left(\frac{-V_m}{20}\right), \tag{7}$$

$$\beta_h(V_m) = \frac{1}{\exp\left(\frac{30 - V_m}{10}\right) + 1}; \tag{8}$$

$$\alpha_n(V_m) = 0.01 \frac{10 - V_m}{\exp\left(\frac{10 - V_m}{10}\right) - 1}, \tag{9}$$

$$\beta_n(V_m) = 0.125 \exp\left(-\frac{V_m}{80}\right); \tag{10}$$

and parameters

$$\bar{g}_{Na} = 120.0\,\mathrm{mS/cm}^2, \quad \bar{g}_K = 36.0\,\mathrm{mS/cm}^2, \quad g_{leak} = 0.3\,\mathrm{mS/cm}^2,$$

$$E_{Na} = 115.0\,\mathrm{mV}, \quad E_K = -12.0\,\mathrm{mV}, \quad E_{leak} = 10.613\,\mathrm{mV},$$

$$C_m = 1.0\,\mu F/cm^2.$$

References

[1] A. L. Hodgkin and A. F. Huxley, A quantitative description of membrane current and its application to conduction and exciation in nerve, *Journal of Physiology*, 117:500-544, 1952.