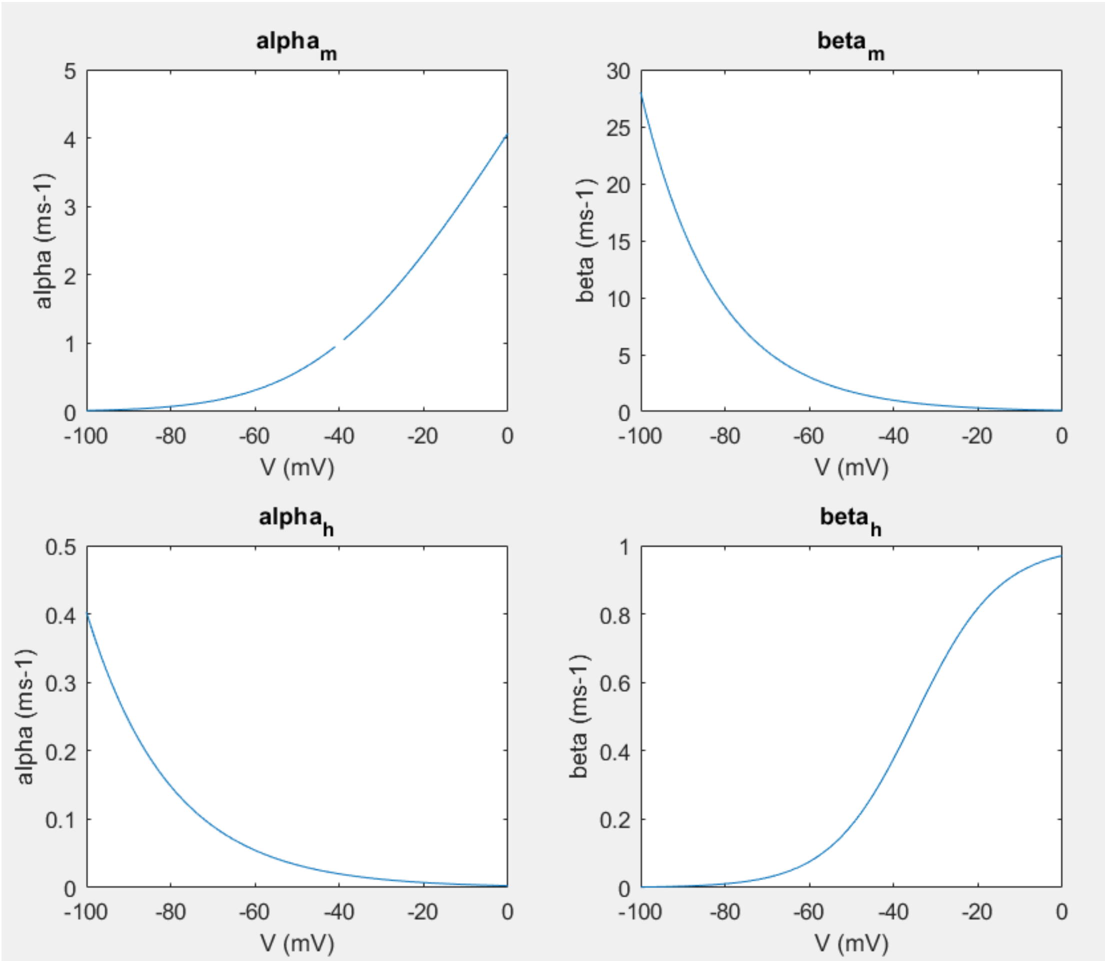

3.1 The Hodgkin-Huxley model

Using the squid giant axon preparation, Hodgkin and Huxley measured the membrane current due to K^+ and fast Na^+ ion channels and arrived at Eq. 2.19 introduced at the end of the previous lecture. In this lecture, we analyze this model and show that it produces an action potential under suitable stimulation. We will then use the model to explain how this occurs.

The complete HH model reads:

$$C\frac{dV}{dt} = -\frac{V - V_L}{R_m} - \bar{G}_{Na}m^3h(V - E_{Na}) - \bar{G}_K n^4(V - E_K) + I_e, \tag{3.1}$$

where m, h and n are gating variables obeying equations of type 2.3,

$$\begin{aligned} \dot{m} &= \alpha_m(V)(1-m) - \beta_m(V)m, &(3.2)\\ \dot{h} &= \alpha_h(V)(1-h) - \beta_h(V)h, &(3.3)\\ \dot{n} &= \alpha_n(V)(1-n) - \beta_n(V)n, &(3.4)\end{aligned}$$

with transition rates $\alpha(V)$ and $\beta(V)$ given by

$$\begin{aligned} \alpha_m(V) &= \frac{0.1(V+40)}{1-e^{-0.1(V+40)}}\ ; \quad \beta_m(V) = 4e^{-0.0556(V+65)}, &(3.5)\\ \alpha_h(V) &= 0.07e^{-0.05(V+65)}\ ; \quad \beta_h(V) = \frac{1}{1+e^{-0.1(V+35)}}, &(3.6)\\ \alpha_n(V) &= \frac{0.01(V+55)}{1-e^{-0.1(V+55)}}\ ; \quad \beta_n(V) = 0.125e^{-0.0125(V+65)}. &(3.7)\end{aligned}$$