Sander Land 2017 for tension

Crossbridge states

$$\frac{dB}{dt} = k_b \cdot \mathrm{CaTRPN}^{-n_{Tm}/2} \cdot U - k_u \cdot \mathrm{CaTRPN}^{n_{Tm}/2} \cdot B$$

$$\frac{dW}{dt} = k_{uw}U - k_{wu}W - k_{ws}W - \gamma_{wu}W$$

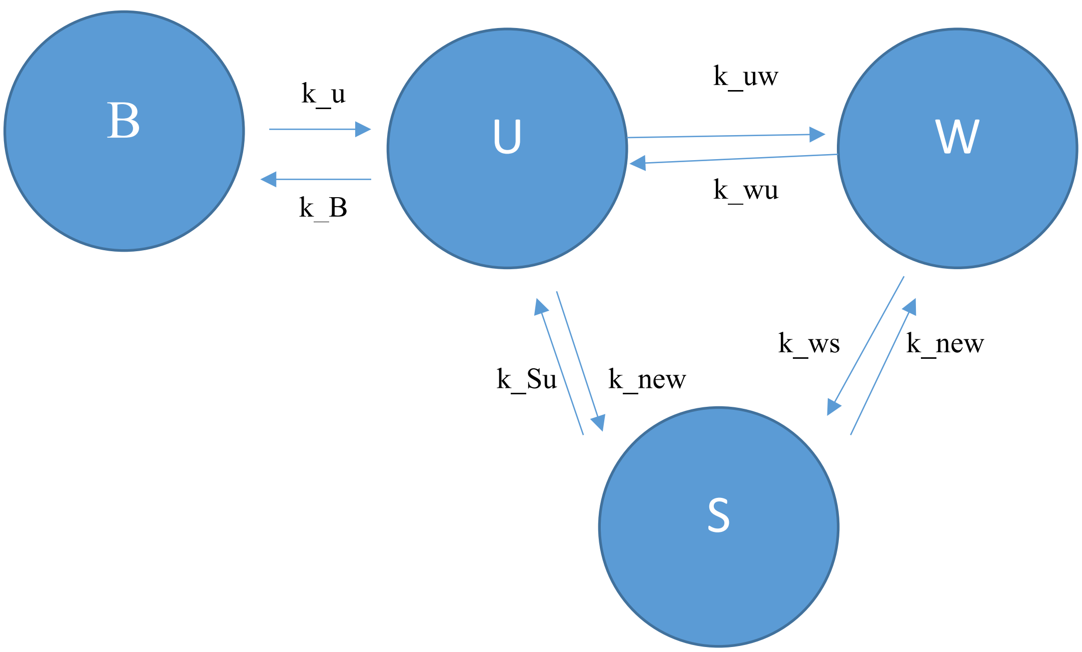
$$\frac{dS}{dt} = k_{ws}W - k_{su}S - \gamma_{su}S$$

$$\frac{d\zeta_w}{dt} = A_w\frac{d\lambda}{dt} - c_w\zeta_w$$

$$\frac{d\zeta_s}{dt} = A_s\frac{d\lambda}{dt} - c_s\zeta_s$$

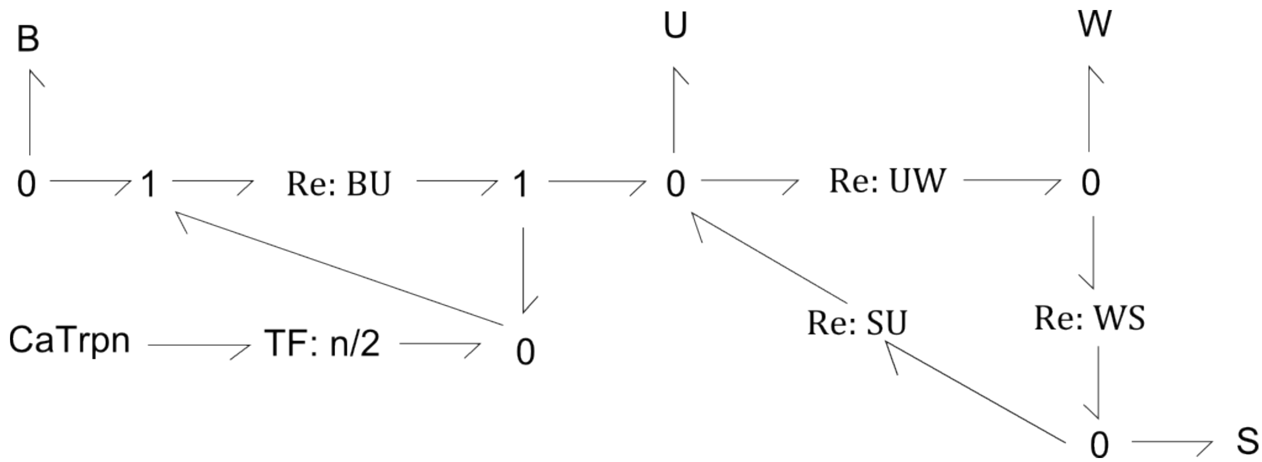
$$T_a = \frac{T_{ref}}{r_s}\left(S(\zeta_s + 1) + W\zeta_w\right)$$

TRANSFORMER



Add extra reactions between S+W, U+S to make them reversible (rate constants = eps)

Dimensionalise B,U,W,S to be in fmol units, by multiplying by MS, the number of myosin sites available



Active tension: Mass damper spring system for zeta and lambda

$$\frac{d\zeta_w}{dt} - A_w\frac{d\lambda}{dt} + c_w\zeta_w = 0$$

$$v_1 + v_2 + v_3 = 0$$

$$\frac{d\zeta_s}{dt} - A_s\frac{d\lambda}{dt} + c_s\zeta_s = 0$$

$$v_4 + v_5 + v_6 = 0$$

Equations are treated as mass-spring-damper system where first-order ODEs are damping terms. There are 2 independent variables.

- Dimensionalise ζ to G using $\mathrm{G} = SL_0\zeta$
- Dimensionalise λ to SL using $SL = SL_0\lambda$
- SL_0= length of sarcomere at rest

This makes each v term have units $\frac{m}{s}$

Each term in ODEs are NOT converted into potentials $\mu[=]\frac{J}{m}$ (no need).

Spring system for Active Tension

$$T_a = \frac{T_{ref}}{r_s}S(\zeta_s + 1) + \frac{T_{ref}}{r_s}W\zeta_w$$

$$T_a = F_{T_S} + F_{T_W}\ [=]\ kPa$$

- use dimensional forms of S, W, ζ, T
- units of tension are already a unit of potential, as $kPa[=]\ \frac{kJ}{mol^3}$
- each term of RHS is a 'spring' and the LHS is the resultant 'forcing function

Passive Tension

Passive tension = $F_{tot} = F_1 + F_d$

$$F_1 = a(\exp(bC) - 1)$$

$$F_d = a\eta \frac{dC_d}{dt}$$

Given

$$\frac{dC_d}{dt} = \frac{kC_s}{\eta} = \frac{k(\lambda - 1 - C_d)}{\eta}$$

This can be modelled as a summation of a damper and spring about a one node (see Fig 3 on exposure of this model's workspace)

$$\frac{dC_d}{dt} + \frac{kC_d}{\eta} - \frac{k(\lambda - 1)}{\eta} = 0$$

For BG, dimensionalise C_d using $C_{dd} = C_d * SL_0$ where SL_0 is the sarcomere length at IC

$$\frac{dC_{dd}}{dt} + \frac{kC_{dd}}{\eta} - \frac{k(SL - SL_0)}{\eta} = 0$$

$$v_d + v_k - v_f = 0\ [=] \frac{m}{s}$$

To be consistent, units of η must be changed to $[=]ms$ instead of remaining as $[=]\frac{1}{ms}$

Do not change equation for dashpot force F_d as it is already dimensional: just sub in $C_d = \frac{C_{dd}}{SL_0}$