Mathematical Modelling and Scientific Computing in the Biosciences II

Exercise 2 (Due: 7 December)

The Chay-Keizer ODE model for pancreatic beta cells with ER is given in lecture and on course website.

- Question 1 (5 points): integrate the ODE system numerically (up to time = $1.5 * 10^5$), using a stiff method (e.g., ode23s); you should observe spiking behavior. Plot all 4 state variables with respect to time.
- Question 2 (3 points): as was discussed in lecture, in spiking behavior there is an underlying fast system controlled by a slow system. From the plots of Q1, what would be reasonable as the slow variable? Explain.
- Question 4 (15 points): Using the solution to Q2, plot the bifurcation diagram using the slow variable as the bifurcation parameter. You should see bistability as well a Hopf point (hint: you may need to continue to negative "parameter" values to find the Hopf point). Do continuation of limit cycles from the Hopf point. Plot both the voltage V, amd [Ca]_i , as well as the period of oscillations for the limit cycle.
- Question 5 (2 points): what effect should varying σ have on the burst period?
- Question 6 (5 points): the geometry of the bifurcation diagram captures behavior of the time-series solution. We see in the time series that spiking phase starts when [Ca]_ER reaches below a certain critical value. If one were to change the level of [Ca]_ER at the onset of spiking, how would one change the geometry (e.g., location or distances of point to curves) of the bifurcation diagram?