Milestone 4 Overall goal:

Finish Reproducing Figure 1B; Reproduce Figure 2 from main paper

Figure 1B:

Shows that:

1. Independent of light intensity when you have a higher proportion of damped cells, the system is more easily entrained.
2. When you adjust the intensity, higher intensities further boost the entrainment ability of the model.

Figure 2A:
Conditions: 100% self-sustained cells for the entire SCN; only VL cells are light-sensitive.

Shows that:
1. The light sensitive VL leads the DM.
2. (Ideally?) Peaks are at the transitions from dark to light (use t-cycle of 23.6h).
3. Plot the mean of some appropriate state variable over time and check if it is synchronized.

Figure 2B:
Conditions: 100% self-sustained cells for DM, and 70% non-self-sustained cells for VL. Only VL is light-sensitive.

Shows that:
1. The light sensitive VL (slightly) leads the DM.

Figure 2C:
Conditions: 100% self-sustained cells for VL, and 70% non-self-sustained cells for DM. Only VL is light-sensitive.

Shows that:
1. The light sensitive VL still leads the DM.

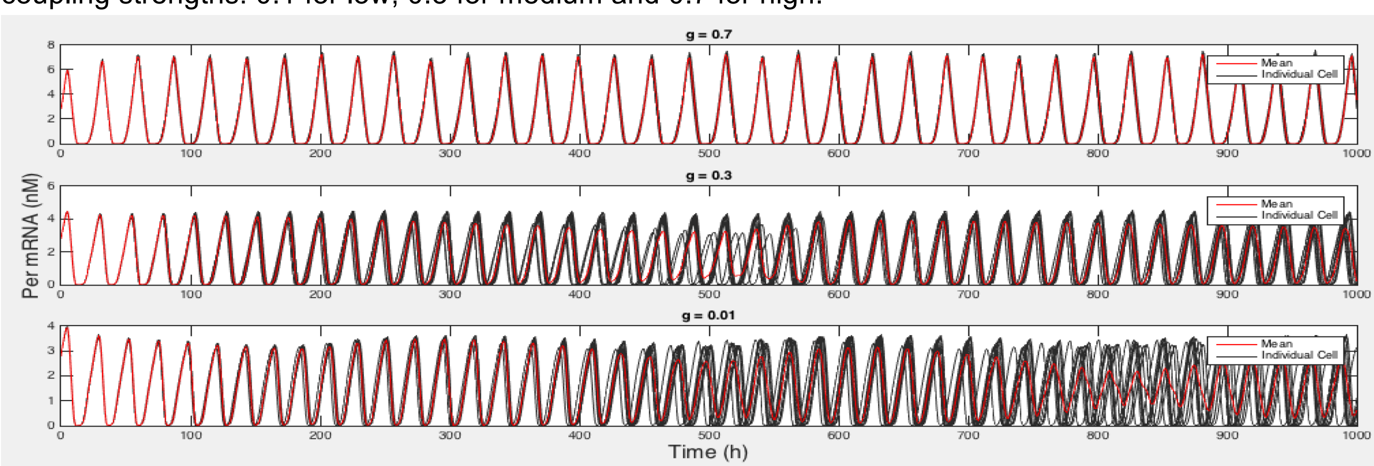
Milestone 3 Accomplishments:

Victoria:
Finished figure 1.a. This was a difficult figure, because of the many pitfalls discussed in my presentation due to the sensitivity of the system. Sensitivity is probably due to the fact that we only have three states, so any changes can have larger effects than would be seen in larger models. Pitfalls include coupling strength being too strong or weak and looking at a window of time either in the transient period of the simulation or for systems with many damped oscillators, after the system has already damped out.

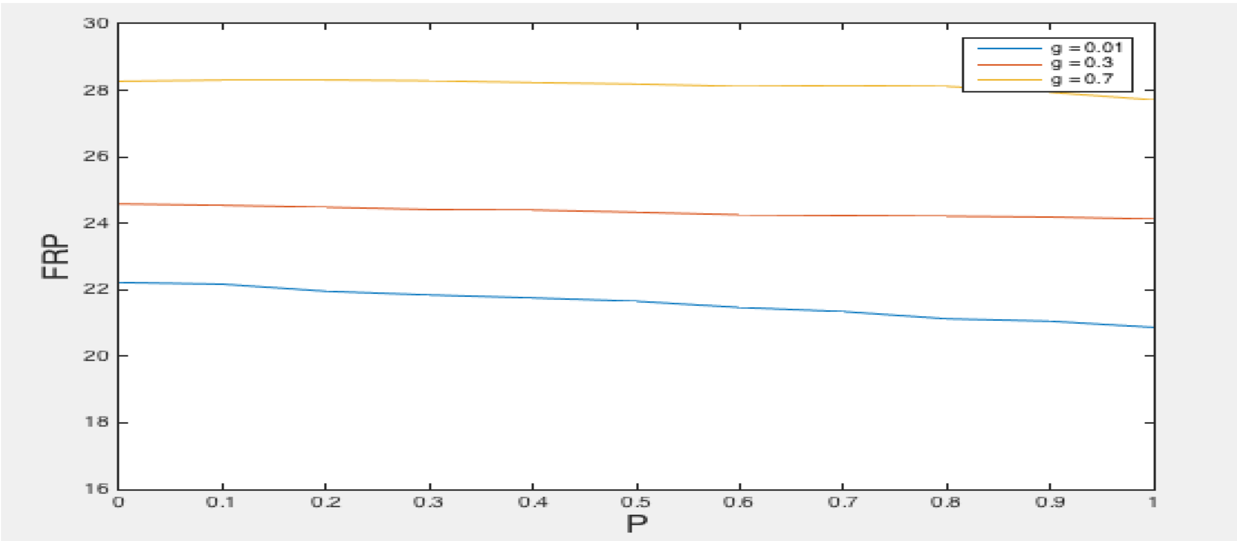
Due to these pitfalls, I was unable to run my simulation automatically and each simulation needed to be done by hand. Also you may notice that there is a higher variability in my fig1a than in others, this may be fixed by plotting average FRP over many simulation runs as opposed to a single run.

I also did work on fig1b. I defined the meaning of entrained/not entrained for my system. I choose a signal strength of 0.005 and this produced results similar to fig1b in the main paper. I also chose signals of 0.001 and 0.0005, but discovered that these signals were too weak to create the desired results. I also tried a signal strength of 0.01, but this produced a simulation that was able to entrain to all t-cycles.

Douglas: I completed figure 1.a. Similar to Victoria, I am running my simulations for a long time (1800 hours) and calculating period from only the last segment of the simulation (the last 800 hours). Moreover, I also determined good *g* values to represent low, medium, and high coupling strengths: 0.1 for low, 0.3 for medium and 0.7 for high.

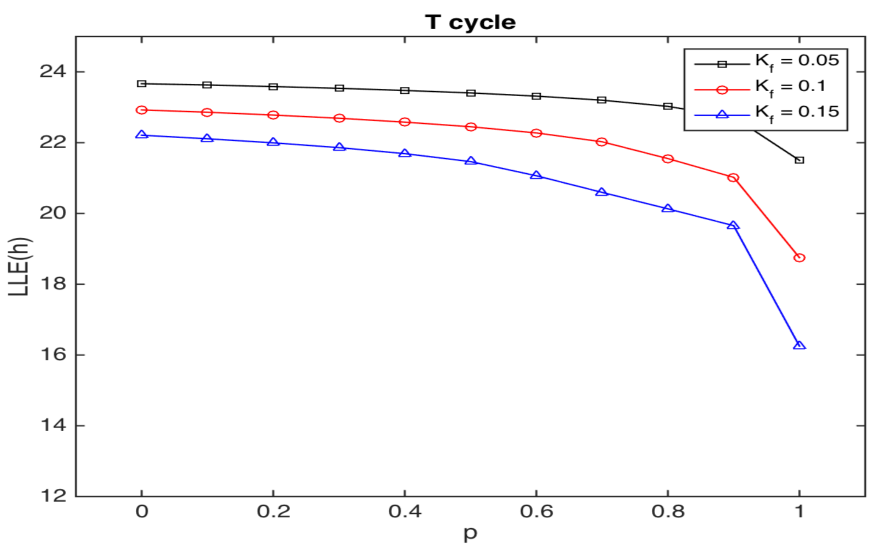


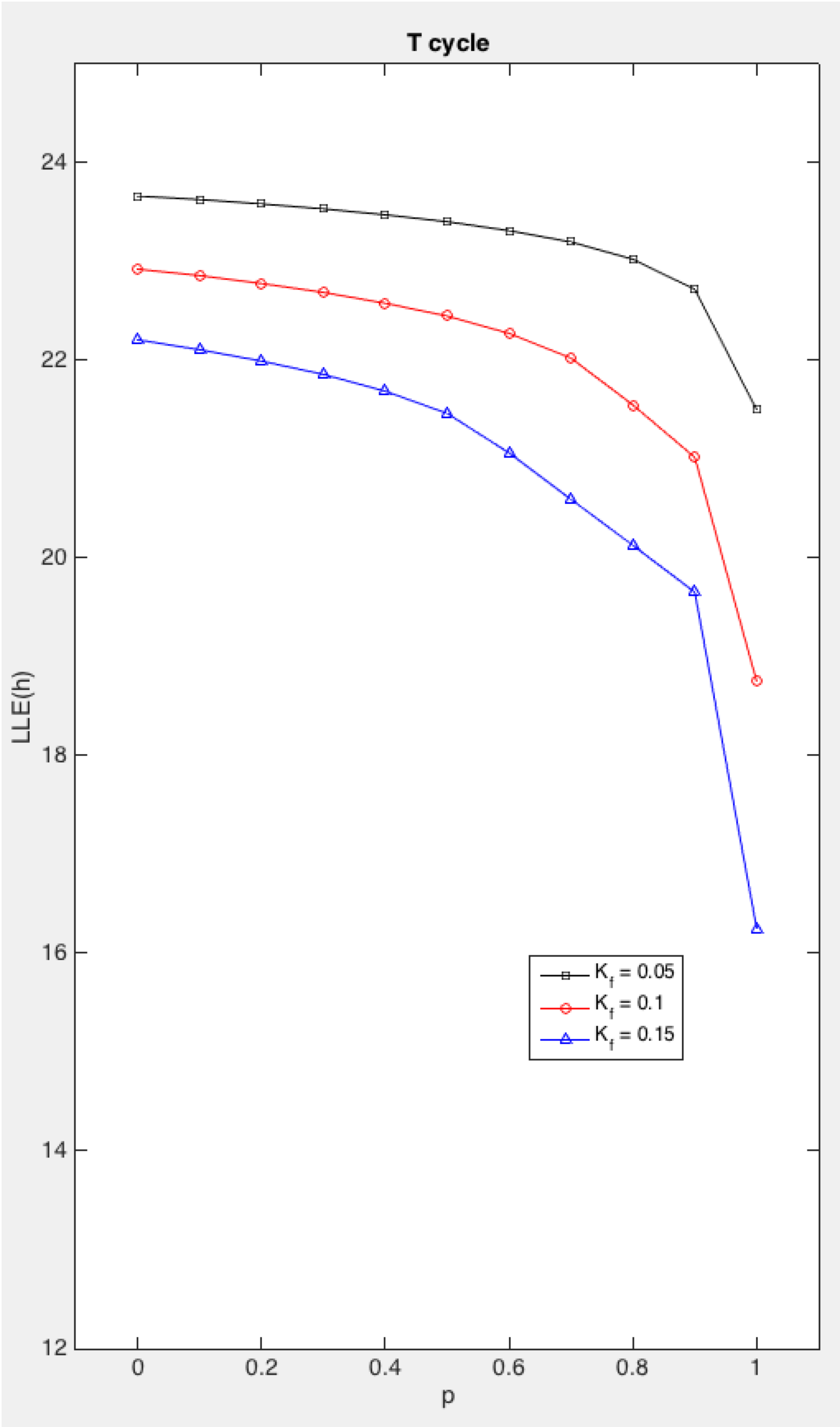
I was also able to reduce differences in intrinsic periods within my damped/sustained parameter libraries by changing the values I was using for *vsp0,* which I was adjusting to get damped and sustained oscillations. For damped oscillations I used a *vsp0* of 1.1 and for sustained I used a *vsp0* of 1.25. Here's what I got for Figure 1 A.



Fan:

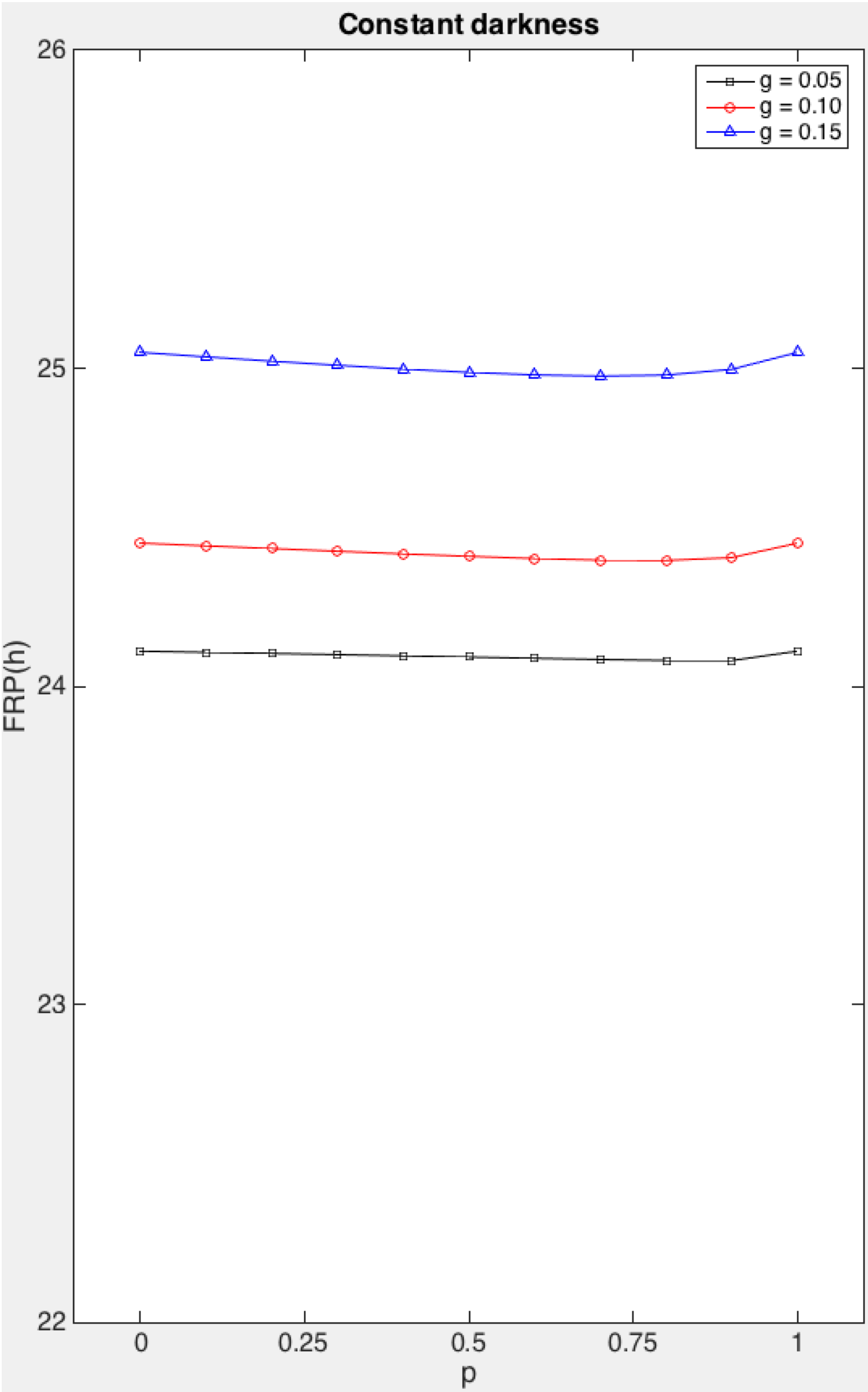
Completed part B of Fig.1. To find out the LLE, I ran the simulation with a relatively wide range of possible external cycles. After locating the 0.5h-interval that the LLE for each proportion value, I subdivided each interval further into 0.005h-intervals. I ran the simulation with 40 cells in total, and with 4 million timesteps. The end result (after fixing numerous bugs such as reversed R values of non-self-sustained and self-sustained cells, and 43.2h external cycles instead of 23.6h) turned out to have a similar trend with the one in the paper, though the values were slightly different. But at least the standard deviations of X and Y values can be as small as 0 or 1e-5 in my simulations now.





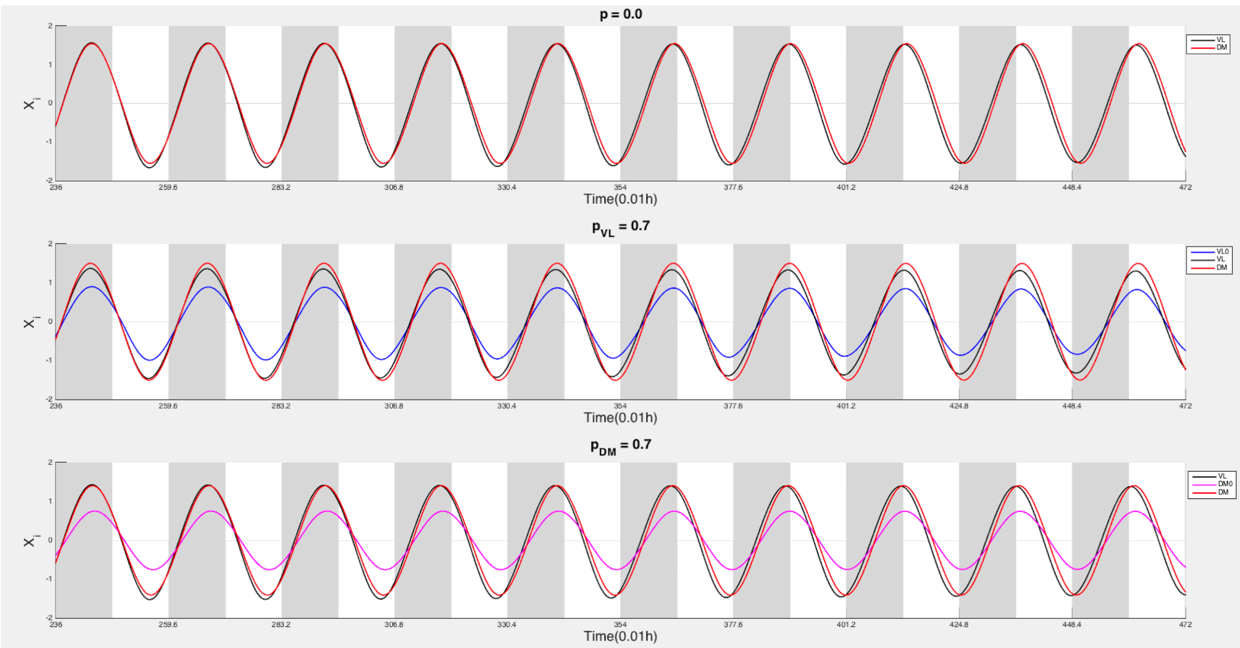
T cycle
LLE(h)
p
24
22
20
18
16
14
12
0
0.2
0.4
0.6
0.8
1
K_f = 0.05
K_f = 0.1
K_f = 0.15

After I found out that my R values are reversed, I re-run my fig1A to get the correct result:

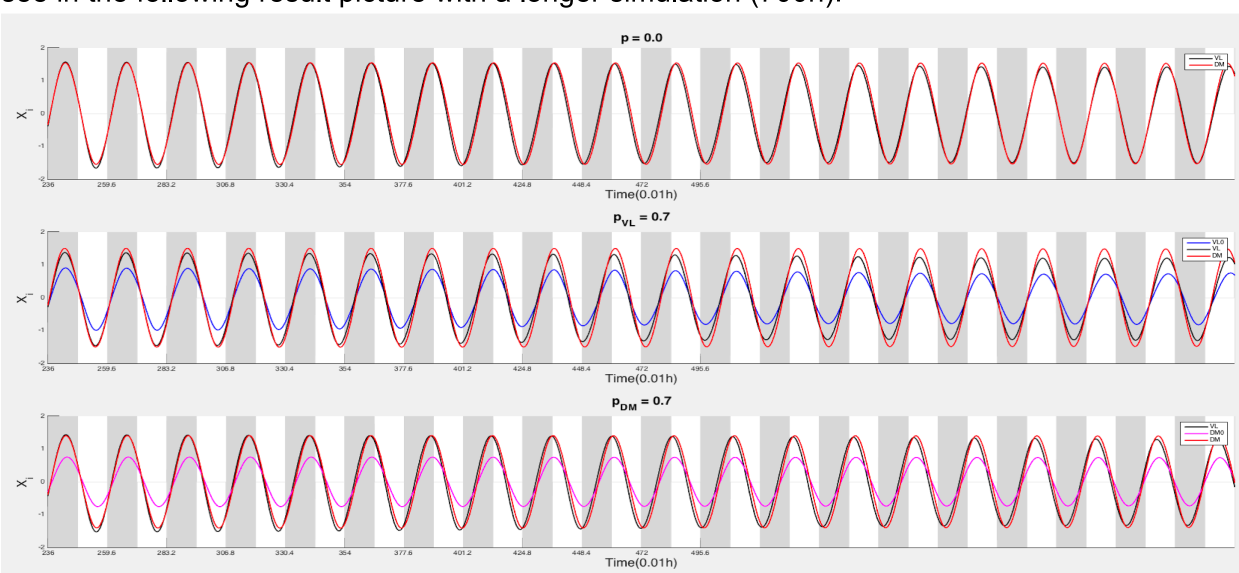


I also attempted to reproduce Fig.2 from the paper. I ran the simulation for 500 hours (roughly 21 LD-cycles) to see if I can catch a stabilized trend. The figure had 11 full cycles, so I selected the 11th to 21st cycles in the simulation for my figure, where all cells start to oscillate regularly. The trend of the result was as expected -- VL cells are always ahead of DM cells. The non-self-sustained and self-sustained VL cells don't show much difference in the peak times, though self-sustained ones seems to be slightly leading; this trend is reversed for DM cells.

One thing worth noting is the amplitude difference between my result and the one in the paper. Either my self-sustained VL cells are displaying a slightly smaller amplitude, or my self-sustained DM cells are having a larger amplitude than in the main paper. Not sure if this is something of concern, though, since the overall trend meets expectation.

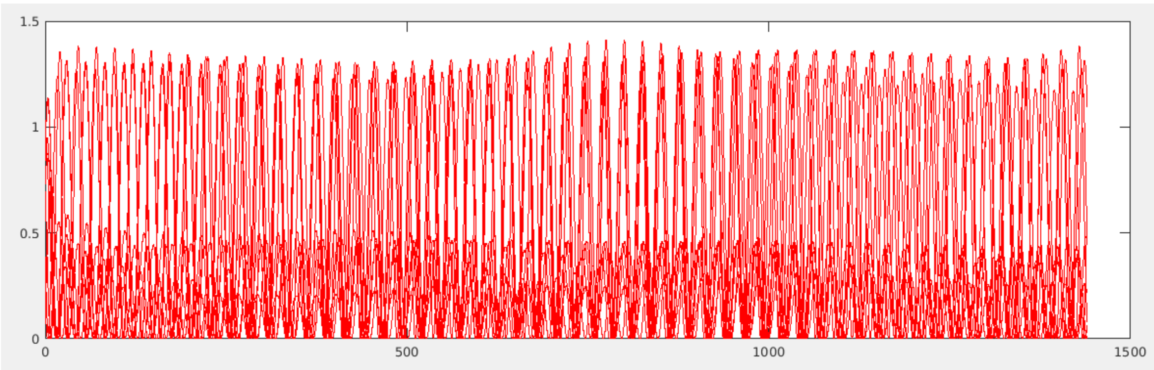


Another thing of concern is that my cycles seem to drift off from the external cycle, as you can see in the following result picture with a longer simulation (700h).

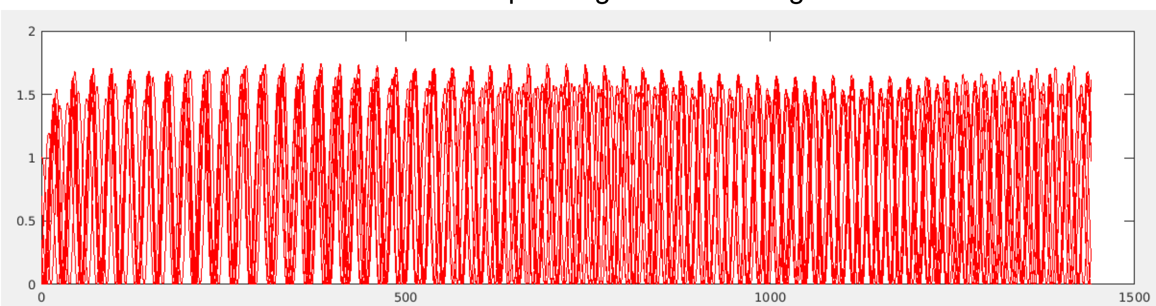


I am not certain if this is bad, though. The paper's figure has a trend where the peaks get closer to the external cycle as time goes (though very slow), but we don't know if that's what's really happening over a longer range of time, since they did not disclose that result. In Fig1B almost all setups have a LLE smaller than the 23.6h used here, so one might expect to not see any drifting-away-from-the-cycle result, but the assumption that both VL and DM are sensitive to light in Fig1B also casts a shadow on this expectation.

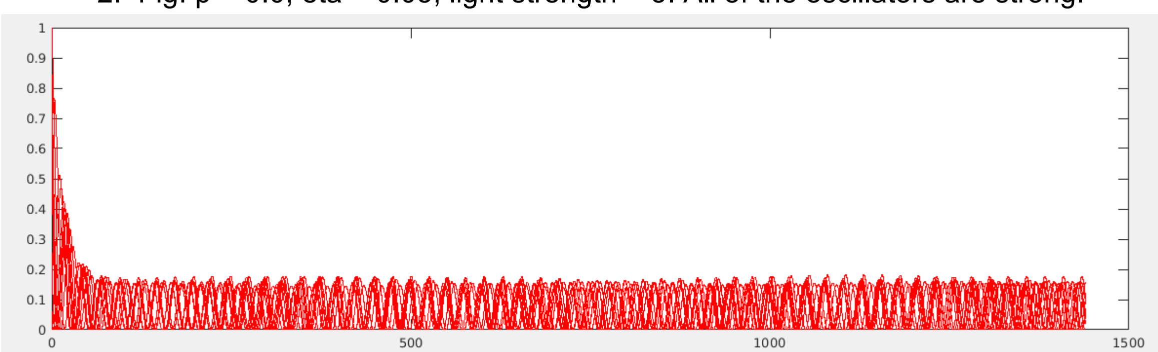
Jay:



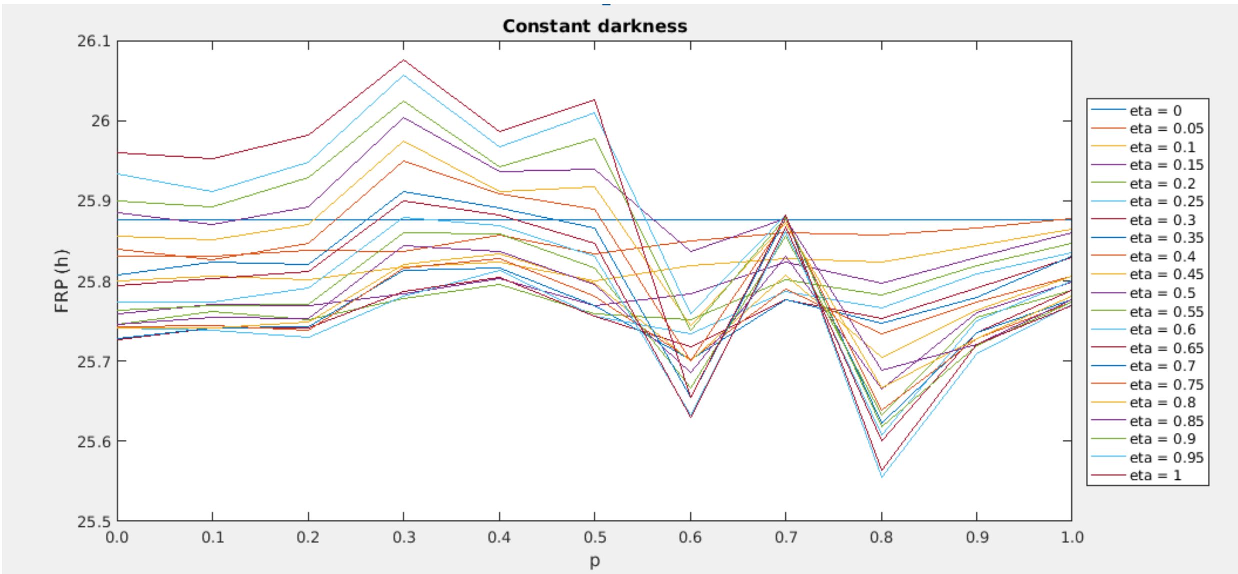
1. Fig: p = 0.5, eta = 0.05, light strength = 5. Two groups can be seen here, strong oscillators and weak oscillators peaking at different highs.



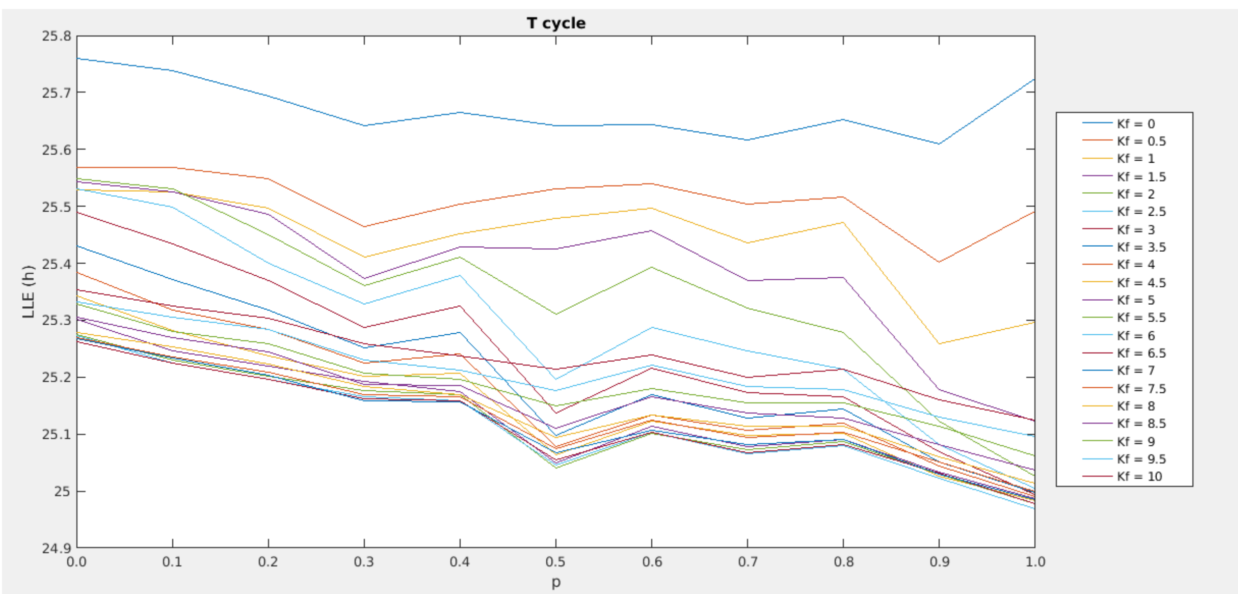
2. Fig: p = 0.0, eta = 0.05, light strength = 5. All of the oscillators are strong.



3. Fig: p = 1.0, eta = 0.05, light strength = 5. All of the oscillators are weak, we can see this drop off. The weak oscillators don't piddle out completely, just operate at a lower steady state amplitude.



4. Fig: Attempting to replicate Fig. 1 a from Gu, Tang, Rohling & Yang (2016; *Scientific Report*), since the Phase-Amp model's coupling strength parameter: eta doesn't operate exactly like g in Fig. 1 a, I plotted 20 values of eta (0 to 1, with 0.05 intervals). This is helpful for finding values for eta that result in qualitatively similar results to those shown in Fig. 1 a. The model results are quite level, within a similar range (between 24 and 26, loosely speaking).



5. Fig: Attempting to replicate Fig. 1 b from Gu, Tang, Rohling & Yang (2016; *Scientific Report*), since the Phase-Amp model's light intensity parameter: light_strength doesn't operate exactly like g in Fig. 1 b, I plotted 20 values of light_strength (0 to 10, with 0.5 intervals). This is helpful for finding values for light_strength that result in qualitatively similar results to those shown in Fig. 1 b. The model results are similarly downward trending, the lower limit in Fig, 1 b is 21 FRP, here we get as low as 25 FRP, we will need to tweak the parameters more to get a more qualitatively similar result.

Next: I need to get a lower LLE from this model.