### nonlinear plasmid copy number model

We now consider the mechanisms for plasmid copy number controlling. For plasmid harboring the ColE1 origin, replication initiation process is controlled by RNA II-RNA I pairs. The copy number of plasmid satisfies the followed equation

where is the RNA II initiation rate, is the DNA replication abolish term that describes the RNA I repression, and is given by

We suppose the replication abolish process is a hyperbolic repression, is the concentration of RNA II, and is the inhibition constant. The concentration of RNA II, , can be described by followed equation:

We suppose the RNA II transcription process is faster than the plasmid replication process, and the degradation of RNA II is more rapidly than the growth dilution rate , i.e. , than Using the quasi-steady suppose, we have:

Now, we have the simplified model

where, denotes the plasmid copy number, is the probability of the primer transcription results in replication. is the growth rate. We rewrite the transcription rate of as .

where, .

The equilibrium of the plasmid copy number is given by

.

RNA II initials the plasmid replication  
RNA I binds to RNA II forming complex.

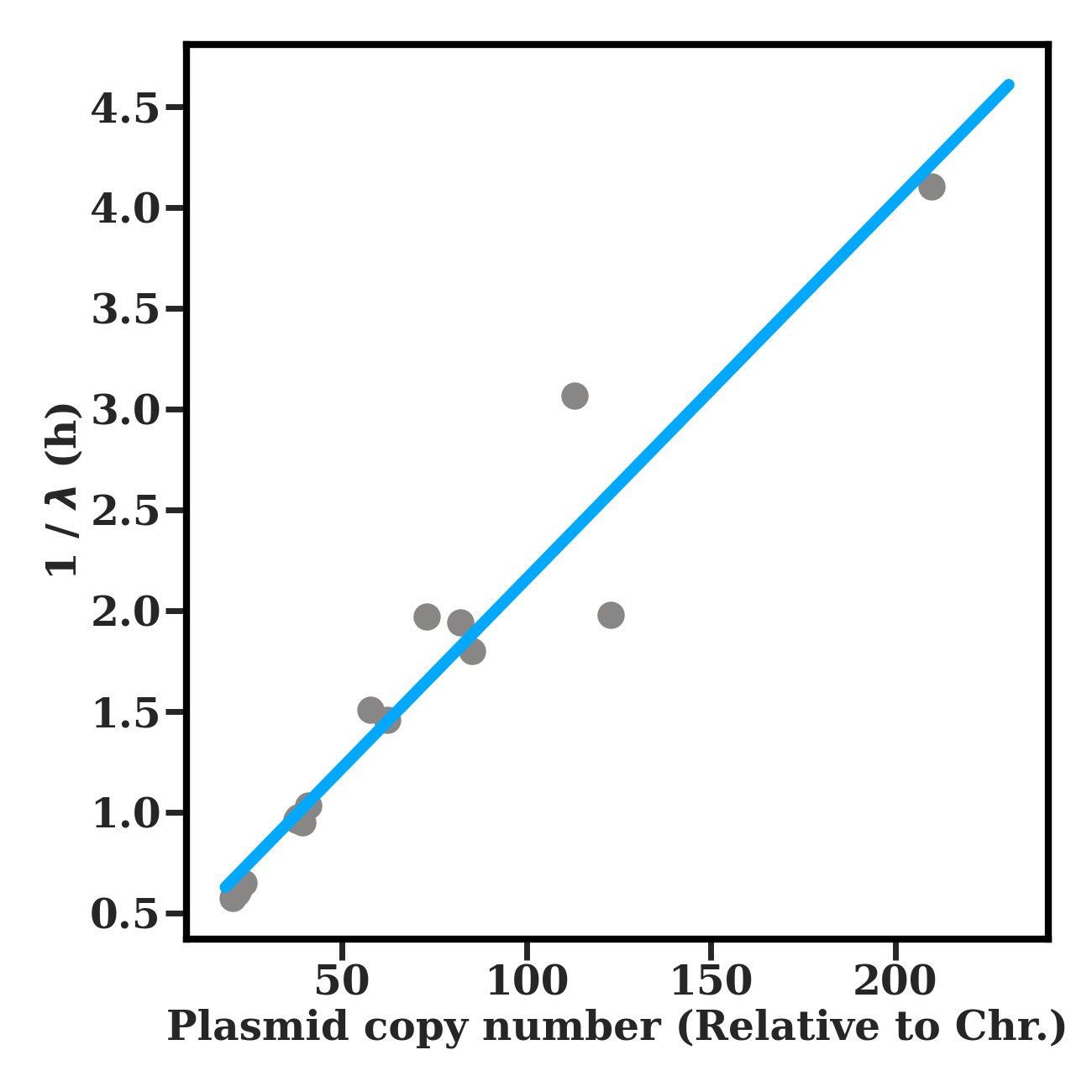


image-20211214100805225

The fitting . the slope is 0.0187, and the interception is 0.283.

When the growth rate decreases, the slope becomes steep. It can be explained that the is the function of growth rate (RNA seq data of plasmid origin).

We suppose the is a constant, and . We have the .

Thus, we have . we have the re-scaled

Now, we have the simplified model

where, denotes the plasmid copy number, is the probability of the primer transcription results in replication. is the growth rate. We rewrite the transcription rate of as .

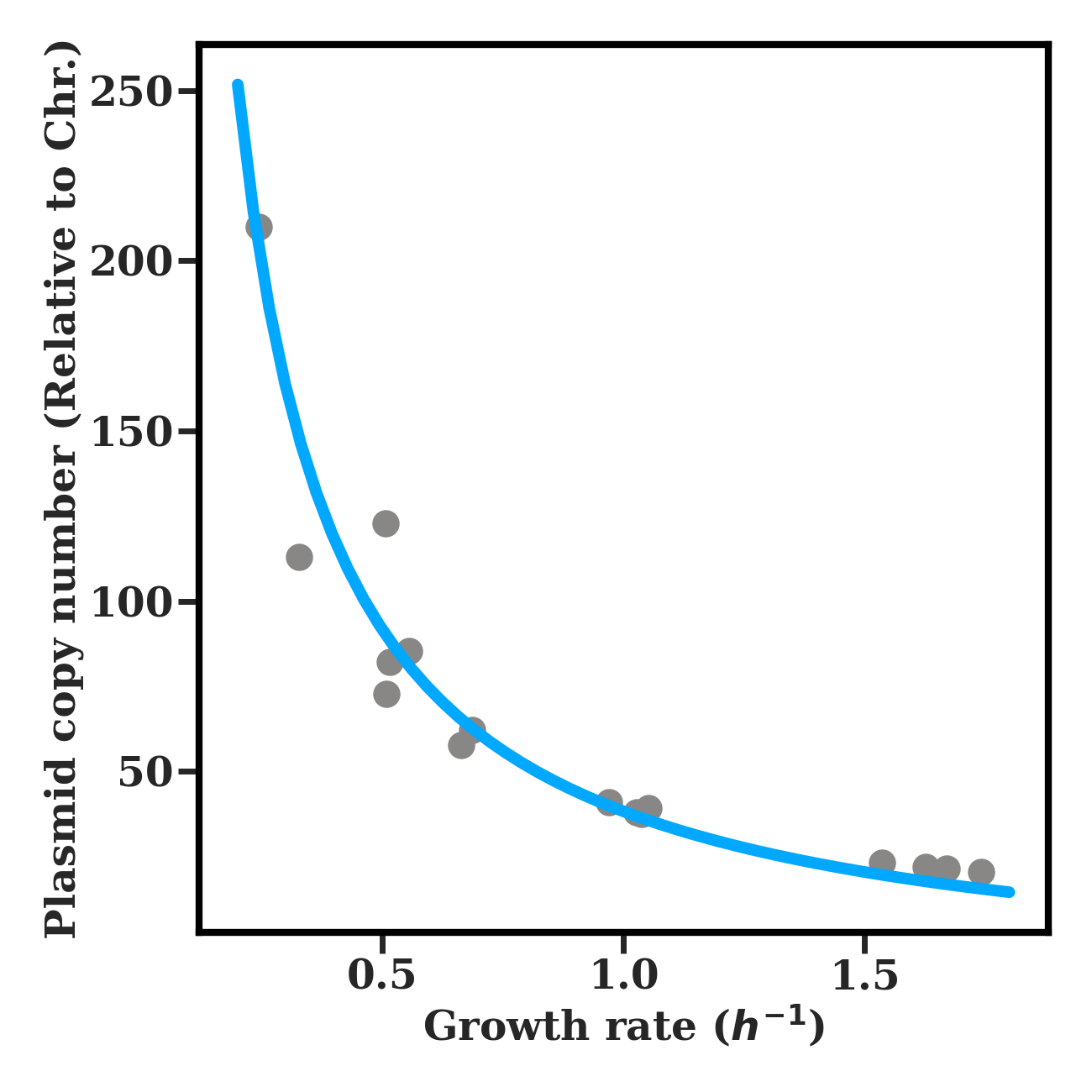


image-20211214095957639

The code for simulating the plasmid copy number: sub\_model/plasmid\_control.py

the code used in the Data Fitting Block

|  |  |  |  |
| --- | --- | --- | --- |
| Parameter | Value | Unit | Description |
|  | 3.54 |  |  |
|  | 15.09 | - |  |
|  |  |  |  |

### Perturbed growth rate condition

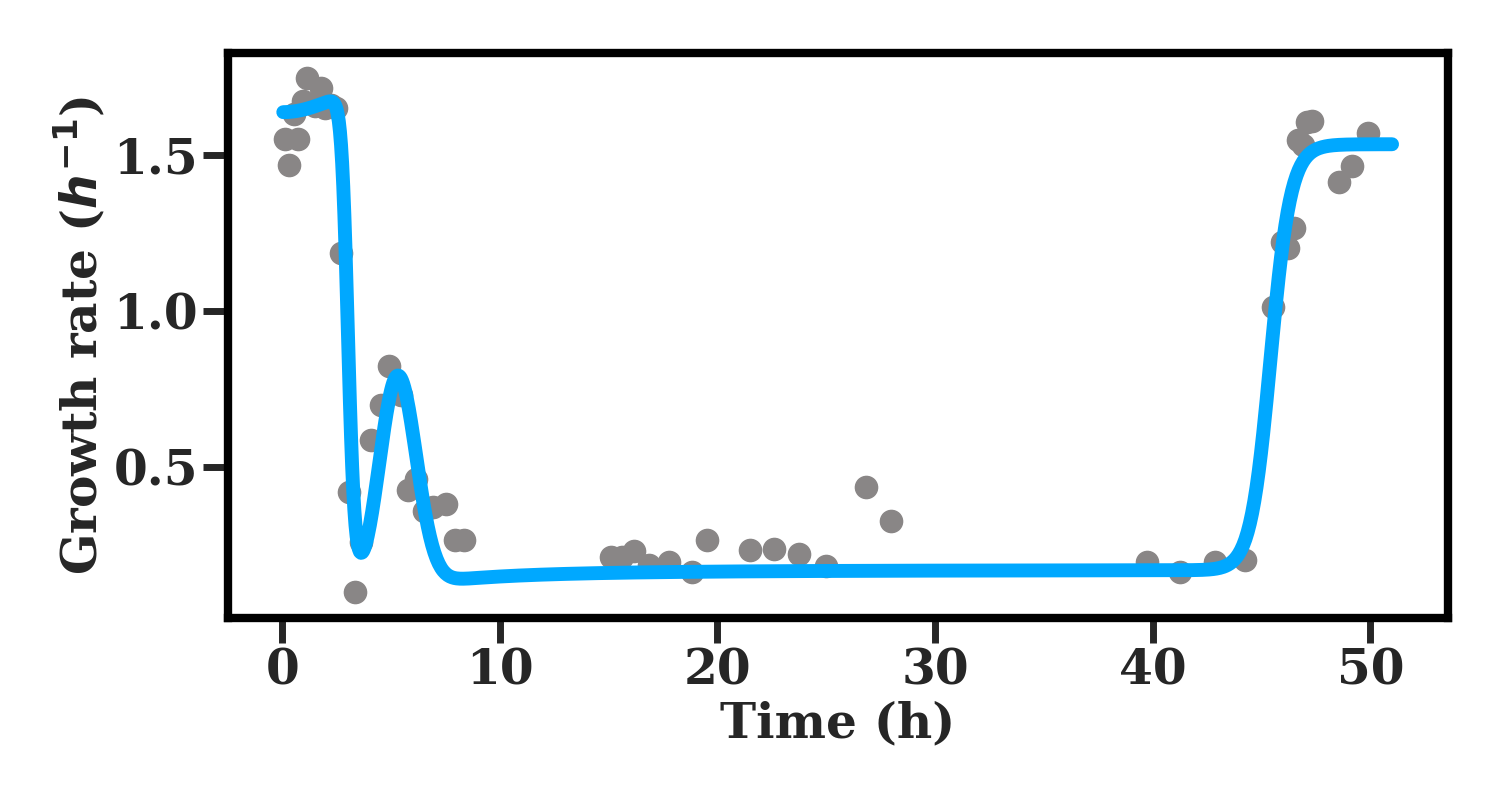


image-20220206224622224

M5\_L3 down up shift  
Data: sub\_model/growth\_rate\_down\_up\_shift\_20210310.xlsx  
Code: sub\_model/gr\_updown\_shift.py:164

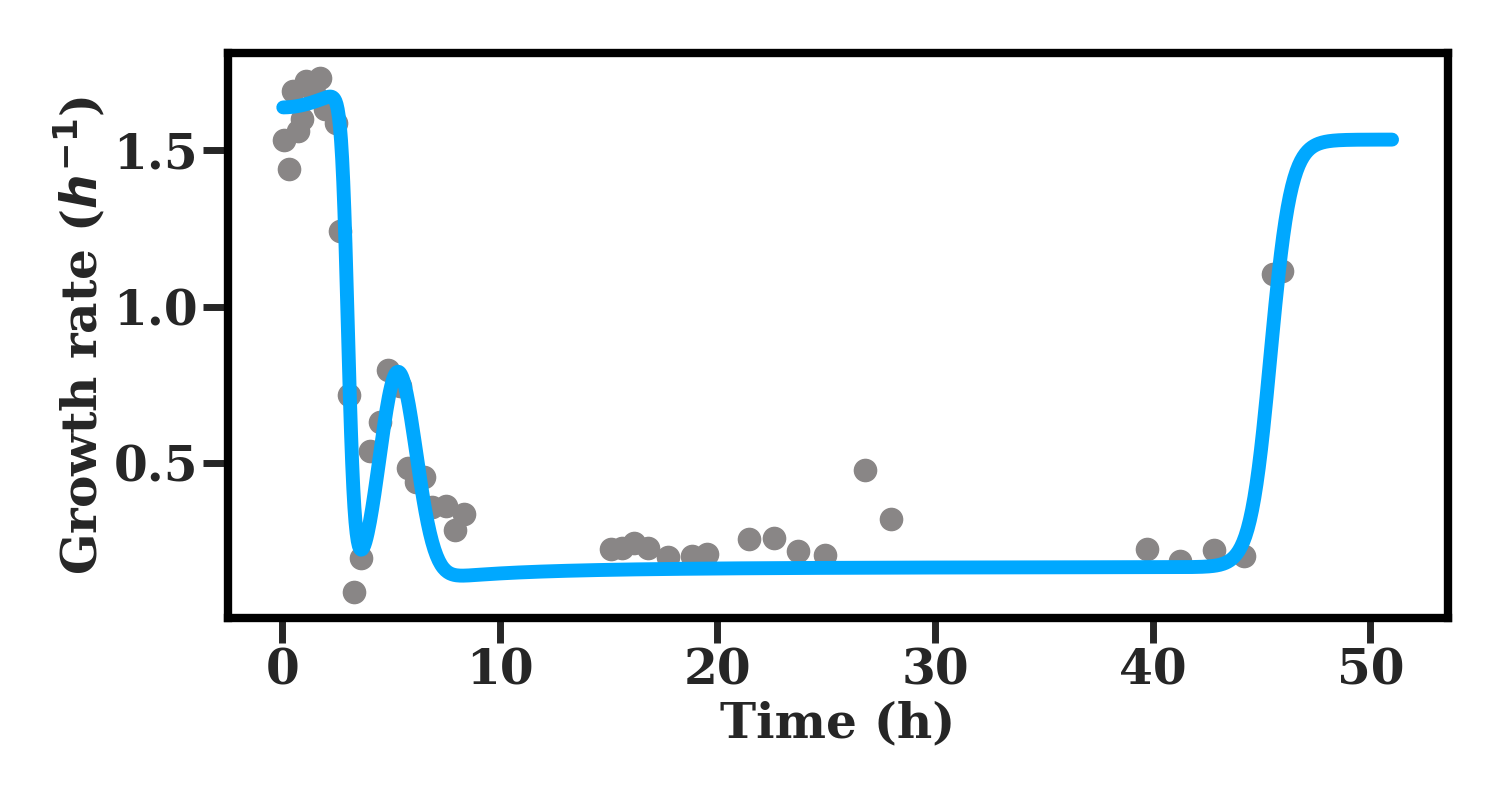


image-20220206224636566

L2 down up shift  
Data: sub\_model/growth\_rate\_down\_up\_shift\_20210310.xlsx  
Code: sub\_model/gr\_updown\_shift.py:164

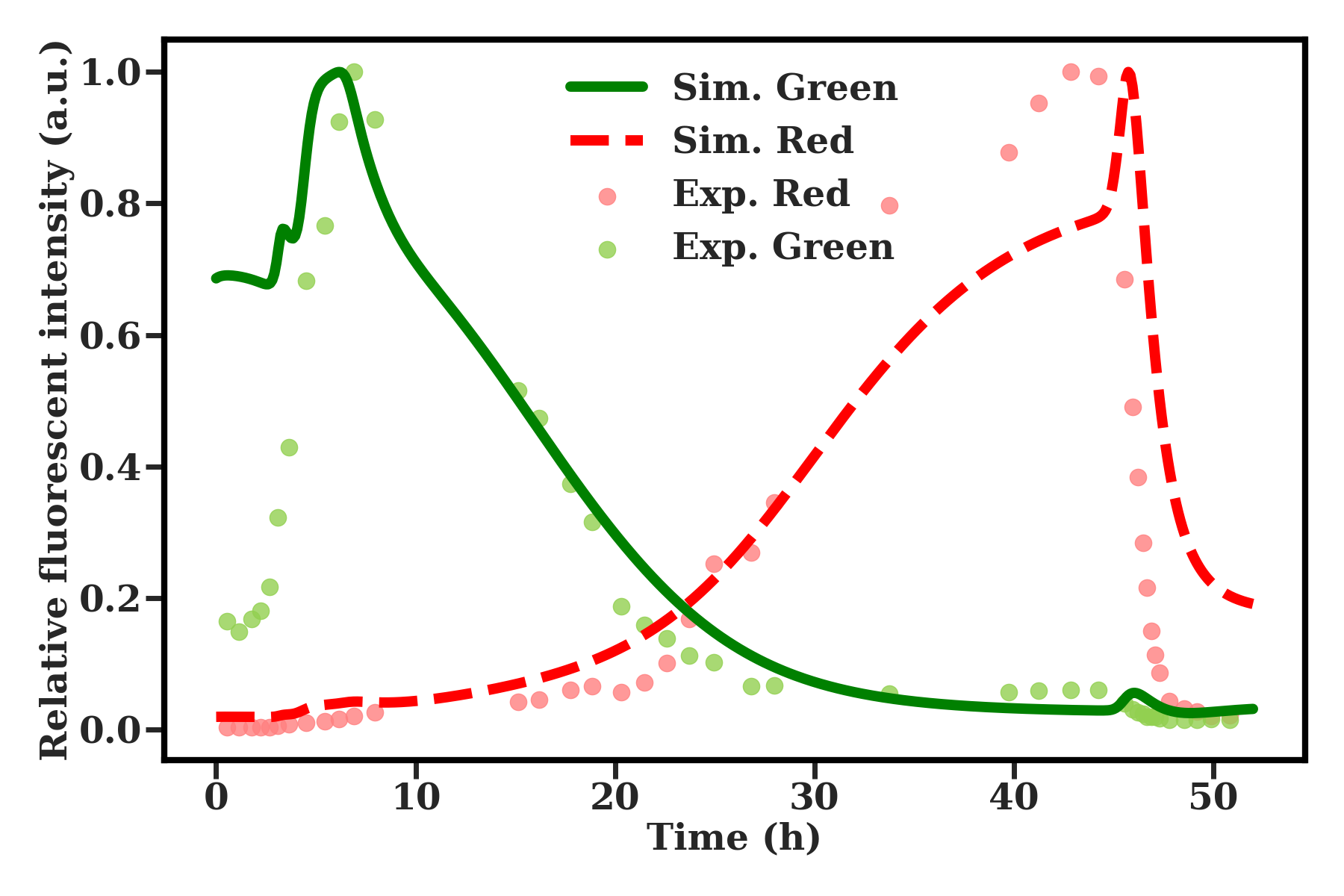


image-20220209144209987

code source: sub\_model/gr\_updown\_shift.py:262

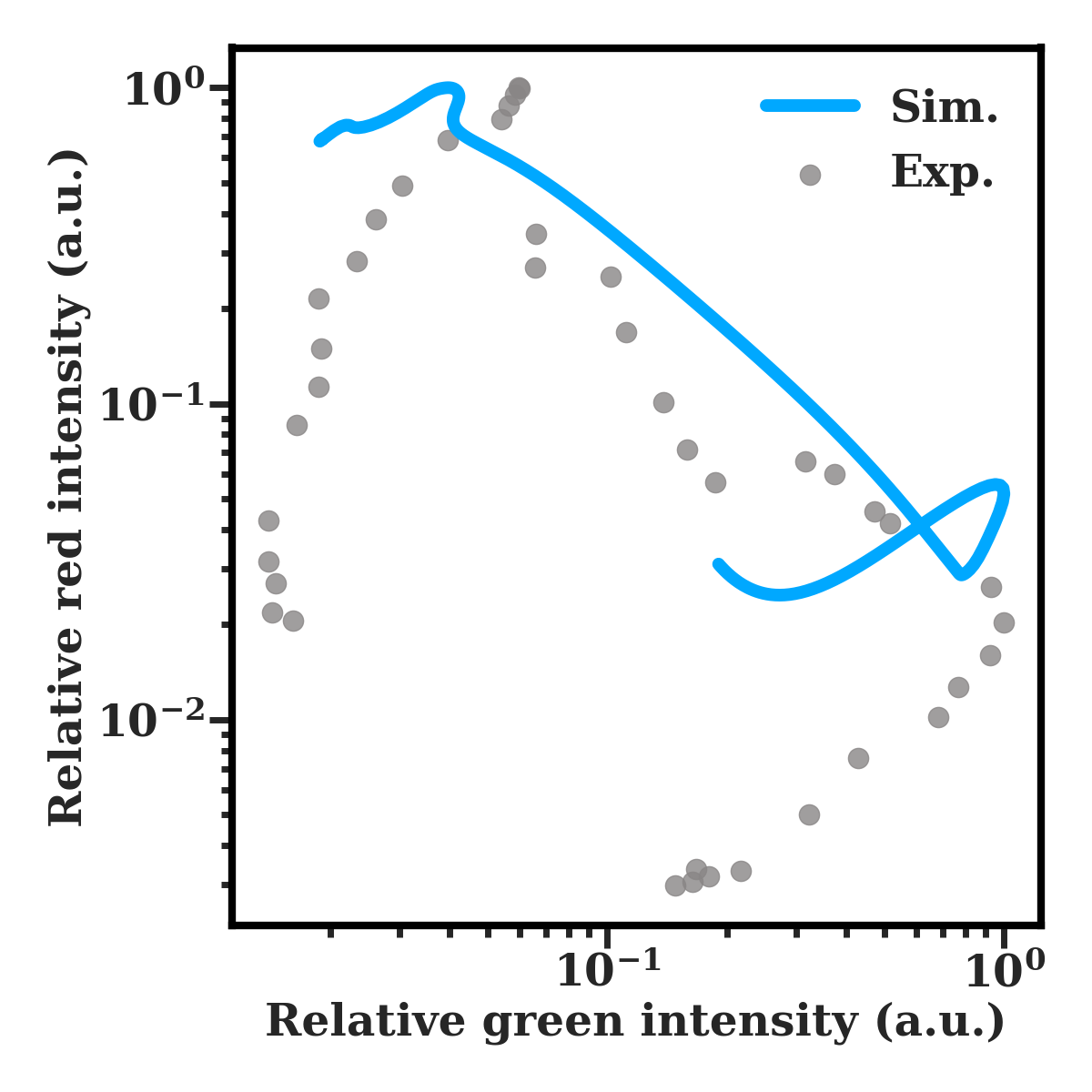


image-20220209143319719

code source: sub\_model/gr\_updown\_shift.py:247

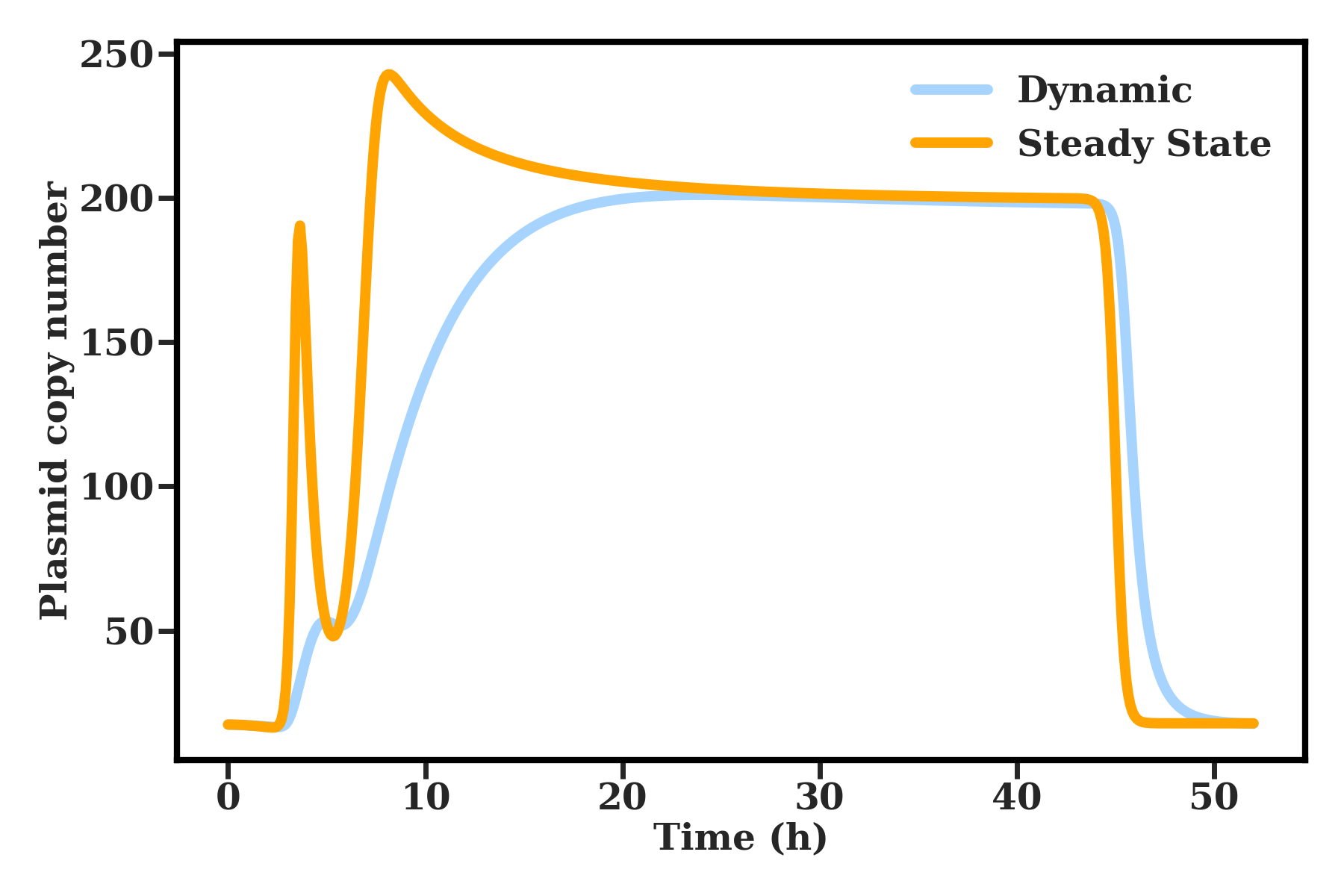


image-20220209184051953

Code: sub\_model/gr\_updown\_shift.py:283