Modifying interactions to switch steady states

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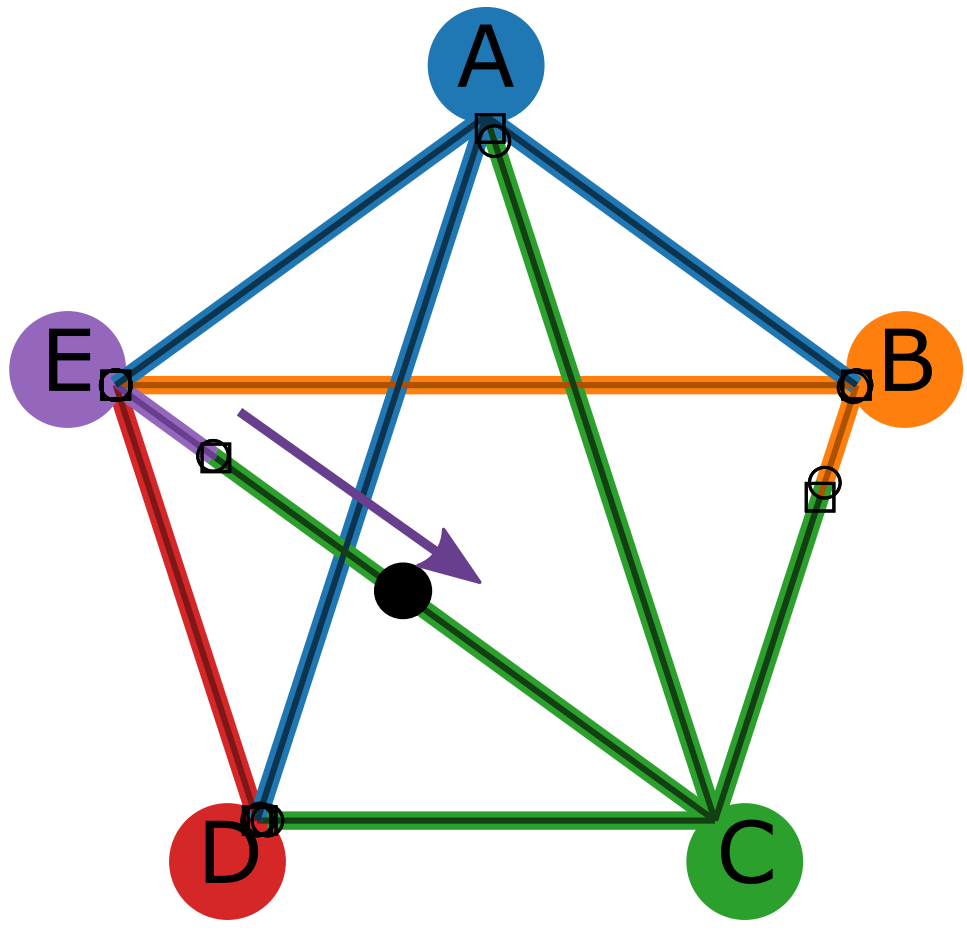
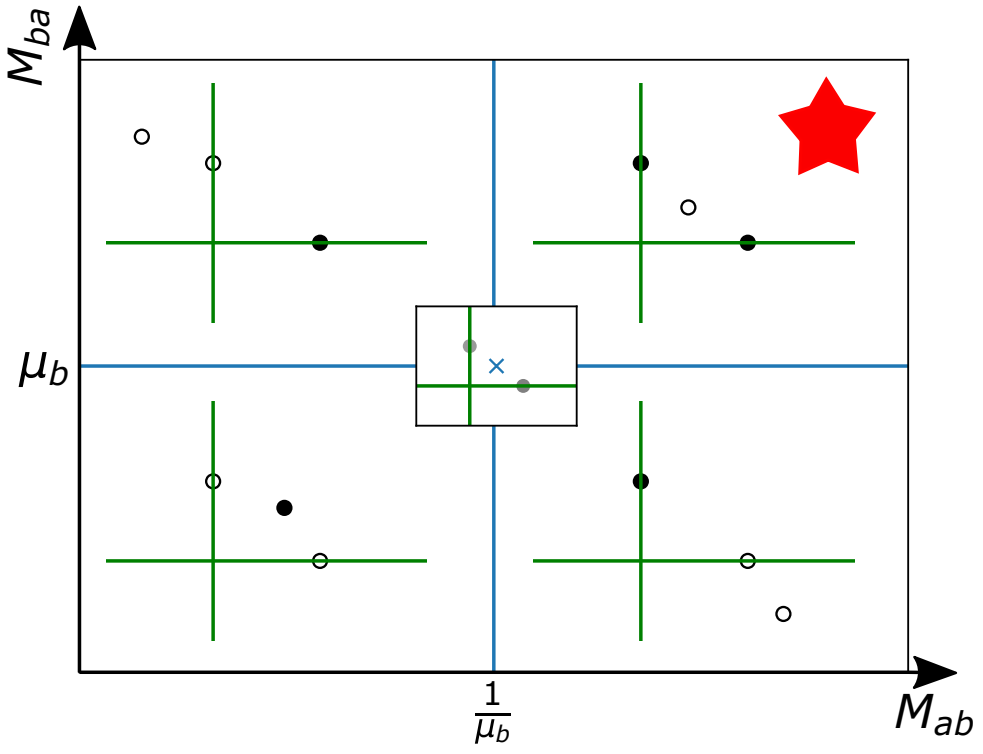
Project Goal

- Move separatrix to switch steady states
- Changing interaction matrix using SSR as a guide



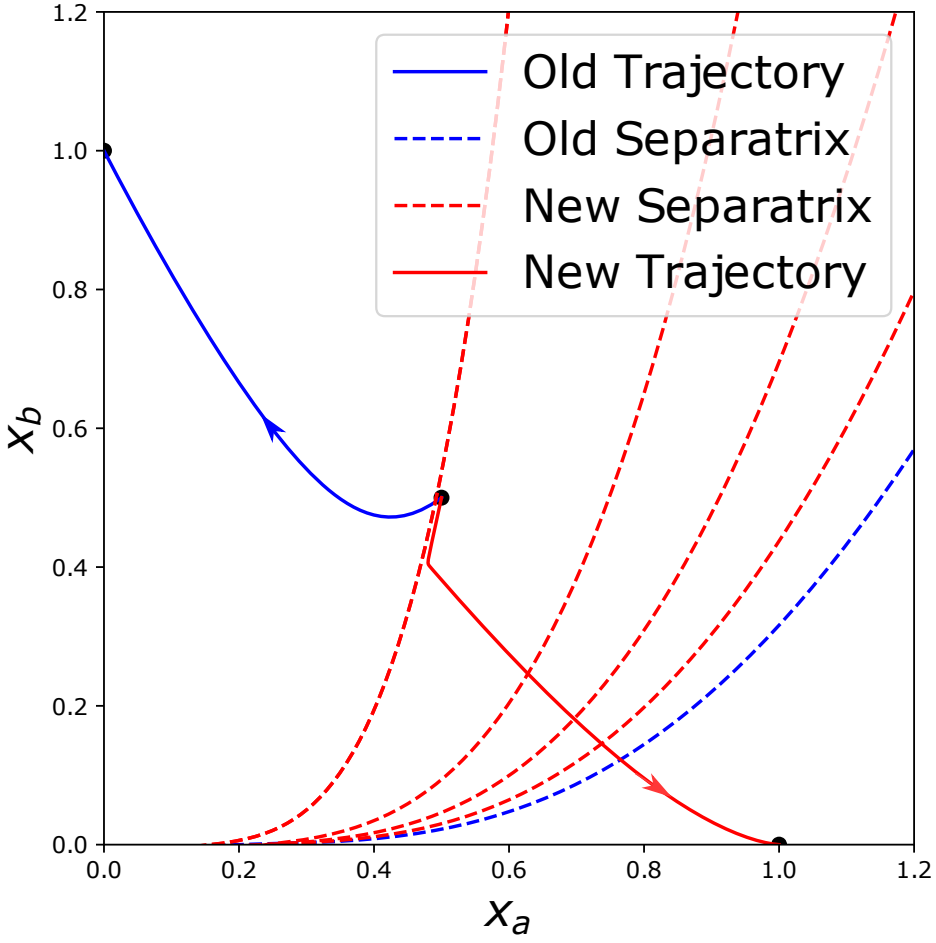
Bifurcation Analysis

- Separatrix moves with the third steady state
- Originally in upper right region
- going towards upper left

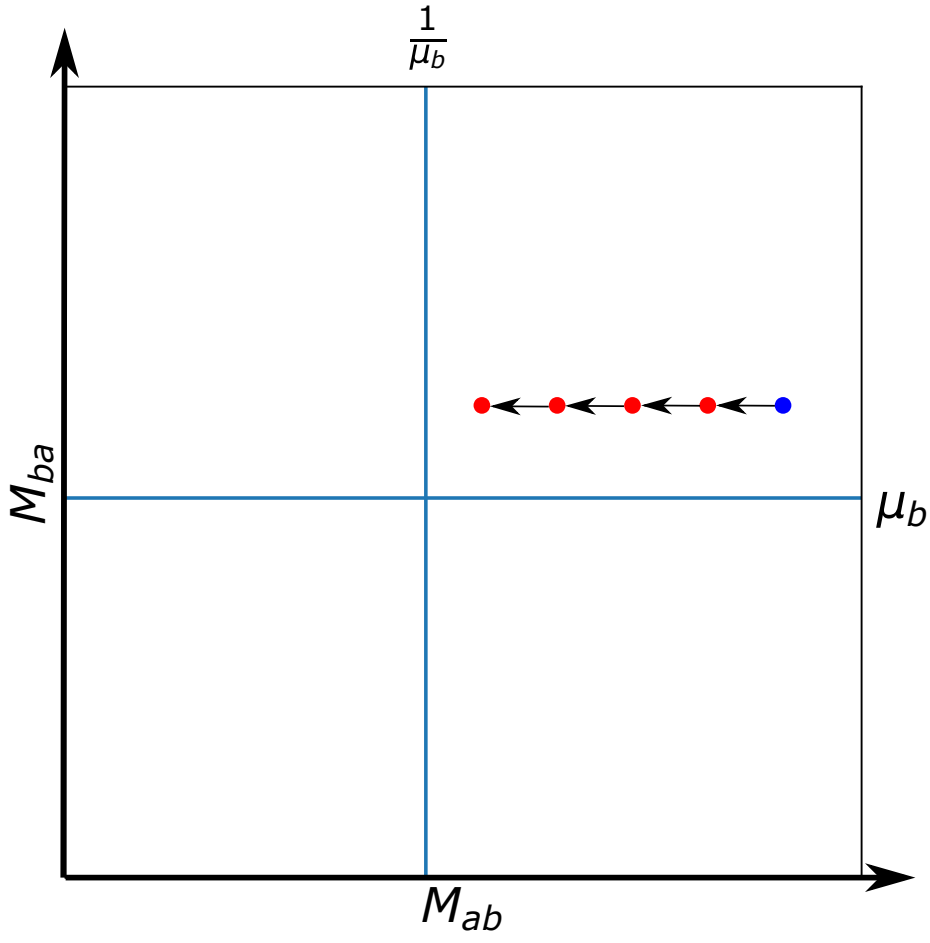


Black dots shows stable steady states, and hollow dots shows unstable steady states

Change in 2-D matrix



Microbial Phase Space



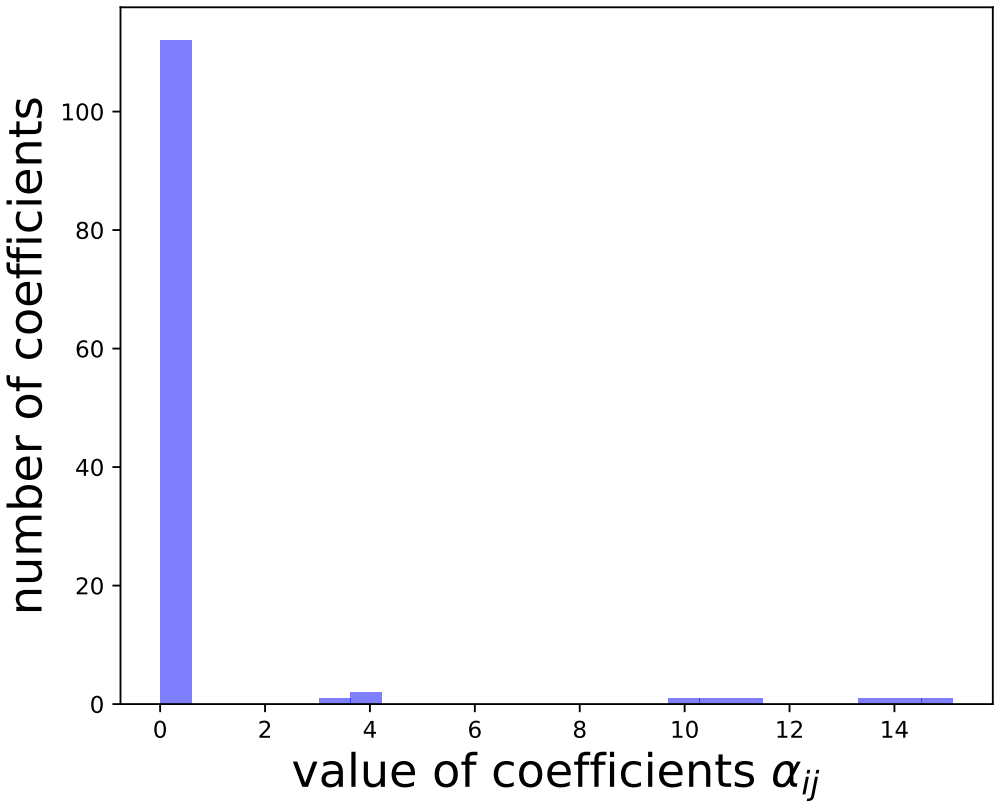
Parameter Space

Change in K

$$M_{ab} = \vec{y_a}^T K \vec{y_b}$$

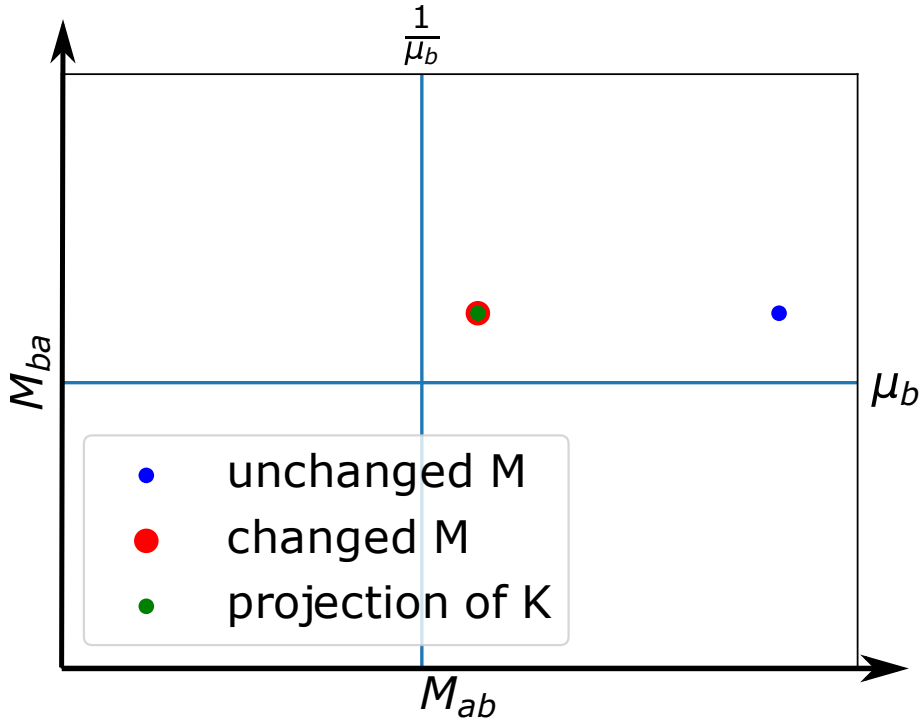
$$= \sum_{i=1,j=1}^{11,11} \alpha_{ij} K_{ij}$$

- 121 coefficients
- Most are 0
- M_{ab} most sensitive to change in k_{ij} with the largest α_{ij} coefficient



Projection of ΔK back to 2-D

- Change in K could change M_{ba}
- In this case M_{ba} does not change
- Check if SSR coefficients for M_{ba} and M_{ab} are orthogonal



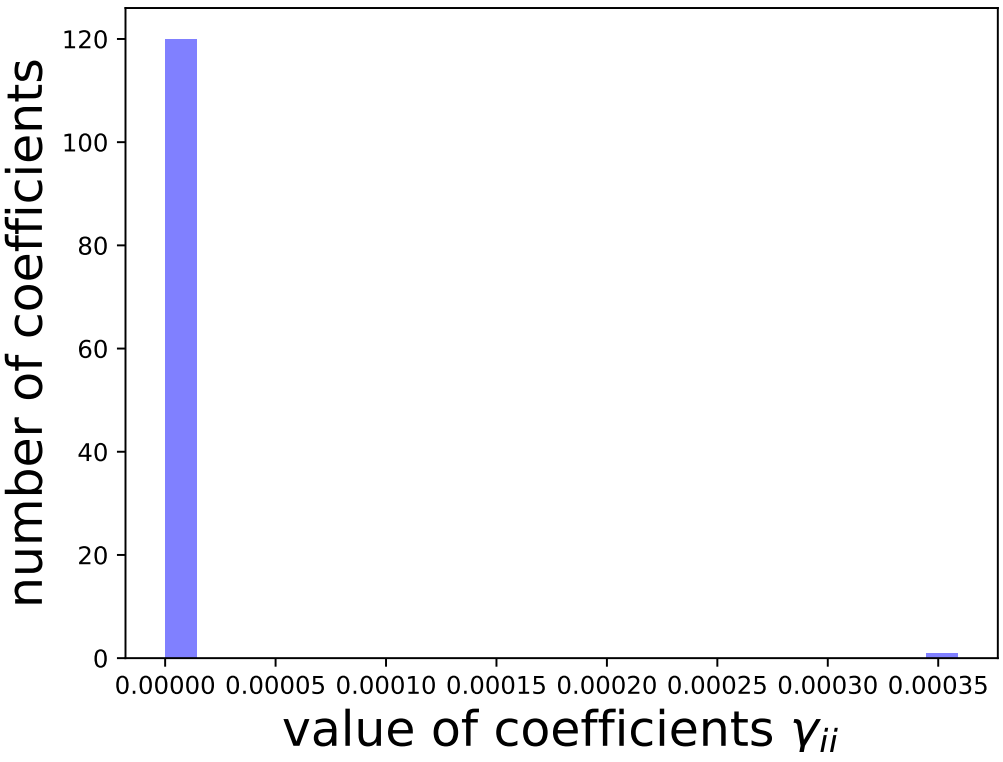
Projection of ΔK back to 2-D

$$M_{ab} = \sum_{i=1,j=1}^{11,11} \alpha_{ij} K_{ij}$$

$$M_{ba} = \sum_{i=1,j=1}^{11,11} \beta_{ij} K_{ij}$$

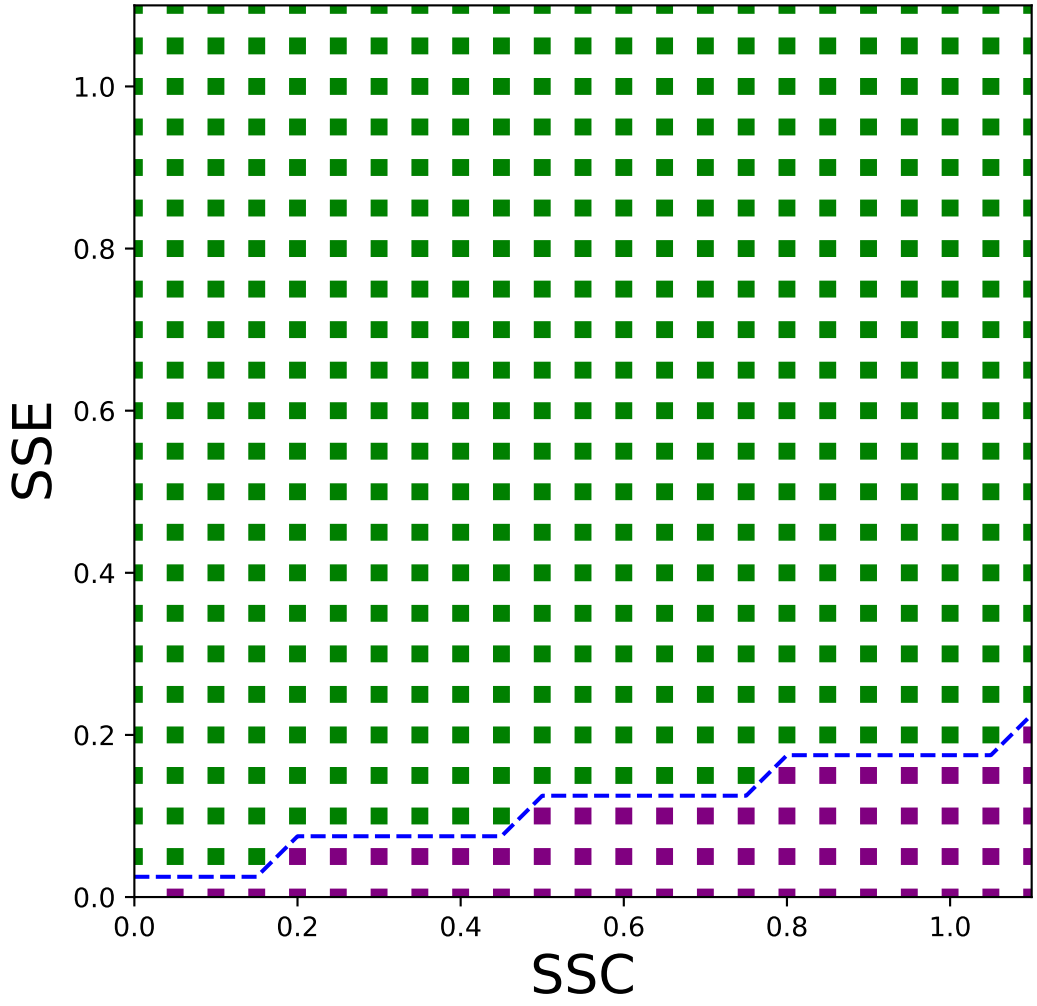
$$\gamma_{ij} = \alpha_{ij} \beta_{ij}$$

- check the value of γ_{ij}
- α_{ij} and β_{ij} are nearly orthogonal, with one exception



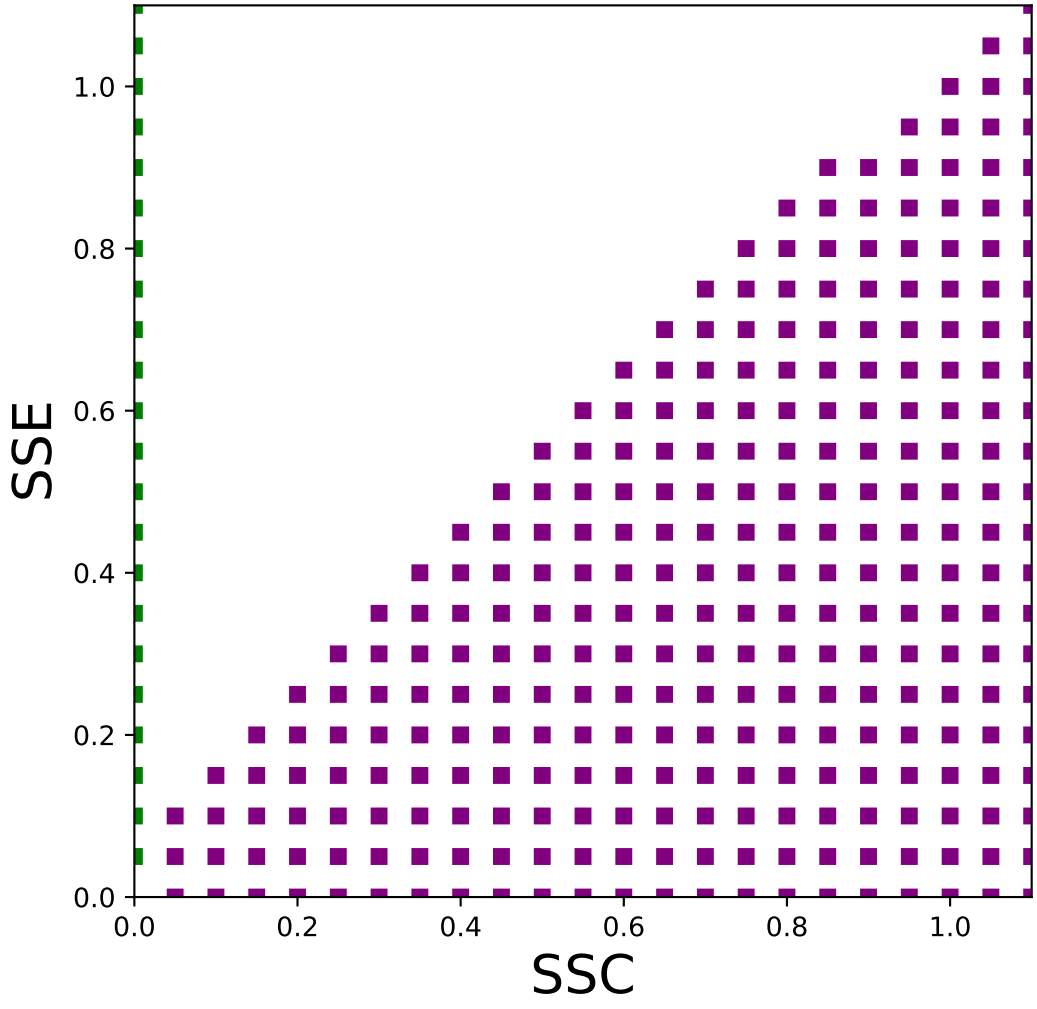
Separatrix in 11-D

- Numerically calculate separatrix by simulation
- Generate a separatrix curve



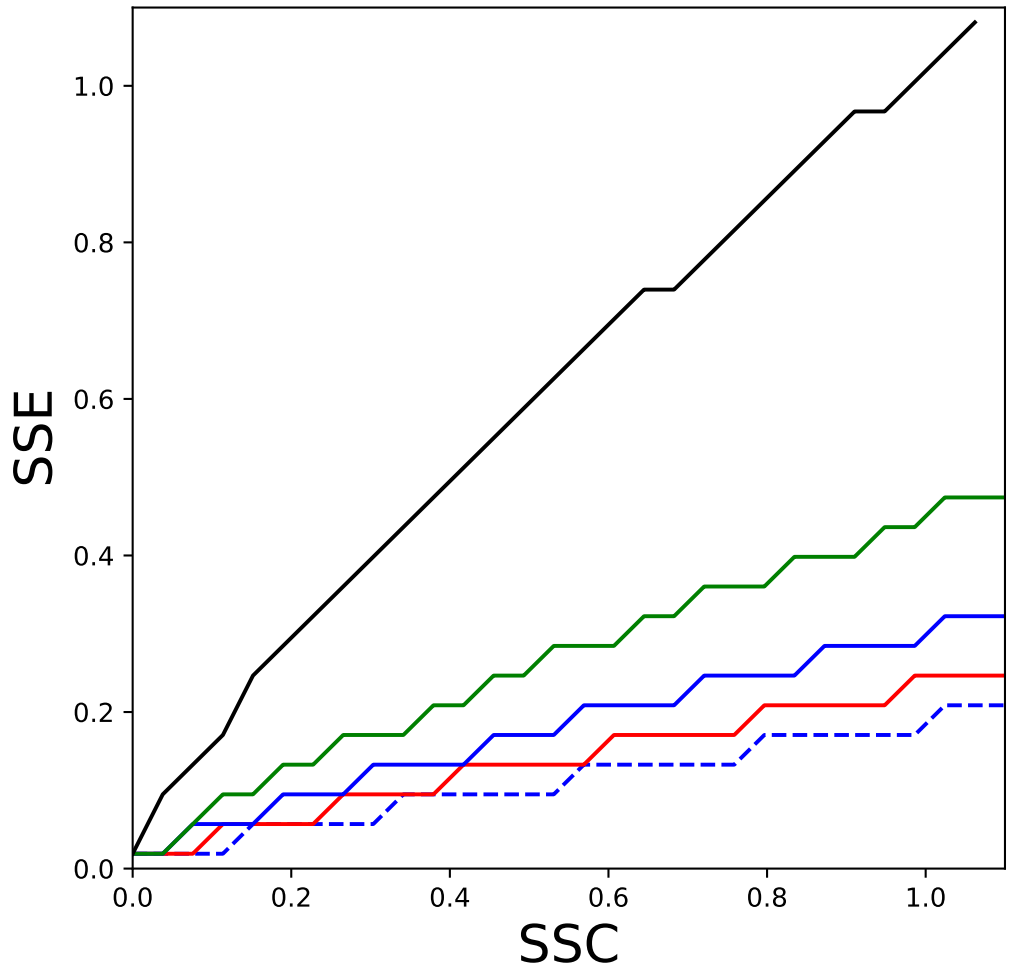
Change in 11-D separatrix

- 11-D simulation after change in K
- Half of the plane does not go to either steady states

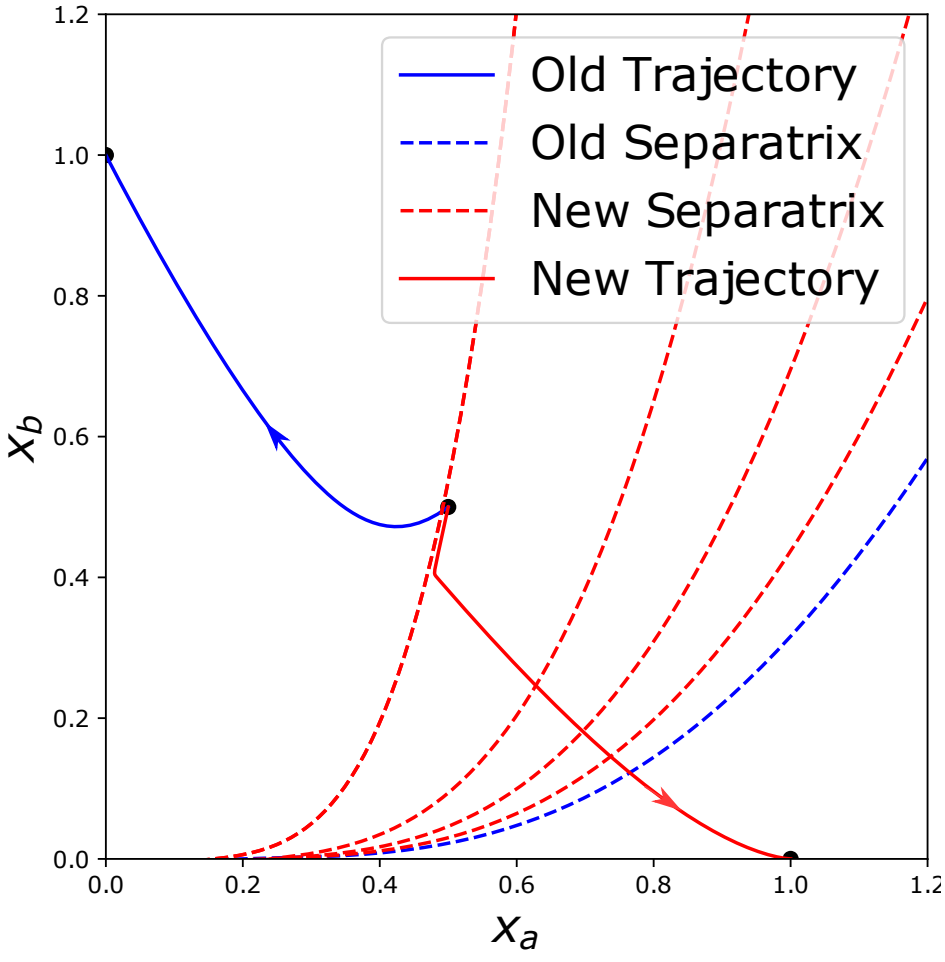


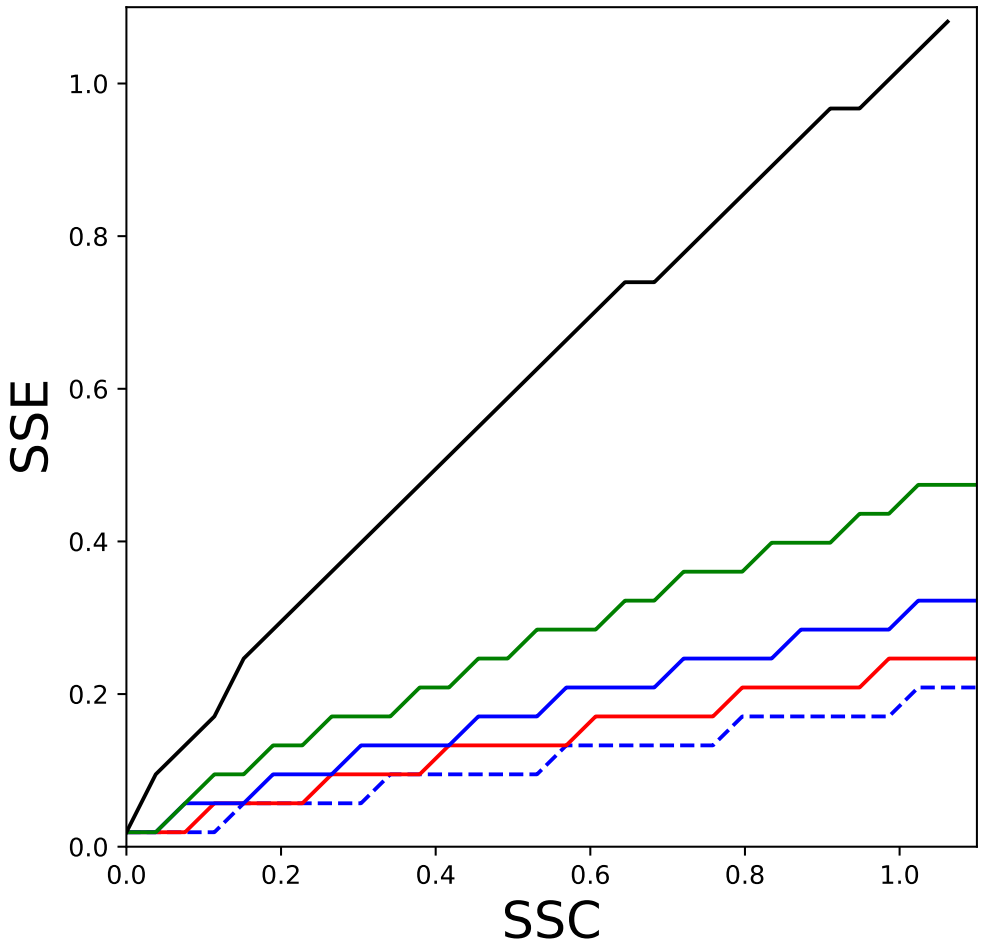
Change in 11-D separatrix

- the separatrix changes with small changes of K
- similar to change in M



Change in 11-D separatrix





Future steps

- Apply the procedure to other pairs of steady states
- Make the change in interaction matrix temporary
- Other complex systems