TREND
FAIR 2011

Multiscale Oscillator Interactions in Large Networks of Networks

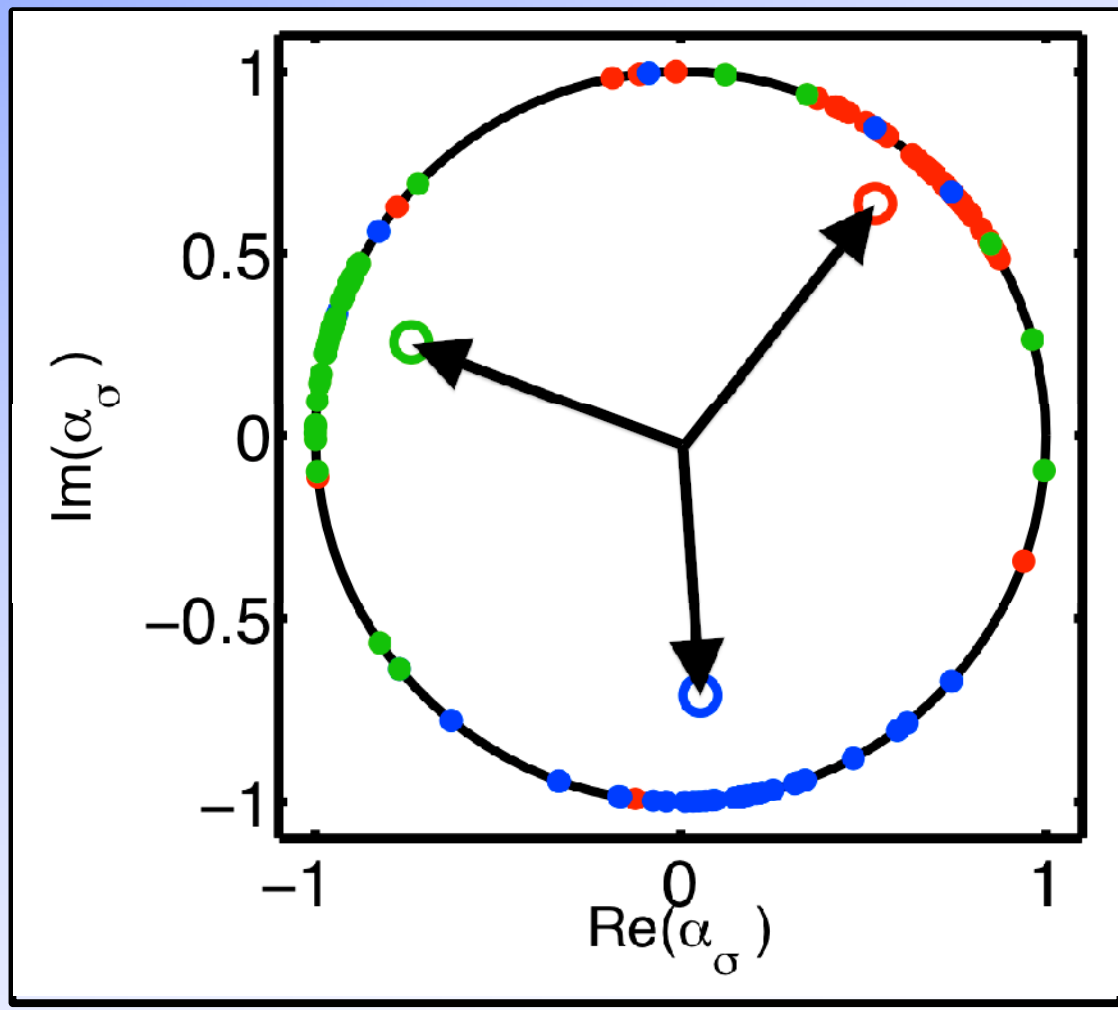
Dustin Anderson, Ari Tenzer
Edward Ott, Thomas Antonsen, Michelle Girvan, Gilad Barlev

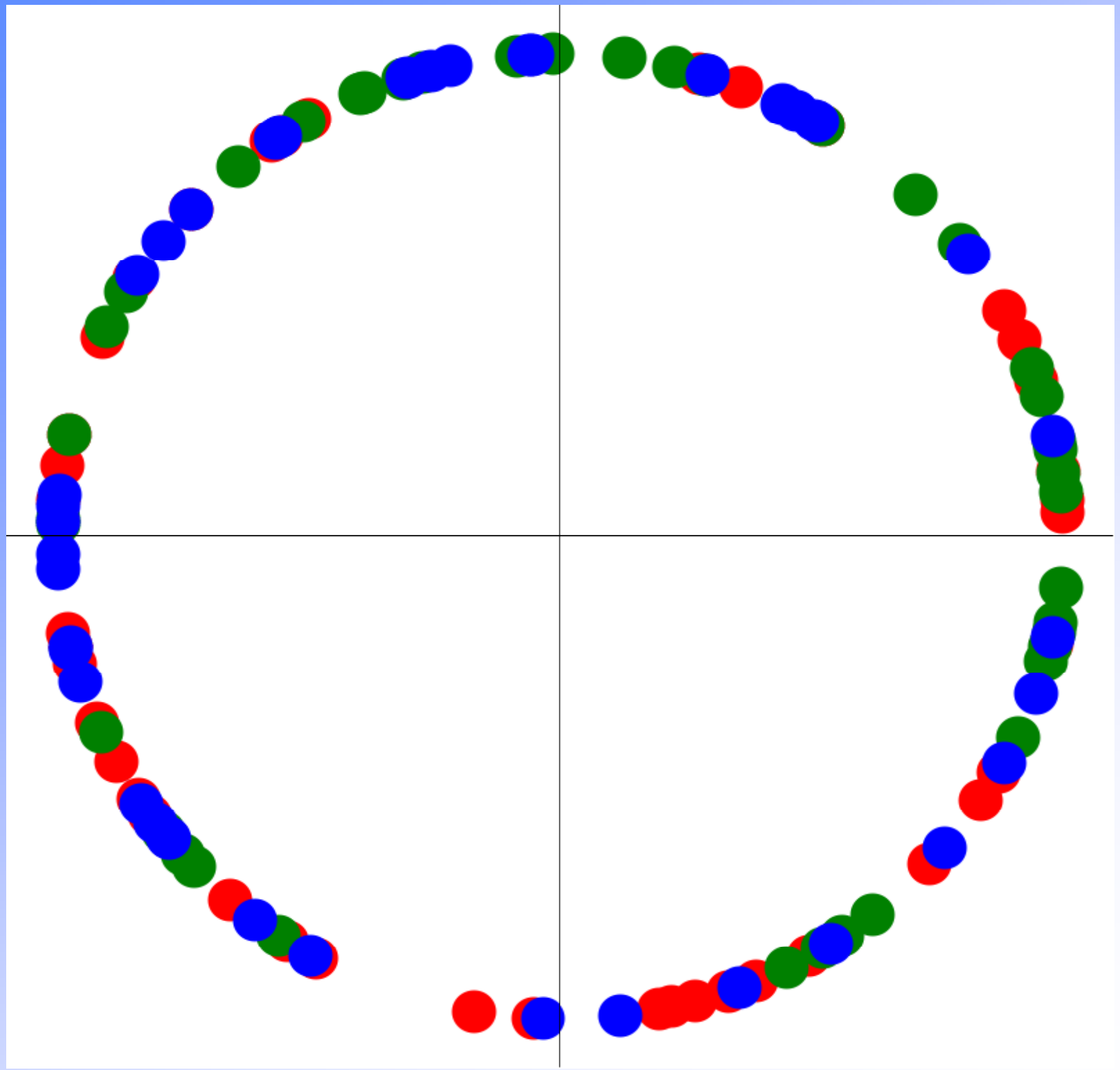
Why study oscillator groups?

- Neurons can act as oscillators and display synchronization.
- Such neural oscillators often synchronize in groups. Ex: Visual Cortex.
- Goal: Study how groups of oscillators interact.

The Model

- N oscillators are placed in M groups.
- Order parameters quantify the degree of synchronization in each group.
- Each oscillator oscillates at a rate determined by its natural frequency and a coupling term.
- Coupling within a group is “attractive”; coupling between groups is “repulsive”.





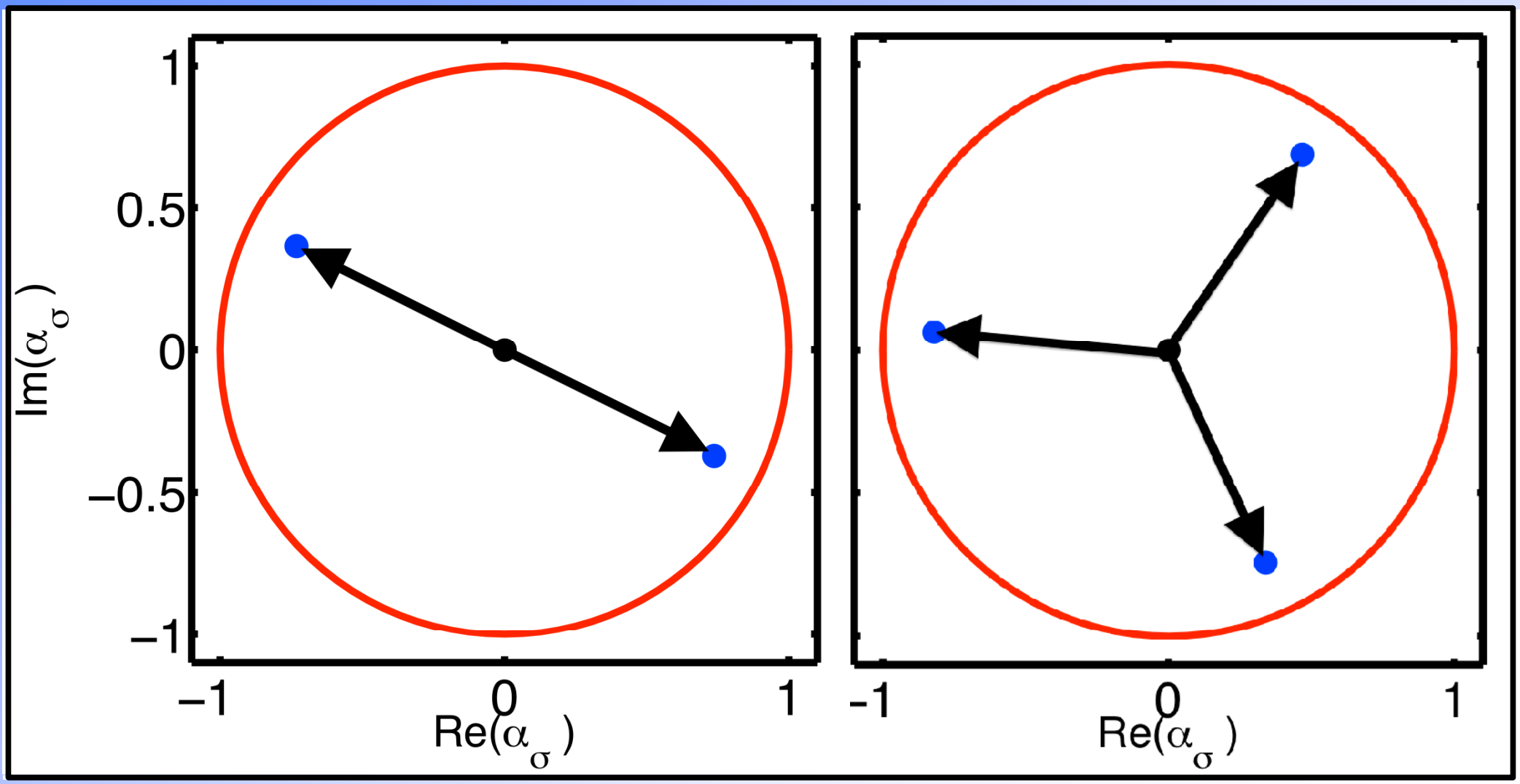
Simplifying Things...

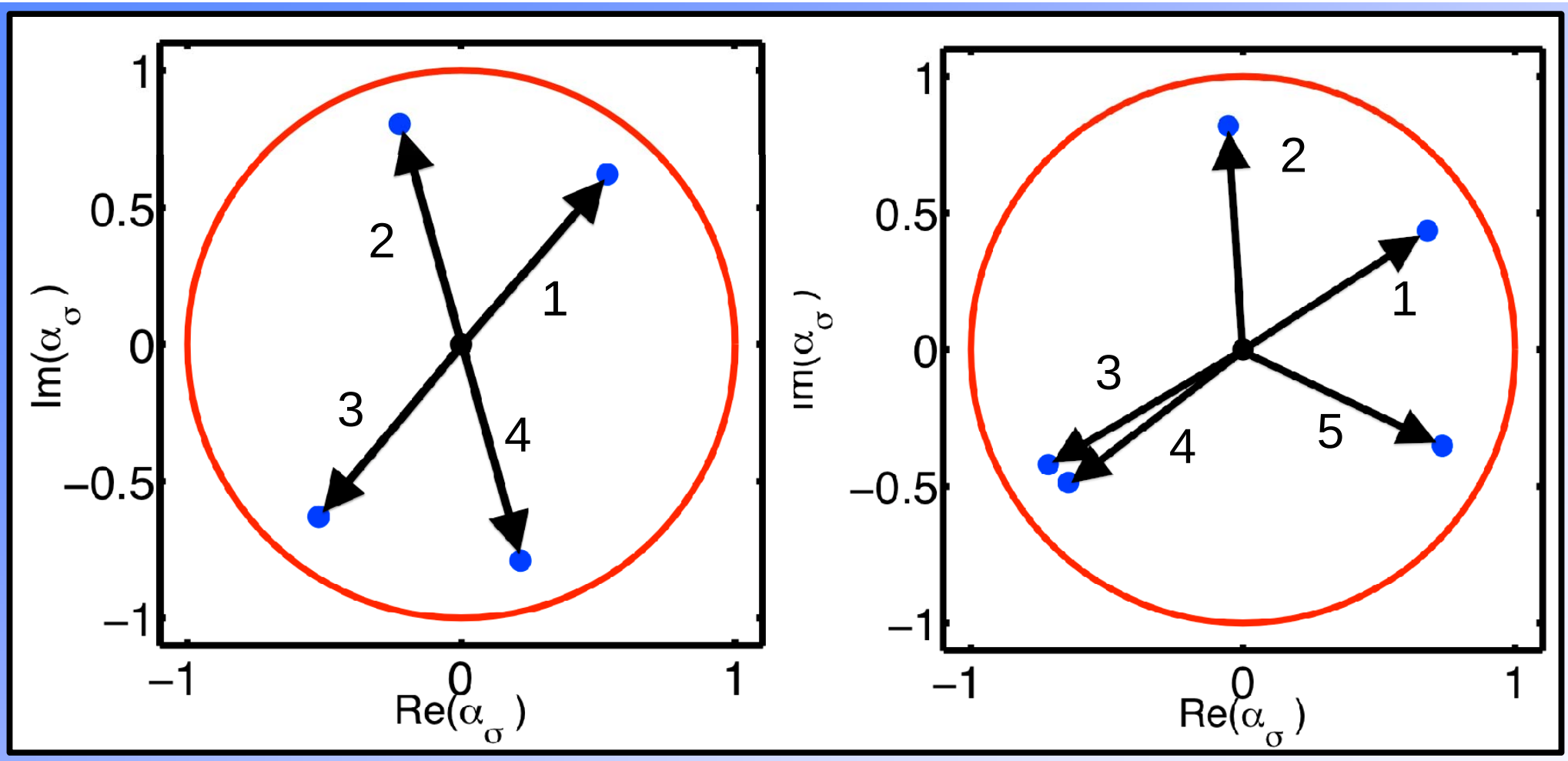
- Instead of the huge number of equations describing individual oscillator phases, we examine a small number of equations describing the group order parameters.

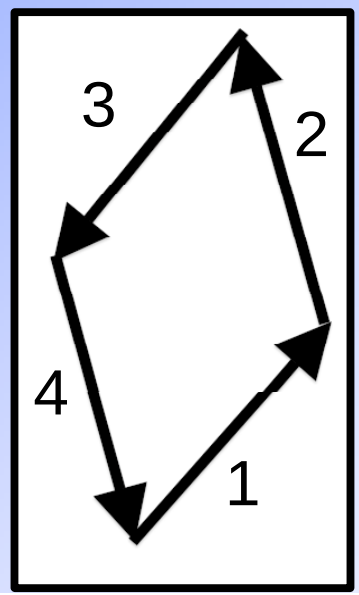
- Using this simplification, we find that the only stable equilibria are those for which all order parameters have the same length, and the sum of the order parameters is zero.

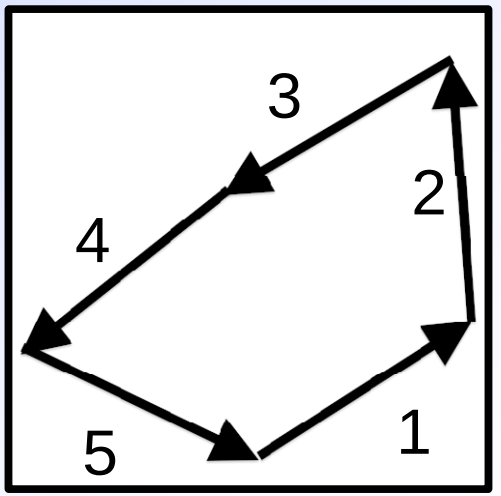
Two Group Equilibrium

Three Group Equilibrium

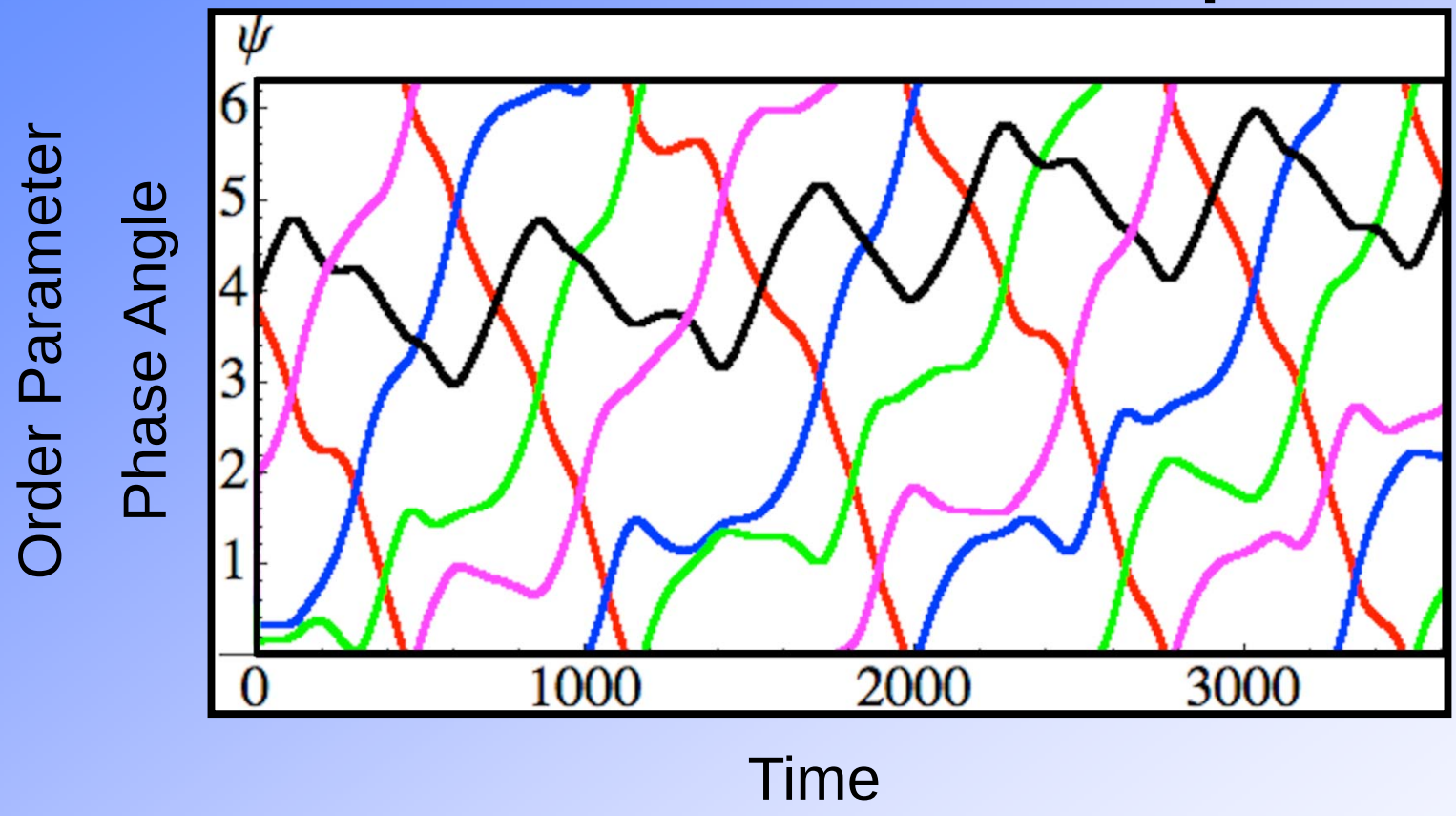



1
0.5
0
−0.5
−1
−1
0
1
Im(α_σ)
Re(α_σ)
2
1
3
4
1
0.5
0
−0.5
−1
−1
0
1
Im(α_σ)
Re(α_σ)
2
1
3
4
5


3
2
4
1


3
2
4
5
1

Nonidentical Groups



- We modify the group frequency distributions and coupling strengths.
- We use a two timescale analysis to determine equations governing the dynamics of this system.

Conclusion

- We study the behavior of interacting oscillator groups by describing the behavior of the group order parameters.
- We find and classify the possible equilibria of the system.
- We also analyze the dynamics of the system with nonidentical groups.