

C. Gros, Self-Organization: Theory and Simulation, summer-term 2014

1 Bifurcations and Chaos in Dynamical Systems

1.1 Basic Concepts of Dynamical Systems Theory

1.2 Fixpoints, Bifurcations and Stability

1.2.1 Fixpoints Classification and Jacobian

1.2.2 Bifurcations and Normal Forms

1.2.3 Hopf Bifurcations and Limit Cycles

1.3 Global Bifurcations

1.3.1 Catastrophe Theory

1.4 The Logistic Map and Deterministic Chaos

1.5 Dynamical Systems with Time Delays

2 Self Organization and Pattern Formation

2.1 Interplay between Diffusion and Reaction

2.1.1 Travelling Wavefronts in the Fisher Equation

2.1.2 Sum rule for the Shape of the Wavefront

2.1.3 Self-Stabilization of Travelling Wavefronts

2.2 Interplay between Activation and Inhibition

2.2.1 Turing Instability

2.2.2 Pattern Formation

2.2.3 The Gray-Scott reaction diffusion system

2.3 Collective Phenomena and Swarm Intelligence

2.3.1 Collective Decision Making and Stigmergy

2.3.2 Collective Behavior and Swarms

2.3.3 Opinion Dynamics

2.4 Car Following Models

2.4.1 Linear Flow and Carrying Capacity

2.4.2 Self-Organized Traffic Congestions

3 Dissipation, Noise and Adaptive Systems

3.1 Dissipation and Adaption

3.1.1 Dissipative Systems and Phase Space Contraction

3.1.2 Strange Attractors and Dissipative Chaos

3.1.3 Adaptive Systems

3.1.4 Conserving Adaptive Systems

3.2 Diffusion and Transport

3.2.1 Random Walks, Diffusion and Levy Flights

3.2.2 The Langevin Equation and Diffusion

3.3 Noise-Controlled Dynamics

3.3.1 Stochastic Escape

3.3.2 Stochastic Resonance

4 Darwinian Evolution, Hypercycles and Game Theory

4.1 Introduction

4.2 Mutations and Fitness in a Static Environment

4.3 Deterministic Evolution

4.3.1 Evolution Equations

4.3.2 Beanbag Genetics: Evolutions Without Epistasis

4.3.3 Epistatic Interactions and the Error Catastrophe

4.4 Finite Populations and Stochastic Escape

4.4.1 Strong Selective Pressure and Adaptive Climbing

4.4.2 Adaptive Climbing Versus Stochastic Escape

4.5 Prebiotic Evolution

4.5.1 Quasispecies Theory

4.5.2 Hypercycles and Autocatalytic Networks

4.6 Macroecology and Species Competition

4.7 Coevolution and Game Theory