

Course 20105401 - Winterterm 2015 - FU Berlin

Nonlinear Dynamics- Introduction to an analytic treatment of nonlinear systems

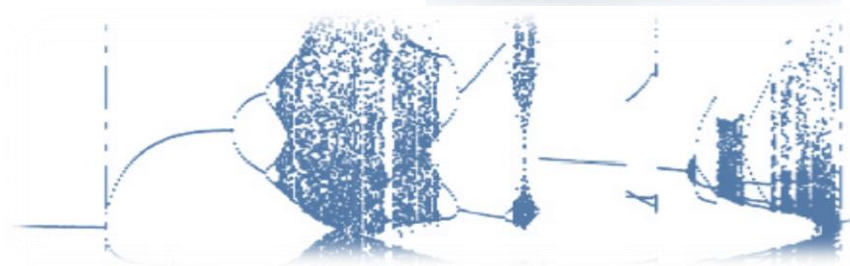
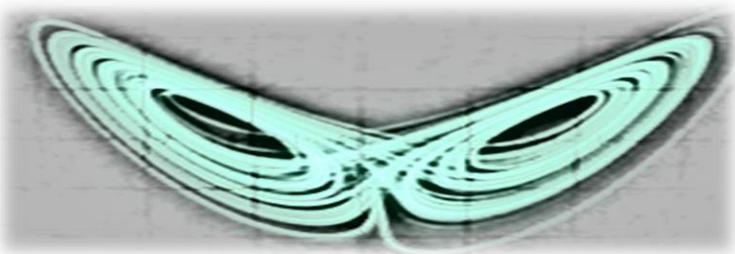
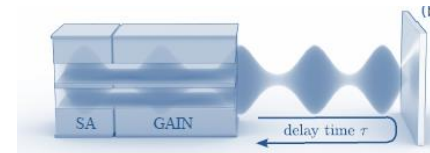
Prof. Dr. Kathy Lüdge

Location: 0.1.01 Hörsaal B (Arnimallee 14)

Time: Mi 14:00-16:00

Contents

- Dynamical systems and deterministic chaos
- Stability analysis: - linear stability of systems with time delay
- - nonlinear stability analysis with asymptotic methods
- Coupled systems and networks
- Nonlinear dynamics in laser systems



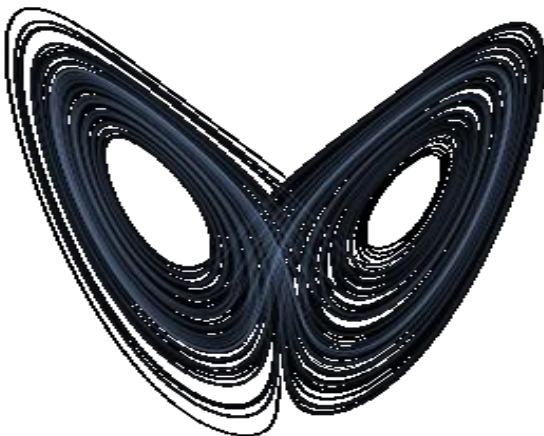
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1. Dynamical systems and deterministic chaos

- (1) Vector fields
- (2) **Stability** and long-term behaviour – *conservative and dissipative systems*
- (3) Classification of **bifurcations**
- (4) Deterministic chaos

Continuous systems (*differential equations*)

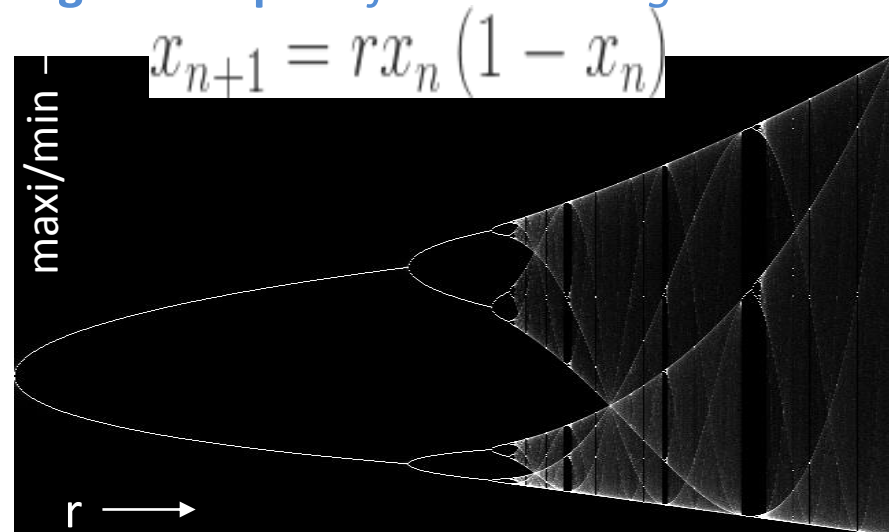
Lorenz attractor –
trajectory in phase space



Courtesy: en.wikipedia.org

Discrete systems (*iterative equations*)

Logistic map – *bifurcation diagram*



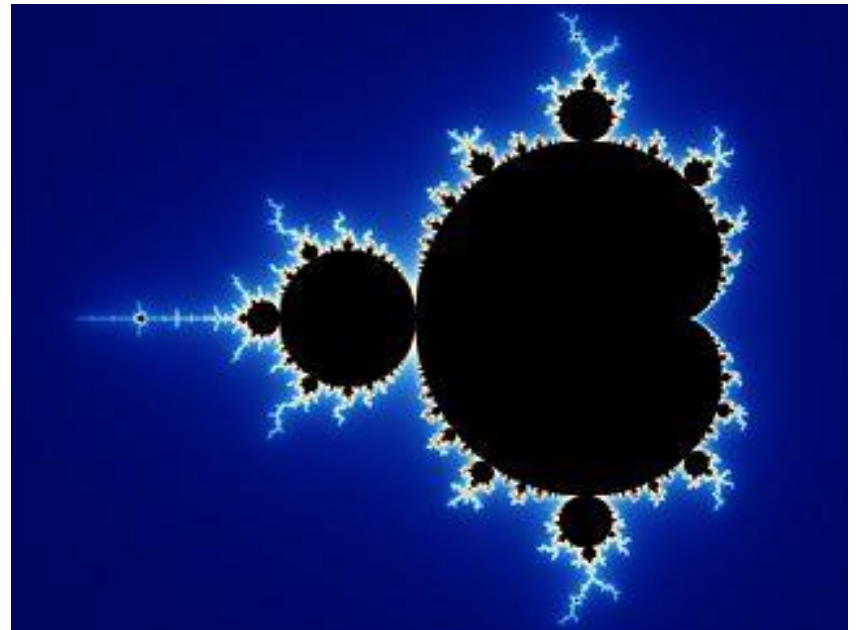
Courtesy: batchloaf.wordpress.com

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Fractals: Mandelbrot set



Courtesy: en.wikipedia.org

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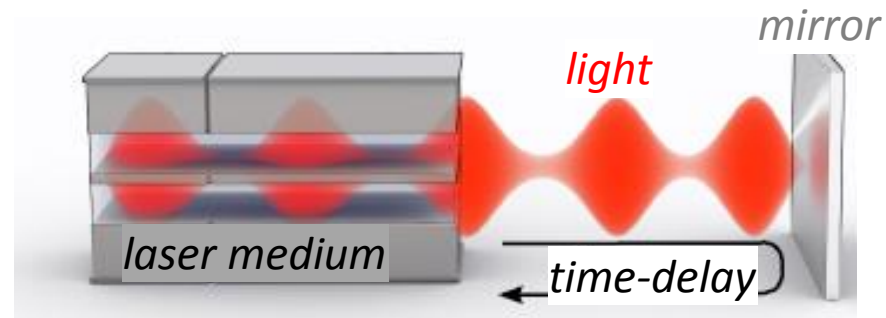
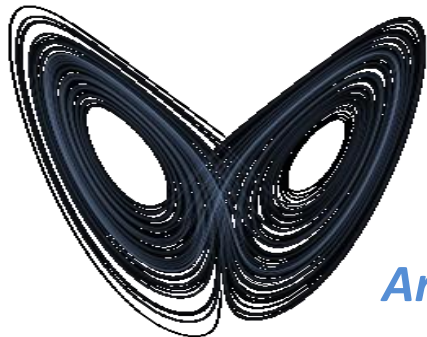
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2. Control schemes

- (1) Linear control
- (2) Chaoscontrol – *OGY, Pyragas, adaptive control*
- (3) **Time-delayed feedback control** – *stability analysis with delay*

How to analyze the dynamics with delay?



Are there orbits that can be stabilized?

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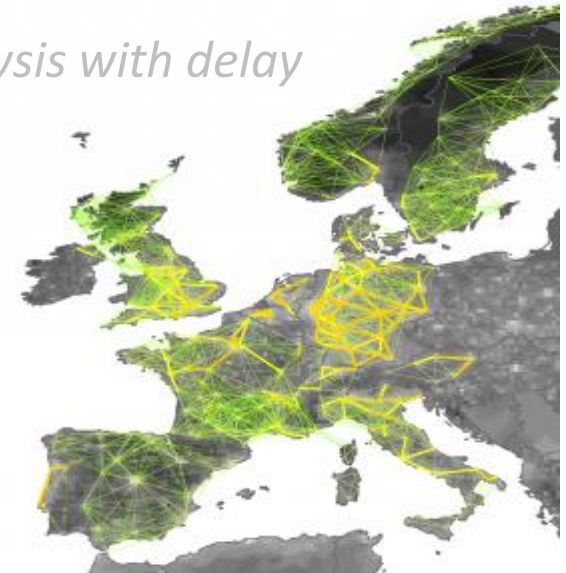
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- (1) 2 coupled elements (neurons, lasers)
- (2) Classification of networks
- (3) **Synchronization**



Curtesy: gleamviz.org



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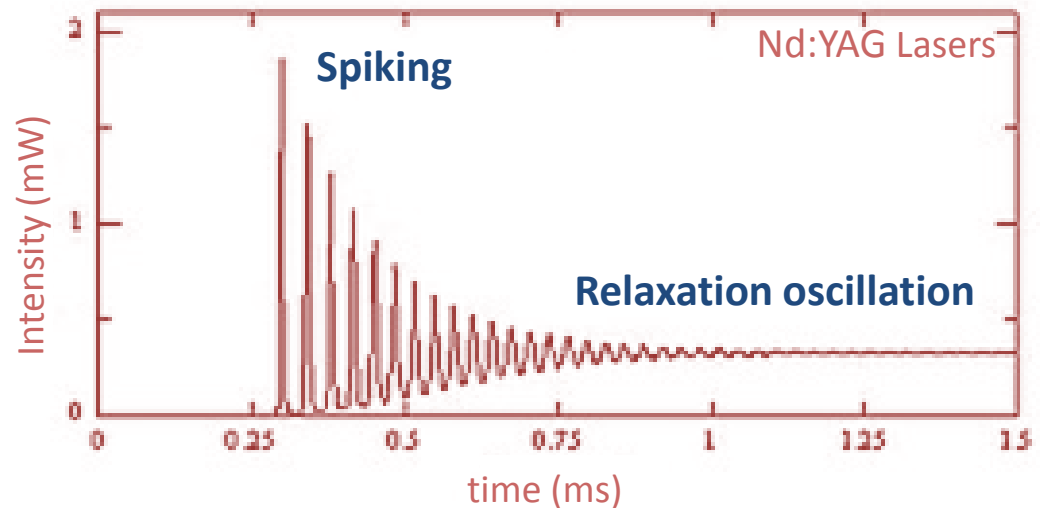
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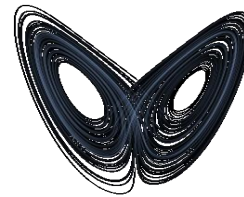
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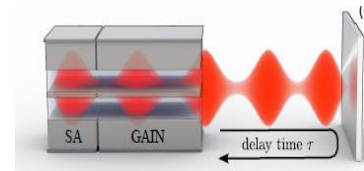
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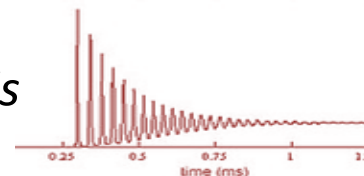
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Exercise - Wednesday 16:00-17:30 (room E2)

- **Takes place every 2nd week**

Dates:

21.10.	1st home work (<i>needs to be handed in one week later</i>)
4.11.	2nd home work
18.11.	3rd home work
2.12.	4th home work
16.12.	5th home work
13.1.	6th home work
27.1.	

- **Requirement for certificate:** 50% of the attainable points
- **Goal:** Learn numerical and analytical tools to analyze nonlinear systems

Information

- **Course** in **Modern methods in Theoretical Physics A** for master students
5 credit points
Oral exam at the end (last week of semester)
- **Webpage**
<http://www.physik.fu-berlin.de/einrichtungen/ag/ag-luedge/teaching>

Literature

Nonlinear dynamics

- Steven Strogatz, *Nonlinear dynamics and Chaos*, Westview Press 2000
- John Guckenheimer, *Nonlinear oscillations, dynamical systems, and bifurcations of vector fields*, Springer (1986)

Networks

- Marc Newman, *Networks: An introduction*, Oxford University Press (2010)

Asymptotic methods

- T. Erneux, P. Glorieux, *Laser Dynamics*, Cambridge Univ. Press, 2010