

LV 3233 L 152 - Sommersemester 2016

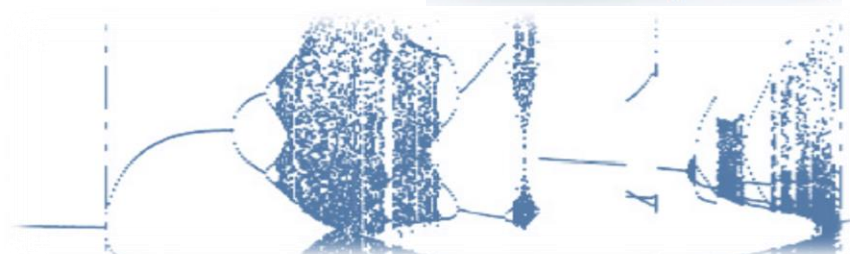
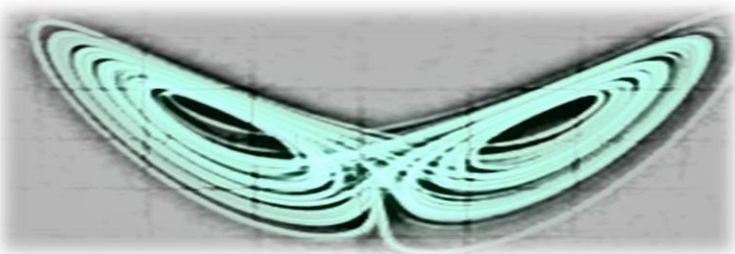
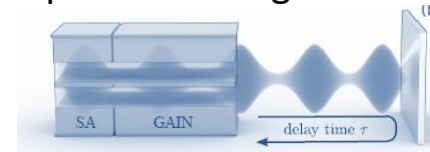
# Theoretische Physik VI (Vertiefung)

## *Nichtlineare Dynamik und Kontrolle*

**Dozenten:** Prof. Dr. Kathy Lüdge  
Prof. Dr. E. Schöll, PhD

**Wann/Wo:** **Do & Fr** 10:15 im EW203 (VL)  
**Mi** 12:15 im EW 731 (Übung)

- Inhalt:**
- Dynamische Systeme und deterministisches Chaos
  - Stabilitätsanalyse nichtlinearer Differenzialgleichungen mit und ohne Delay
  - Gekoppelte Systeme , Netzwerke, Rauschen
  - Laserdynamik: Einschaltverhalten, Normalformanalyse, optische Injektion
  - Modengekoppelte Laser: Multiple-delay Modelle, Analyse komplexer Pulszüge
  - Analytische Beschreibung von Phasenrauschen



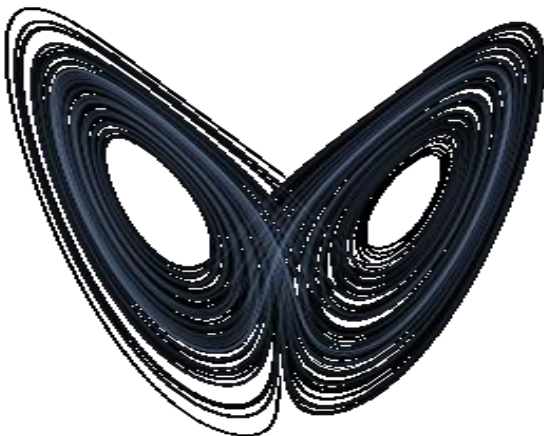
# Contents

## 1. Dynamical systems and deterministic chaos

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

### Continuous systems (*differential equations*)

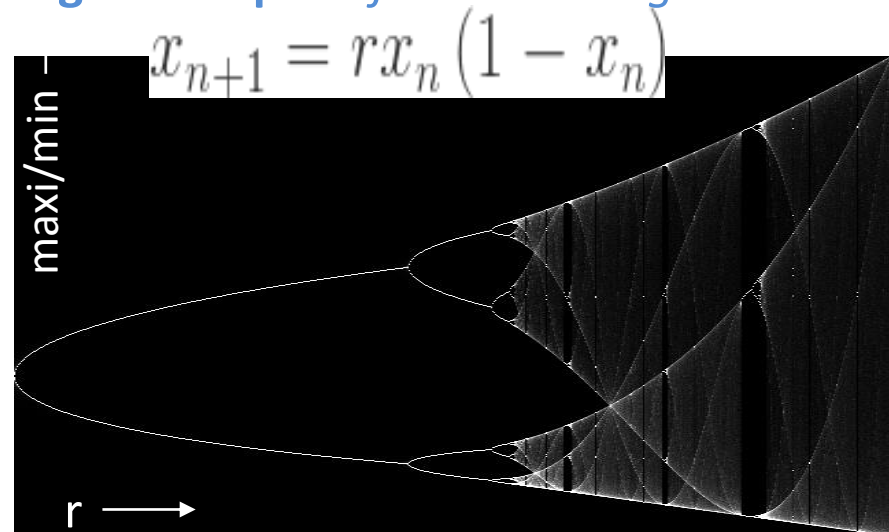
**Lorenz attractor** –  
*trajectory in phase space*



Courtesy: en.wikipedia.org

### Discrete systems (*iterative equations*)

**Logistic map** – *bifurcation diagram*

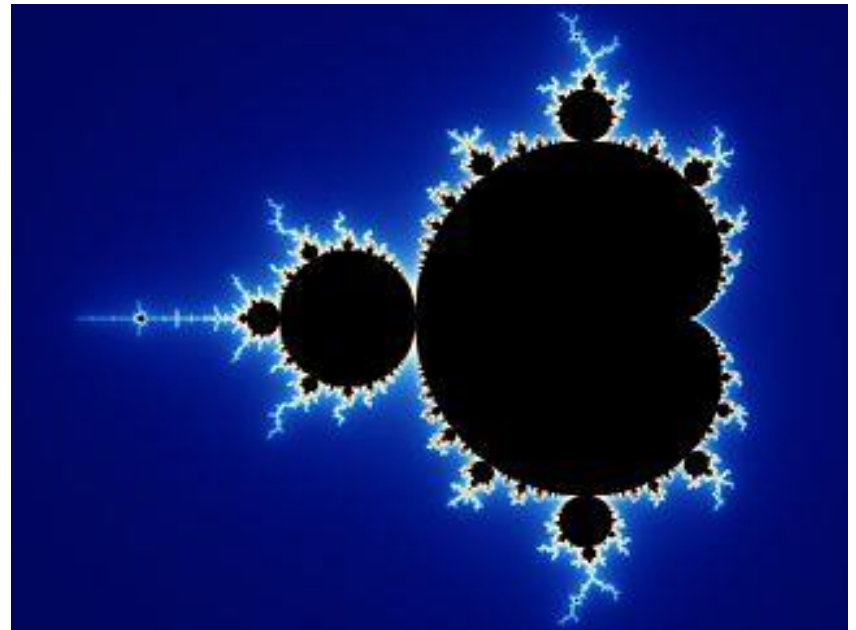


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Fractals: Mandelbrot set



Courtesy: en.wikipedia.org

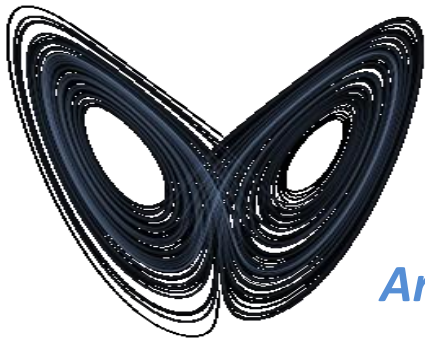
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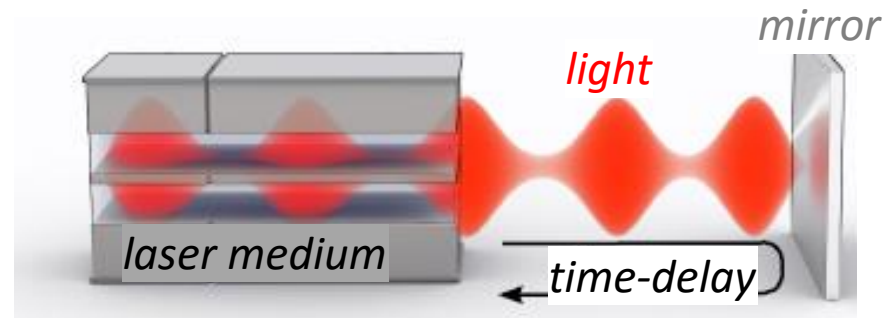
## 2. Feedback control

- (1) **Time-delayed feedback control** – *stability analysis with delay*
- (2) Chaoscontrol with *Pyragas scheme*



*Are there orbits that can be stabilized?*

*How to analyze the dynamics with delay?*



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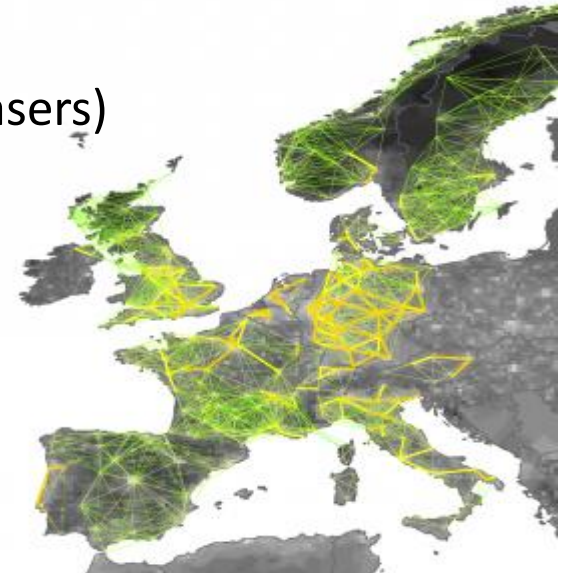
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- (1) Coupled elements, synchronization (neurons, lasers)
- (2) Effect of noise



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

## 2. Feedback control

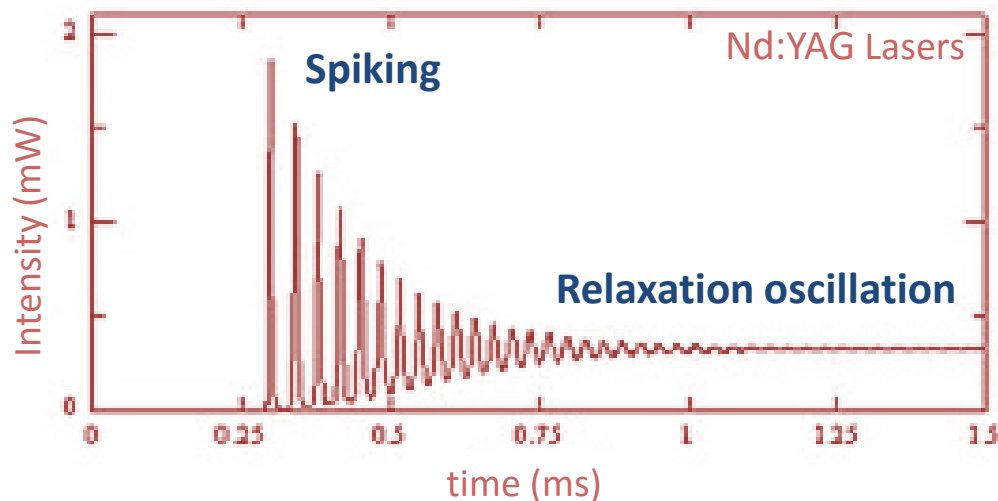
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- (1) Coupled elements, synchronisation
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## 4. Nonlinear laser dynamics

- (1) Turn-on and spiking dynamics – *nonlinear stability analysis*
- (2) Laser with optical injection – *bifurcation analysis*
- (3) Mode locked laser – *multiple-delays, complex pulse trains*
- (4) Analytic approach to phase noise spectra



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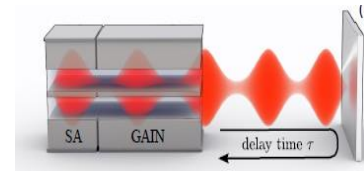
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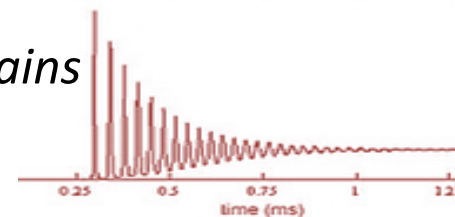
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# Übung - Mittwoch 12:00-14:00 Raum EW731

- **Übungszettelbetrieb**

- Übungszettel werden **Freitag in der VL** ausgeteilt
- **Mittwoch** in der nächsten Übung besprochen
- 1 Woche später am **Mittwoch vor der Übung** abgegeben

- **Scheinkriterium:** 50% der Punkte aus den Übungszetteln und aktive Teilnahme am Tutorium

- **Ziel:** Erlernen **analytischer** und **numerischer** Werkzeuge zur Analyse nichtlinearer Systeme

**Assistent für die Übung:** Dr. Benjamin Lingnau (EW629)



# Information

## Theoretische Physik VI (Vertiefung) "Nichtlineare Dynamik und Kontrolle"

Der Besuch dieser Lehrveranstaltung (VL+UE) entspricht **10 ECTS-Punkten**.

- Zusammen mit der LV *Theoretische Physik V: Quantenmechanik II* ergibt sich das **Pflichtmodul** Theoretische Physik V/VI des *Masterstudiengangs Physik*.  
grundlagenorientierte Studienrichtung: TP V und VI  
anwendungsorientierte Studienrichtung: TP V oder VI
- Die Vorlesung kann auch als **Wahlpflichtfach (8 SWS)** mit dem *Seminar: Nichtlineare Dynamik (Chimera States and Applications Di 16:00)* kombiniert werden (insgesamt 12 ECTS-Punkte).

## Webpage

[http://www.itp.tu-berlin.de/menue/lehre/lv/ss\\_2016/.../pflichtveranstaltungen\\_masterstudium/ndk16/](http://www.itp.tu-berlin.de/menue/lehre/lv/ss_2016/.../pflichtveranstaltungen_masterstudium/ndk16/)

# Literatur

## Grundlagen

- [Steven H. Strogatz](#), *Nonlinear Dynamics And Chaos: With Applications To Physics Biology, Chemistry And Engineering* (Studies in Nonlinearity), Westview Press (2000)
- [Ed Ott](#), *Chaos in dynamical systems*, Cambridge Univ. Press (2002)
- [John Guckenheimer](#), *Nonlinear oscillations, dynamical systems, and bifurcations of vector fields*, Springer (1986)

# Weiterführende Literatur

## Dynamische Systeme:

- ❑ E. Schöll, S. Klapp, P. Hövel, *Control of self-organizing nonlinear systems*, Springer (2016)
- ❑ F. M. Atay, *Complex Time-Delay Systems*, Springer (2010)
- ❑ E. Schöll, H.G. Schuster, *Handbook of chaos control*, Wiley (2008)
- ❑ H. Haken, *Synergetics, Introduction and Advanced Topics*, Springer (2004)

## Laserdynamik:

- ❑ T. Erneux, P. Glorieux, *Laser Dynamics*, Cambridge Univ. Press (2010)
- ❑ H. Haken, *Laser light dynamics*, North Holland (1985)
- ❑ K. Lüdge, *Nonlinear Laser Dynamics - From Quantum Dots to Cryptography*, Wiley (2012)

## Zeitverzögerte Dynamische Systeme:

- ❑ T. Erneux, *Applied Delay Differential Equations*, Springer (2009)
- ❑ A. Bellen, M. Zennaro, A. Bellen, *Numerical Methods for Delay Differential Equations*, Oxford Univ. Press (2003)

## Stochastische Systeme:

- ❑ C. W. Gardiner, *Handbook of stochastic method*, Springer (2004)
- ❑ N. G. van Kampen, *Stochastic processes in physics and chemistry*, North-Holland (2008)