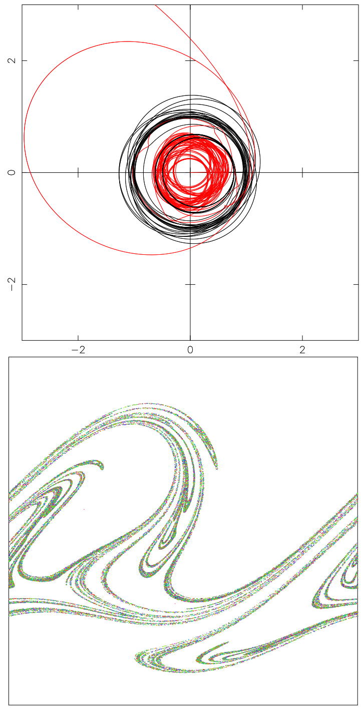
Computational Physics

2+2 SWS, 6 CP (summer term)

Nowadays, physicists are mainly concerned with two subjects: one is the devise of models, normally in form of differential equations, the other one is their approximate solution, normally by the help of more or less large computers. Problems from classical mechanics normally rely on ordinary differential equations, those of electrodynamics, quantum mechanics, continuum mechanics or hydrodynamics are formulated by partial differential equations which are often nonlinear. Special emphasis is laid on deterministic but chaotic behavior of low dimensional systems like the nonlinear pendulum or the three body problem of celestial mechanics.
In a certain way, computational physics can be seen as a link between theory and experiment. The often rather involved equations need a numerical treatment, usually in connection with certain simplifications and approximations. Is the code once written, the 'experimental' part begins.
A computer on which for instance a turbulent pipe flow is simulated, can to some extend be regarded as a test station with easy access to output values such as flow rates, velocities, temperatures, and also to input parameters like material constants or geometric boundary conditions.



Two examples for Deterministic Chaos in low dimensions.

To follow the lectures, the students should have basic knowledge in theoretical physics and should also be able to write numerical codes in a scientific oriented language like FORTRAN or C. Applications in MATLAB will be also discussed.

Contents of lecture:

- **Nonlinear maps.** Standard map, chaos and Lyapunov exponents, fractals, neural networks, Kohonen's model
- **Dynamical systems.** Stability analysis, Hamiltonian systems, symplectic integration, dissipative systems
- **Ordinary differential equations.** Classical mechanics, pendulum, Kepler problem, molecular dynamics, chaos, SIR models
- **Monte Carlo methods.** Random numbers, MC integration, classical gas, Ising model

Literature

M. Bestehorn, *Computational Physics*, De Gruyter (2018)