Mini-course on Geometric Numerical Integration

Course Description.
Ordinary differential equations (ODEs) often appear in the dynamical description of systems in physics, chemistry, biology, engineering, etc. Many differential equations exhibit geometric properties that are preserved by the dynamics. Recently, there has been a trend towards the construction of geometric numerical integrators. Such numerical methods are of particular interest in the simulation of mechanical systems, where the preservation of invariants such as the energy, momentum or symplectic form is important, especially in long-term simulations (of the outer solar system for example).

This mini-course offers a first introduction to the field of Geometric Numerical Integration (GNI). In short, we will be interested in the development and numerical analysis of structure-preserving numerical methods for differential equations.

Topics covered in this mini-course are:

- Brief exposition of classical numerical methods for ODEs
- Numerical methods that preserve properties of Hamiltonian systems
- Problems with highly oscillatory solutions
- GNI for partial differential equations and stochastic differential equations.

These topics will be illustrated by applications from physics, molecular dynamics and astronomy.

The mini-course will be complemented by theoretical and practical exercises in Matlab.

Lecture notes will be provided.

Background.
Calculus 1 and 2. Basic knowledge in numerical methods for ordinary differential equations. Basic knowledge of Matlab.

Target Audience.
Advanced Bachelor students. Master students. PhD students. Students from physics and other sciences with a basic knowledge in ordinary differential equations are welcome.

Main References.
E. Hairer, C. Lubich, G. Wanner: *Geometric Numerical Integration*,
http://www.springerlink.com/content/978-3-540-30666-5#section=491904&page=1
B. Leimkuhler, S. Reich: *Simulating Hamiltonian Dynamics*,
http://dx.doi.org/10.1017/CBO9780511614118
E. Hairer, C. Lubich, G. Wanner: *Geometric Numerical Integration Illustrated by the Störmer-Verlet Method*, 2003,
http://www.unige.ch/~hairer/preprints.html

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