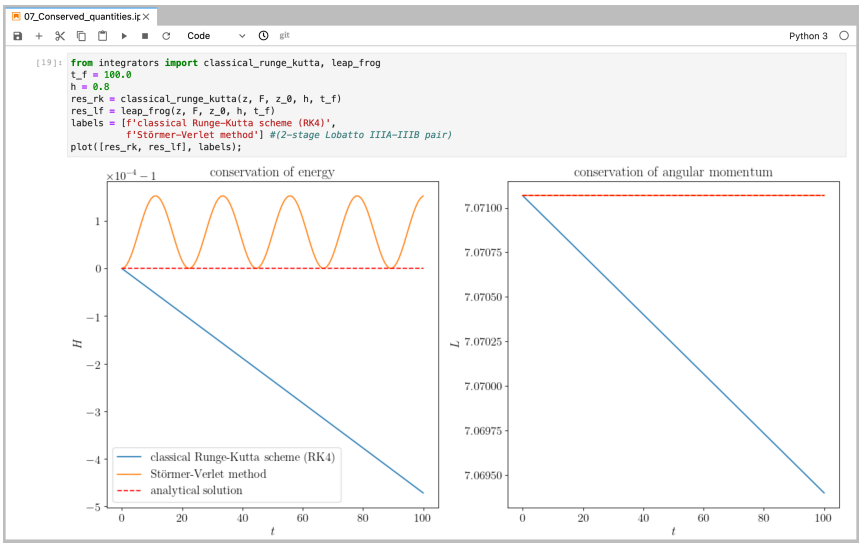
Geometric Numerical Integration (Summer Semester 2021)

Dynamical relations in science and engineering are commonly written as differential equations. These equations often present **conservation laws** or underlying **geometric structures** that have consequences for the behaviour of the solutions. In most cases it is not possible to solve these equations analytically and the use of numerical methods is required.

In this course we will approach the topic of **numerical integration of ordinary differential equations** while preserving some of the structure and qualitative properties of the original system. This is called **geometric numerical integration**. The resulting methods of this approach also present higher degree of stability which is particularly important for long-term simulations, and are devoid of some common numerical artefacts such as artificial numerical damping.

We will analyse dynamical systems and integration methods both from a theoretical and a practical point of view. Regarding the latter, we will give an introduction to **programming in Python** for the implementation of these methods.



Analysis of conserved quantities for the Kepler problem in Jupyter lab using Python 3.

Addressed audience: Students of the 5th semester and higher.

Recommended prior knowledge: Some notions of programming, Lagrangian mechanics and ordinary differential equations.

Date and location: The lectures and problem sessions will take place weekly live via Zoom, Tuesdays and Thursdays from 10:15 to 11:45. Student participation is encouraged, guest students welcomed.

Bibliography:

E. Hairer, and G. Wanner, and C. Lubich, Geometric Numerical Integration: Structure-Preserving Algorithms for Ordinary Differential Equations. Springer, 2006.
E. Hairer, and S. Nørsett, and G. Wanner, Solving ordinary differential equations. I Nonstiff problems. Springer, 1993.
E. Hairer, and G. Wanner, Solving ordinary differential equations. II Stiff and differential-algebraic problems. Springer, 2010.
J.E. Marsden, and M. West, Discrete mechanics and variational integrators. Acta Numerica, 2001.
E. Hairer, C. Lubich und G. Wanner. *Geometric numerical integration illustrated by the Störmer–Verlet method*. Acta Numerica, 2003.
E. Süli and D. F. Mayers, An Introduction to Numerical Analysis. Cambridge University Press, 2003.