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PROGRAM

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Special Session 63: Advanced High Order Geometric Numerical Integration Methods for Differential Equations

Sergio Blanes, Universitat Politecnica de Valencia, Spain
Fernando Casas, Universitat Jaume I, Spain

The aim of the proposed special session is to bring together experts in the development, analysis and applications of methods for the numerical integration of differential equations arising in different fields of science and technology. The framework of these schemes is the field of Geometric Numerical Integration, its main goal being to reproduce the qualitative features of the solution of the differential equation which is being discretised, in particular its geometric properties. The motivation for developing such structure-preserving algorithms arises independently in areas of research as diverse as celestial mechanics, molecular dynamics, control theory, particle accelerators physics, and numerical analysis. In this special session we will focus on the analysis and applications of numerical methods within this class that, in addition, provide high accurate approximations.

Geometric integration methods of high order for gradient systems

Miguel Atencia
University of Malaga (Spain), Spain
matencia@ctima.uma.es
Yadira Hernandez-Solano

We propose the higher order extension of numerical methods that preserve the energy-diminishing feature of a system with Lyapunov function. Therefore we focus on ODEs with a Lyapunov function, so that they can be rewritten in the form of a linear gradient, i.e, the right hand side of the ODE consists of the product of a negative-definite matrix and the gradient of the Lyapunov function. Then, the formal construction of discrete gradient methods is straightforward, since they amount to replacing the negative definite matrix with an approximation, and the gradient with a discrete gradient. There is considerable freedom in the choice of these parameters. The technique used in this contribution results from composing a first order discrete gradient method together with its adjoint, yielding a second order method. The basis first order method is based upon the component-wise discrete gradient, whereas the adjoint method is computed in a similar vein, but the order of components is reversed. Finally the proposed method is validated by numerical experiments, showing the main features of the method: it preserves the Lyapunov function, it approximates the continuous system up to second order, and it can be computed explicitly in particular examples.