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Combined Explicit-Implicit Taylor Series Methods

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Hamiltonian systems arise in natural sciences and are used as mathematical models for many practical problems. Due to their wide applications, a large class of numerical methods, usually symplectic ones, has been developed. The most commonly used is Verlet method which is second order, fast, and simple to implement. Here we consider a novel idea proposed and developed in [1]. It is based on Taylor series expansion and produces a large class of methods of various orders of accuracy. The idea of the method is to combine Taylor expansions about the forward and current time levels. Construction of such methods is simple and moreover, they inherit the desired for Hamiltonian systems properties of symmetry and energy conservation. When high order of accuracy is needed, these new methods have lower computational cost than Verlet method.
In some problems of Computational Dynamics, at a given stage of the process, incorporation of a large set of initial conditions or a large set of parameters is required. This motivates us to parallelize the numerical algorithms. Here we consider instruction level parallelism, namely, vectorized instructions combined with OpenMP threads. A comparison between the classical Verlet method and the Combined Taylor Series Methods on some Hamiltonian systems has been made, with main focus on the time-accuracy diagrams. The results illustrate the strengths and the weaknesses of the two different approaches.
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[1] Akishin, P. G., Puzynin, I. V., Vinitsky, S. I. (1997). A hybrid numerical method for analysis of dynamics of the classical Hamiltonian systems. Computers & Mathematics with Applications, 34(2-4), 45-73

Primary author: Dr HRISTOV, Ivan (University of Sofia)

Co-authors: Mr PUZYNIN, I (LIT, JINR, Dubna, Russia); Mr SHEGUNOV, N (University of Sofia, Bulgaria); Dr HRISTOVA, Radoslava (University of Sofia); Prof. DIMOVA, Stefka (FMI, Sofia University); Ms PUZYNINA, T (LIT, JINR, Dubna, Russia); TUKHLIEV, Zafar (JOINT INSTITUTE FOR NUCLEAR RESEARCH); SHARIPOV, Zarif (JINR)

Presenter: TUKHLIEV, Zafar (JOINT INSTITUTE FOR NUCLEAR RESEARCH)

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