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Chaos Many-Body Engine v03: A new version of code C# for chaos analysis of relativistic many-body systems with reactions

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ABSTRACT

In this paper we present a new version of the Chaos Many-Body Engine C# application (Grossu et al. 2012 [1]). In order to benefit from the latest technological advantages, we migrated the application from .Net Framework 2.0 to .Net Framework 4.0. New tools were implemented also. Trying to estimate the particle interactions dependence on initial conditions, we considered a new distance, which takes into account only the structural differences between two systems. We used this distance for implementing the "Structural Lyapunov" function. We propose also a new precision test based on temporal reversed simulations.

New version program summary

Program title: Chaos Many-Body Engine v03

Catalogue identifier: AEGH_v3_0

Program summary URL: http://cpc.cs.qub.ac.uk/summaries/AEGH_v3_0.html

Program obtainable from: CPC Program Library, Queen's University, Belfast, N. Ireland

Licensing provisions: Standard CPC licence, http://cpc.cs.qub.ac.uk/licence/licence.html

No. of lines in distributed program, including test data, etc.: 214429

No. of bytes in distributed program, including test data, etc.: 9512380

Distribution format: tar.gz

Programming language: Visual C# .Net 2010

Computer: PC

Operating system: .Net Framework 4.0 running on MS Windows

RAM: 128 MB

Classification: 24.60.Lz, 05.45.a

Catalogue identifier of previous version: AEGH_v2_0

Journal reference of previous version: Computer Physics Communications 183 (2012) 1055–1059

Does the new version supersede the previous version?: Yes

Nature of problem: Chaos analysis of three-dimensional, relativistic many-body systems with reactions.

Solution method: Second order Runge–Kutta algorithm. Implementation of temporal reversed simulation precision test, and "Structural Lyapunov" function.

Reasons for new version:

1. In order to benefit from the advantages involved in the latest technologies (e.g. LINQ Queries [2]), Chaos Many-Body Engine was migrated from .Net Framework 2.0 to .Net Framework 4.0.
2. In addition to existing energy conservation assessment [3], we propose also a reverse simulation precision test. Thus, for a regular simulation, we considered the corresponding reversed process: initial time equals the end time of regular simulation, and temporal resolution $dt < 0$. One can compare the initial state of the regular system, and the final state of the reversed one ($t = 0$) using, for example, the phase-space distance.

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3. Trying to measure particle interactions dependence on initial conditions, we considered the following distance, which takes into account only the structure differences between two many-body systems with reactions:

$$d_s = \sqrt{\sum_{i=1}^{n} (N_{i1} - N_{i2})^2} \tag{1}$$

where N_{i1} represents the number of particles of type "i" from the first system, and N_{i2} is the corresponding number for the second system. We sum over all particle types.
Inspired by the Lyapunov Exponent method [4], we implemented the evolution in time of the "Structural Lyapunov" function, for two identical systems with slightly different initial conditions:

$$L_s(t) = \ln \frac{d_s(t)}{d_s(0)}. \tag{2}$$

Summary of revisions:

1. Migration from .Net Framework 2.0 to .Net Framework 4.0
2. Implementation of new chaos analysis tools:
   a. Reverse simulation precision test
   b. "Structural Lyapunov" function.

Additional comments:

1. In [1] we applied the Chaos Many-Body Engine to some nuclear relativistic collisions at 4.5 A GeV/c (SKM 200 collaboration [5,6]). We considered also some first tests on He + He head-on collisions at 1 A TeV/c (choose the Simulation\Collision menu, and set the appropriate parameters Fig. 1). However, in this case, more complex reaction schemas should be considered. Further investigation on higher energies is currently in progress.

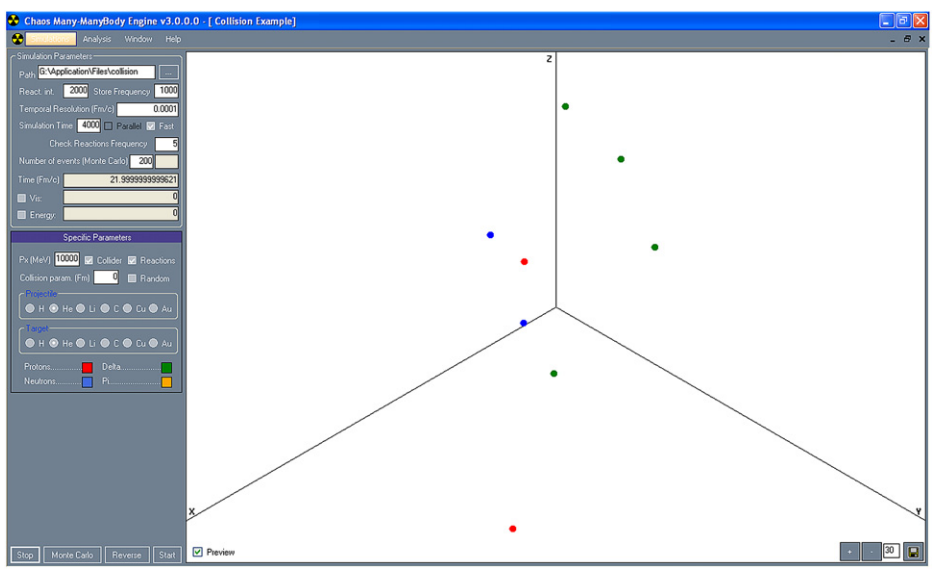

Fig. 1. He+He central, head-on collision at 1 A TeV/c (example of use).

Restrictions: The reverse simulation precision test does not apply for: systems with reactions, parallel simulations, and Monte Carlo simulations.

Running time: quadratic complexity.

Acknowledgments

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References

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