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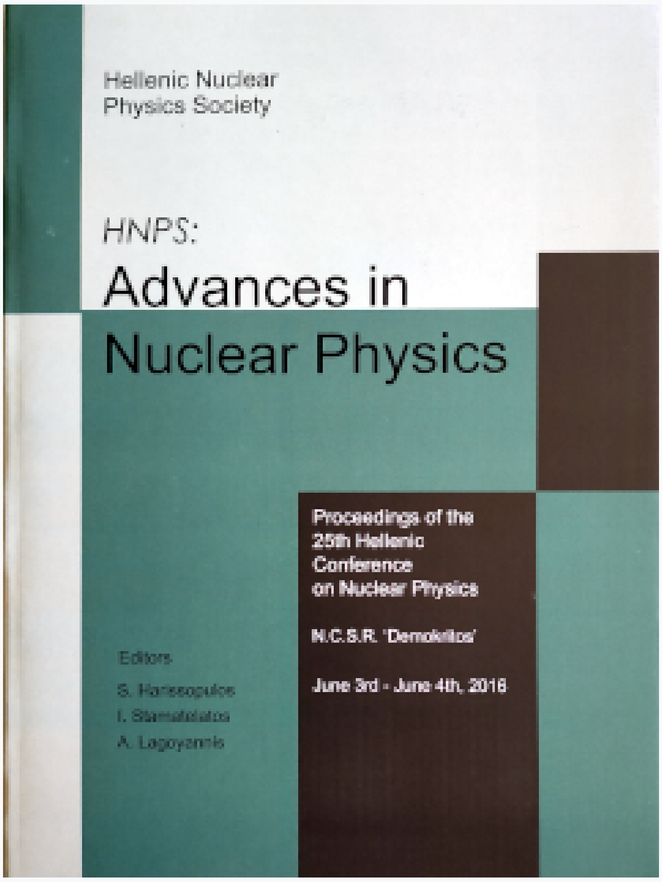

Microscopic description of neutron-induced fission with the CoMD Model: Preliminary Results

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Microscopic description of neutron-induced fission with the CoMD Model: Preliminary Results

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Abstract

In the present work, we initiated a systematic study of neutron-induced fission reactions using the code CoMD (Constrained Molecular Dynamics) of A. Bonasera and M. Papa [1,2]. The code implements an effective interaction with a nuclear-matter compressibility of K=200 (soft EOS) with several forms of the density-dependence of the nucleon symmetry potential. In addition, CoMD imposes a constraint in the phase space occupation for each nucleon restoring the Pauli principle at each time step of the collision). Proper choice of the surface parameter of the effective interaction has been made to describe fission. In this poster, we presented preliminary results of neutron-indued fission on ^{235}U at neutron energies 5, 10, 15, 25, 50 and 100 MeV. Calculated mass and energy distributions are shown and compared with the recent experimental data of Loveland et al. [3]. It appears that the microscopic code CoMD is able to describe the complicated many-body dynamics of the n-induced fission process. Proper adjustment of the parameters of the effective interaction and further improvements of the code will be implemented to achieve a satisfactory description of the experiment data.

INTRODUCTION

The microscopic description of the mechanism of nuclear fission still remains a topic of intense nuclear research. Understanding of nuclear fission, apart from the theoretical many-body point of view, is of exceptional practical importance for energy production, as well as for the transmutation of nuclear waste. Furthermore, nuclear fission is the mechanism that sets the upper limit to the periodic table of the elements (via the so-called fission-recycling process) and plays a vital role in the production of heavy elements via the astrophysical rapid neutron-capture process (r-process).

The present work is a study of neutron-induced fission based on the semi-classical microscopic N-body constrained molecular dynamics (CoMD) model in regards to its ability to describe the full dynamics of the fission process in neutron induced reactions on ^{235}U at low and intermediate energies. We remind that most of the energy released in the fission process appears in the kinetic energy of the fission fragments. The deformed scission-point fragments will return to their equilibrium deformations and the deformation energy will be converted into internal excitation energy. These quantities depend on the mass split in fission which in turn, at low excitation energies, may reflect the fragment nuclear structure. We intent to study these quantities with CoMD model.

RESULTS AND DISCUSSION

We performed CoMD calculations on the neutron induced fission of ^{235}U, at neutron energies 5, 10, 15, 25, 50, 100 MeV. In Fig. 1, we present the mass yield curves for the fission reaction n+ ^{235}U at energy 50 MeV employing the standard and soft symmetry potential [2]. We observe that ^{235}U is undergoing asymmetric fission as indicated from the double-humped curve. In the near future, we plan to explore this feature of the calculations in detail.

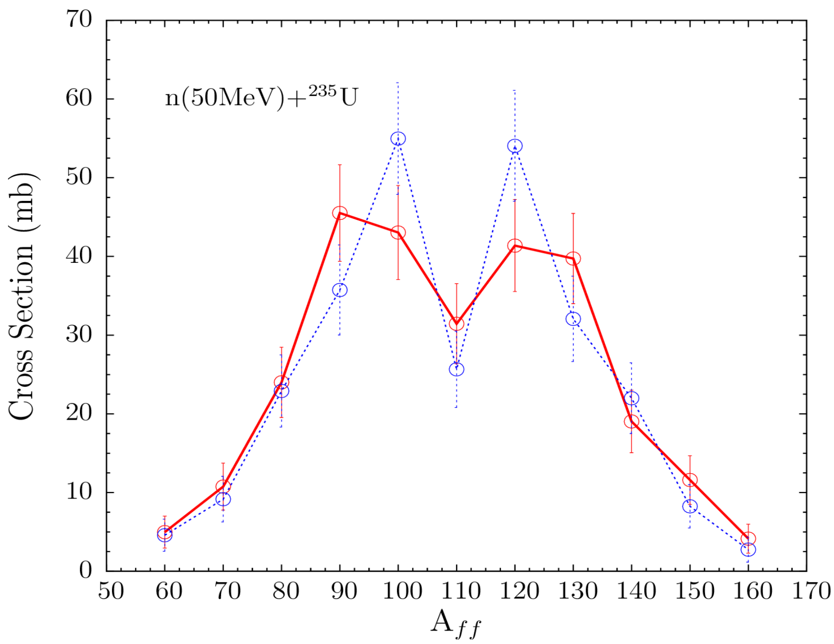

Fig. 1. CoMD calculated mass-yield curves for the fission reaction n(50MeV)+^{235}U. Red points (connected with a continuous line): calculations with the standard symmetry potential [2]. Blue points (connected with a dotted line): calculations with the soft symmetry potential [2].

In Fig. 2, a plot of the total kinetic energy of the fission fragments versus the neutron energy is presented. Our calculations with the CoMD model were performed with the standard and the soft symmetry potential [2] and they were compared with the experimental data a of Loveland et al. [3].

A reasonable agreement (within a few MeV) of our calculations with the data is obtained. We plan to explore and understand the differences in the near future.

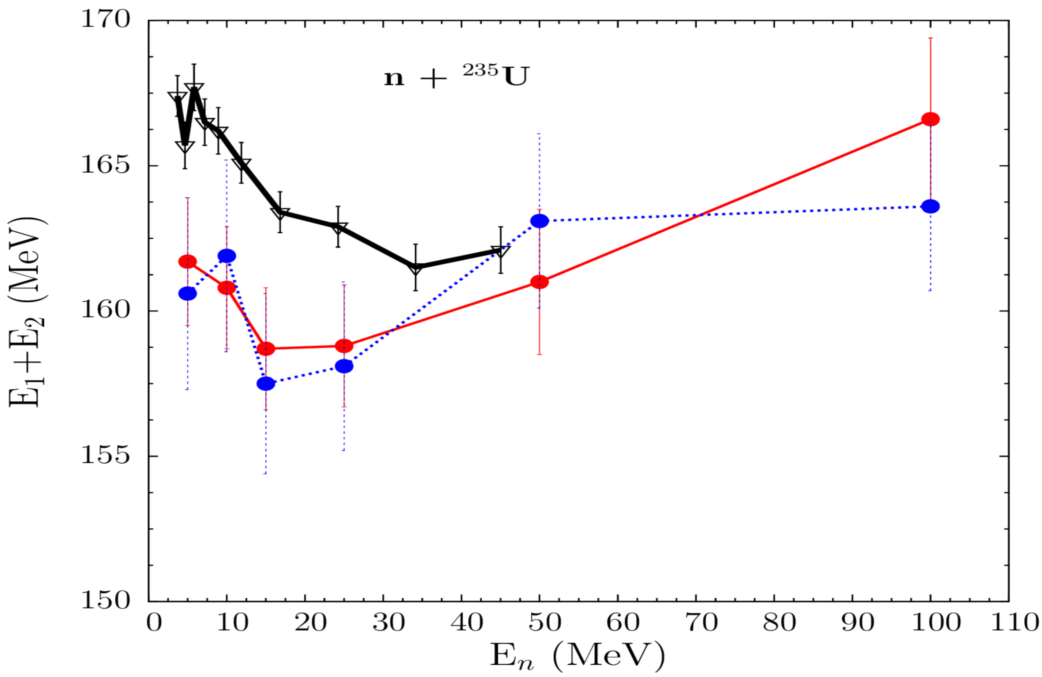

Fig. 2. CoMD calculations of the average total energy of fission fragments from n+^{235}U with respect to neutron energy. Red points (connected with a continuous line) : CoMD calculations with the standard symmetry potential [2]. Blue points (connected with a dotted line): CoMD calculations with the soft symmetry potential [3]. Black points (connected with thick solid line) : experimental data of Loveland et al. [3].

CONCLUSIONS

In the present work we employed the semi-classical microscopic code CoMD to describe neutron-induced fission of ^{235}U in a variety of energies and compared our results with available experimental data. Our preliminary results are in overall agreement with the experimental data. We intend to study systematically neutron-induced fission by calculating various observables such as: mass-yield curves, cross sections, energy distributions, fission time scale, as well as, pre-fission and post-fission neutron emission.
We mention that the present version of the CoMD code does not include the effect of spin-orbit interaction in the mean filed, as a result of the absence of spin dependence of the effective nucleon-nucleon interaction used [1,2]. We intend to add such a dependence in the code to improve our ability to describe the low-energy fission of actinides, and most notably, the well-pronounced double-humped structure of the mass-yield curves.

References

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