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TITLE: BENCHMARKING THE LAHET^{TM} FISSION MODELS

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Benchmarking the LAHET^{TM} Fission Models

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Introduction

There has been considerable interest in improving the fission models in the LAHET[1] Monte Carlo code for the transport and interaction of nucleons, pions, muons, light ions, and antinucleons. Although subactinide fission contributes little to neutron production in lead or tungsten targets, it can be significant for simulation of target activation and fission product contamination. The availability of new data permits new comparisons to be made between experiment and calculation.

Benchmarking the Fission Models

Previous efforts[2] at benchmarking the models have shown that subactinide fission is not well estimated and that there is considerable sensitivity to the physics options employed in conjunction with the fission model. The question of model sensitivity is not addressed here. The examples of LAHET calculations shown all used the default LAHET physics options, e. g., Bertini intranuclear cascade, the RAL fission models, and the Gilbert-Cameron-Cook-Ignatyuk energy dependent level density; the multistage preequilibrium model was not used.

Since the absolute ^{235}U fission cross section is used as a standard to extract the fission cross section from fission cross section ratio measurements, it plays a central role in testing the calculational capabilities. The "final" LANL[3] experimental results have been made available for ^{235}U fission. The comparison with the LAHET calculation shows the results are within 10% above 80 MeV, but there is considerable divergence below. However, the general features of the cross section are followed by the model to low energies. In addition, the real test of the model is a comparison of the fission *yields* (as a fraction of the nonelastic cross section), since that is exactly what the fission models predict. In LAHET, the prediction of the nonelastic reaction rate, and therefore the nonelastic cross section, is a function only of the intranuclear cascade model used.

Subactinide fission is much less well represented by the present model, but new experimental results[4,5] show that the discrepancies may not be as large as previously indicated. Comparisons are shown in figures 1 and 2 for natural Pb and ^{209}Bi. The comparison for Pb shows that although calculated results are everywhere low, the calculated cross sections are within a factor of 2 above 100 MeV and in good agreement near 150 MeV. For ^{209}Bi, the agreement is considerably better. The behavior of the difference suggests that modification of the fission barrier within the model may well lead to improvement.

Summary

One must certainly conclude that the extension of the use of evaluated data libraries for proton and neutrons to 100 MeV or 150 MeV would eliminate most of the difficulties associated with developing good fission models for use with intranuclear cascade-evaporation codes! In any case, the proposed use in LAHET of a global nucleon-nucleus optical potential to determine the elastic and nonelastic reaction rates would allow study of the fission models to focus on the calculated fission yield rather than on the calculated fission rate.

However, there appears to be a growing number of consistent experimental measurements of Pb and Bi fission that may well be a basis for improvement of the subactinide fission model in LAHET. The latter is not an easy task, since, to be done properly, the fission model must be consistent with the intranuclear cascade model and the succeeding precquilibrium and evaporation models. The subactinide fission model is a good candidate for modification, since it is a true model with well-defined physical quantities employed; the actinide fission model is less treatable, since it only employs tabulations of observed rations of fission- to neutron-widths.

1. Richard E. Prael and Henry Lichtenstein, "User Guide to LCS: The LAHET Code System", LA-UR-89-3014, Los Alamos National Laboratory (September 1989).
2. R. E. Prael, "The LAHET Code System: Introduction, Development, and Benchmarking," Transactions of the Workshop on Simulating Accelerator Radiation Environments, Santa Fe, Jan. 1993.
3. P. Lisowski, LANL, personal communication.
4. P. Staples and K.B. Morley, LANL, personal communication.
5. V. P. Eismont *et al.*, "Relative and Absolute Neutron-induced Fission Cross Sections of ^{208}Pb, ^{209}Bi, and ^{238}U in the Intermediate Energy Region", to be published.

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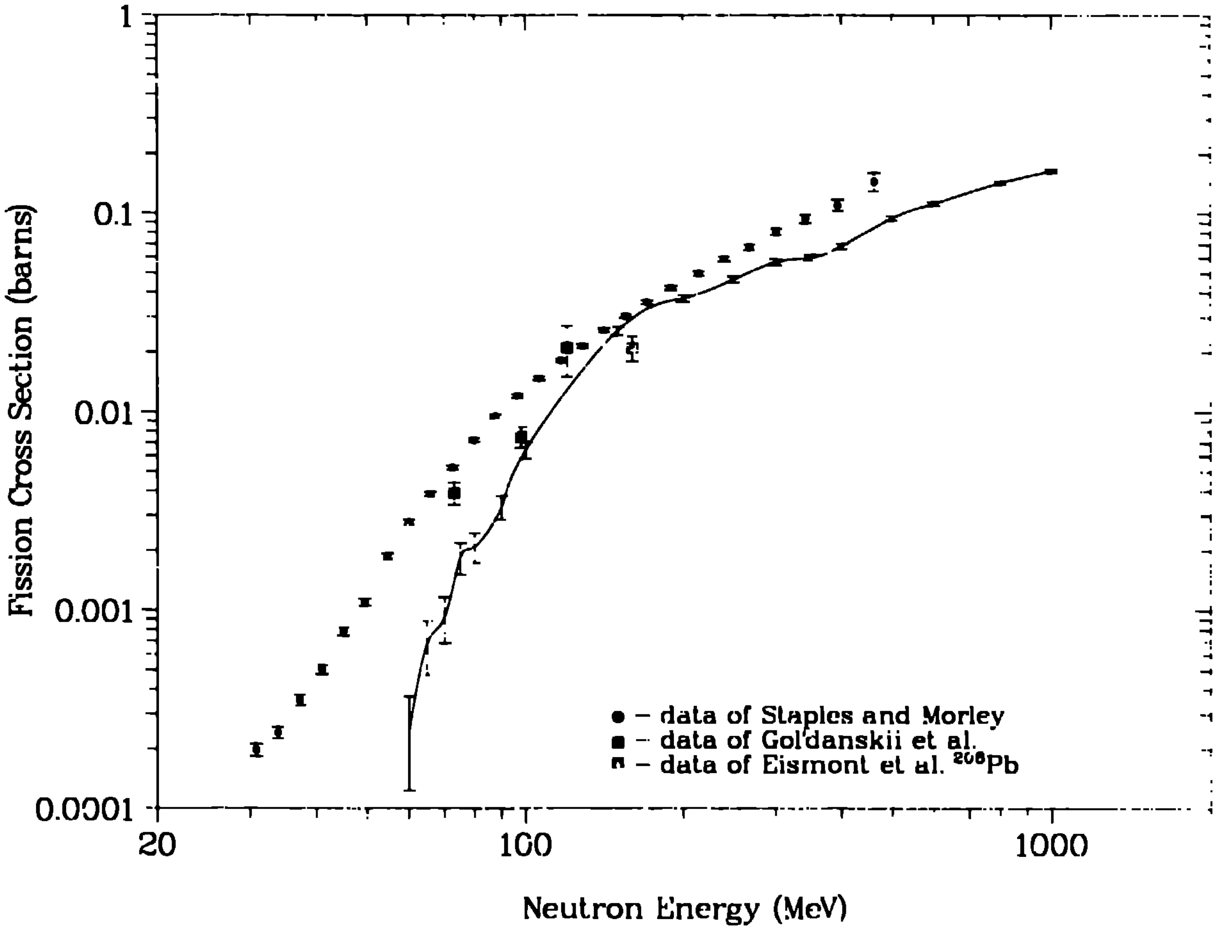

Figure 1: Neutron induced natural Pb fission cross section. LAHET calculations with Bertini INC and default physics options (line).

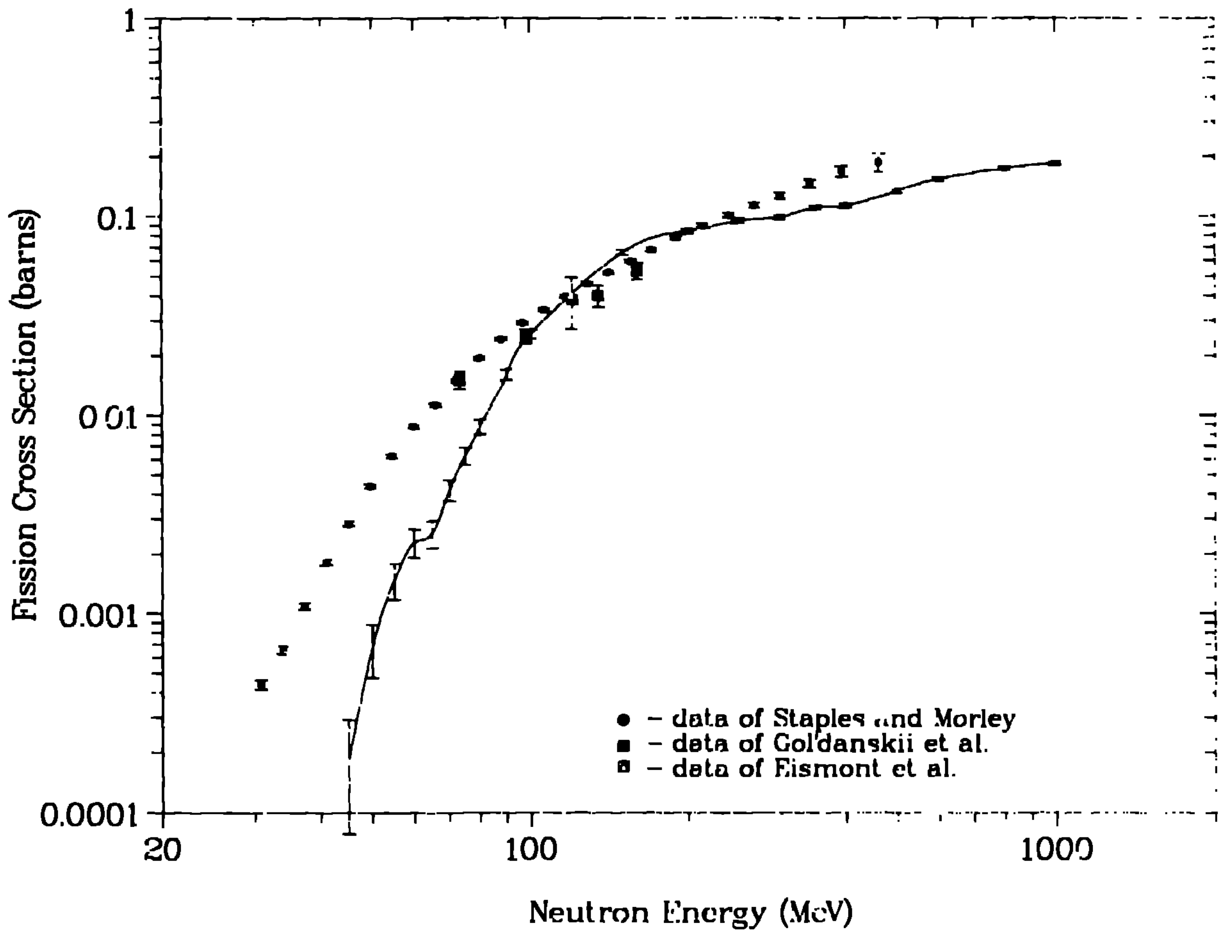

Figure 2: Neutron induced ^{209}Bi fission cross section. LAHET calculations with Bertini INC and default physics options (line).