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Nuclear Data for Accelerator-Transmutation of Waste

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1 Introduction

The development of an accelerator-transmutation of waste (ATW) capability requires a number of nuclear technology developments for the design of the spallation target and the subcritical transmuter. ATW design is guided by radiation transport code simulations, which are used to model particle transport, criticality, activation, and radiation heating and damage. This paper focuses on nuclear data needed to insure the accuracy of such simulations.

2 Results

New ENDF/B-VI data files have been produced for incident neutrons and protons for energies that extend up to 150 MeV (the LA150 library) [1]. By using advanced nuclear models that account for details of nuclear structure and the quantum nature of the nuclear scattering, significant gains in simulation accuracy can be achieved below 150 MeV, where intranuclear cascade calculations become less accurate. To date, evaluations have been completed for isotopes of the following target/blanket and shielding materials: H, Li, C, N, O, Al, Si, P, Ca, Cr, Fe, Ni, Cu, Nb, W, Hg, Pb, Bi. The evaluations are based upon measured data as well as predictions from the GNASH nuclear model code, which calculates cross sections using Hauser-Feshbach, exciton and Feshbach-Kerman-Koonin preequilibrium models. Elastic scattering distributions and direct reactions are calculated from the optical model.

I describe recent developments to the MCNPX radiation transport code [2], which merges MCNP and LAHET in one code and uses the LA150 evaluated data. A number of benchmark comparisons against integral experiments are described, for thick-target neutron production, neutron transmission through macroscopic slabs, and neutron kerma coefficients. Good agreement between calculation and experiment is found. These benchmarks help validate the transport code and the evaluated data for use in accelerator-driven-system simulations of neutron production in a spallation target (n/p), radiation shielding, heating, and damage. As an illustrative example, Fig. 1 shows the calculated (solid line) thick-target neutron production from 68 MeV protons stopping in aluminum, compared with measured data. It is evident that MCNPX simulations that use our new evaluated LA150 data better agree with measurements compared to those that use intranuclear cascade LAHET-type physics (dashed-line).

For an ATW transmuter, the fundamental nuclear data for minor actinides are in many cases poorly understood. This affects our ability to predict the criticality, k_{eff}. Additionally, data uncertainties affect our ability to predict the rates of transmutation of the various radioactive species. Since most designs have, at present, focussed on transmuters that operate at fast neutron energies, the most important energy range is below 20 MeV, and primarily energies in the hundreds-of-keV to few-MeV region for the minor actinides, and lower energies for the fission products. More accurate data are desirable for the minor actinides, for the fission products, and for the coolants such as lead and bismuth [3]. Data at higher energies are needed in certain cases, such as for estimations of radiation damage, and shielding requirements.

For an ATW spallation target, accurate nuclear data are needed in order to predict the number of spallation neutrons produced per incident proton, n/p, which affects the overall economy. Data are also needed to better understand the radionuclides produced through spallation and fission nuclear reactions, for studies of activation, and materials properties. I provide an overview of the status of nuclear theory and modeling for calculations of spallation and subactinide fission.

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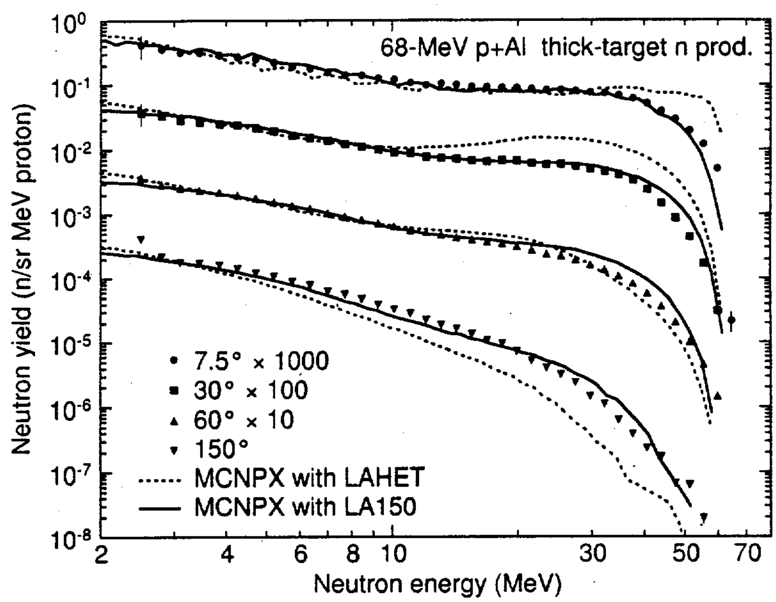

Figure 1: Thick target neutron production spectra for 68 MeV protons incident on aluminum [4] compared with calculations.