Photonuclear data evaluations at Los Alamos

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We have completed a number of new photonuclear evaluations for incident energies up to 150 MeV. These evaluations were based upon GNASH nuclear model calculations, and guided by available experimental data. To date, isotopes of C, Al, Ca, Fe, Cu, Ta, W, and Pb have been completed, and we plan to evaluate photonuclear reactions on O and Si shortly. The goal has been to provide a suite of evaluated libraries essential for simulations of photonuclear reactions on accelerator structural materials, bremsstrahlung conversion and spallation targets, and shielding materials. Certain photonuclear reactions are also important in astrophysical nucleosynthesis.

The GNASH calculations typically use absorption data as an input, and then predict secondary neutron, photon, and charged particle spectra, together with cross sections for (g,n), (g,2n), (g,3n) etc reactions. These calculated results were extensively checked against measurements, such as those compiled in Dietrich and Bermans compilation, or Varlamovs atlas. For a few rare case, such as reactions on carbon, and calcium, secondary double-differential emission spectra measurements exist for monochromatic photons. These data allowed us to validate our modeling of preequilibrium and equilibrium decay processes and our angular-distribution theory. Finally, the measurements of emitted neutron multiplicities from Saclay, by Lepretre et al, also provided a valuable test of the evaluated results.

Most of the evaluations use an ENDF MT5 format, representing the data for inclusive reactions in terms of the total nonelastic cross section (the absorption cross section), yields (or multiplicities) for secondary ejectiles and recoils, and spectra for these ejectiles. In the case of carbon, a slightly different approach was used where, in addition to MT5, the formats MT50 and MT600 were used to represent the important (g,n0) and (g,p0) reactions. These reactions were evaluated from experimental data, and included a Legendre-polynomial dipole description of the angular distributions.

In addition to evaluation work at Los Alamos, research has been undertaken by the MCNP group to expand the MCNP code to include a photonuclear capability, and to process the evaluated data for use by MCNP. This work has been led by Morgan White and Robert Little, with data processing work in an NJOY context by Robert MacFarlane. Great progress has been made and MCNP is now able to perform radiation transport with photonuclear reactions.

Morgan White has performed some MCNP calculations to simulate integral experiments of photoneutron production. Surprisingly, very few experiments seem to exist for neutron production from electron-bremsstrahlung reactions. One of the few careful experiments is that of Barber and George, from Stanford. Generally then MCNP calculations of neutron production per incident electron are in good agreement with the measurements.

We have also led the task of putting together various participant's contributions to the TECDOC. This is being done using LaTeX, and makes use of an extensive BiBTeX database of relevant citations. A large amount of editing and writing has been done. We expect to be able to complete this report in the coming year.