A METHOD FOR (N,ALPHA) AND (N,P) CROSS SECTION MEASUREMENTS USING A LEAD SLOWING-DOWN SPECTROMETER

by

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ABSTRACT

The need for nuclear data comes from several sources including astrophysics, stockpile stewardship, and reactor design. Photodisintegration, neutron capture, and charged particle out reactions on stable or short-lived radioisotopes play crucial roles during stellar evolution and forming solar isotopic abundances whereas these reactions can affect the safety of our national weapons stockpile or criticality and safety calculations for reactors. Although models can be used to predict some of these values, these predictions are only as good as the experimental data that constrains them. For neutron-induced emission of α particles and protons ((n,α) and (n,p) reactions) at energies below 1 MeV, the experimental data is at best scarce and models must rely on extrapolations from unlike situations, (i.e. different reactions, isotopes, and energies) providing ample room for uncertainty.

In this work a new method of measuring energy dependent (n,α) and (n,p) cross sections was developed for the energy range of 0.1 eV - ~100 keV using a lead slowing-down spectrometer (LSDS). The LSDS provides a ~10^4 neutron flux increase over the more conventionally used time-of-flight (ToF) methods at equivalent beam conditions, allowing for the measurement of small cross sections (μb's to mb's) while using small sample masses (μg's to mg's). Several detector concepts were designed and tested, including specially constructed Canberra passivated, implanted, planar silicon (PIPS) detectors; and gas-electron-multiplier (GEM) foils. All designs are compensated to minimize γ-flash problems. The GEM detector was found to function satisfactory for (n,α) measurements, but the PIPS detectors were found to be better suited for (n,p) reaction measurements. A digital data acquisition (DAQ) system was programmed such that background can be measured simultaneously with the reaction cross section. Measurements of the ^{147}Sm(n,α)^{144}Nd and ^{149}Sm(n,α)^{146}Nd reaction cross sections were performed as proofs of concept. The measurement of ^{147}Sm verified and extended a previous measurement while the measurement of ^{149}Sm is the first over the majority of the 0.1 eV to 100 keV energy region.