Improving Our Understanding of Explosive Nucleosynthesis by Measuring (n,α) Cross Sections

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Little is known about the details of the origin of the proton rich isotopes of the intermediate and heavy elements (the so-called *p* isotopes, e.g. ^{92}Mo, ^{96}Ru, ^{102}Pd, ^{106,108}Pd, ^{112}Sn, ...). In general, the *p* isotopes are thought to be produced during stellar explosions (in novae and/or supernovae), either through a series of photodisintegration reactions starting from seed material built up during previous nucleosynthesis processes, or through a chain of charged particle capture reactions on lighter elements. However, the details of how and where the *p* nuclei are synthesized are very uncertain. A better understanding of their origin should lead to better models of novae and supernovae explosions and would also impact related areas such as the origin of isotopic anomalies in meteorites and the formation of the solar system.

A large part of the uncertainty regarding the origin of the *p* isotopes is due to the fact that most of the rates for the nuclear reactions governing the nucleosynthesis flow which produces these nuclides are poorly constrained. In particular, (γ,α) and (*p*,α) reactions constitute some of the most important links in the nucleosynthesis chain thought to be responsible for their origin. However, it is very unlikely that the rates for these reactions will be determined by direct experiments and they are also currently very poorly constrained by theory (because of our poor knowledge of the α-nucleus optical potential, which forms a crucial part of the nuclear statitical model used to calculate these rates).

As explained in the last progress report, the uncertainties in the (γ,α) and (*p*,α) reaction rates could be reduced considerably by making a series of (*n*,α) measurements at ORELA. We expect to begin taking data in early 1999. In preparation for the experiments, we have compared calculated cross sections from the updated, state-of-the-art statistical model code "Non-Smoker"[3] to previous calculations[4,5]. The results, shown in figure 1 reveal a systematic difference between the new and older calculations. The general trend of the newer calculated cross sections to be systematically larger than the older calculations as the mass number increases is thought to be mainly due to differences in the alpha-nucleus potentials in the models. This comparison between calculated cross sections indicates that (*n*,α) measurements at ORELA will be sensitive to the poorly constrained α-nucleus optical potential; hence, these measurements should help to significantly reduce the uncertainties in explosive nucleosynthesis calculations.

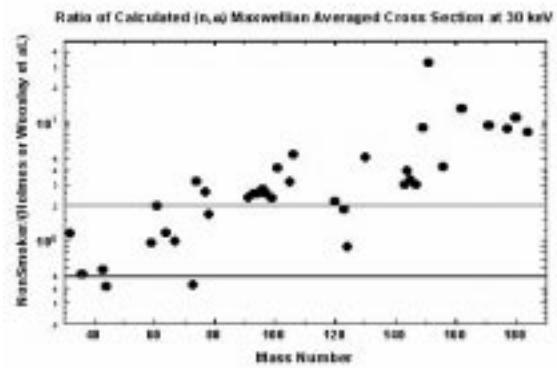

Figure 1: Ratio of calculated 30-keV Maxwell-averaged (n,α) cross sections.

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