Elastic scattering of ^{13}C at 12 MeV/n on ^{27}Al

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X-ray bursts are the most frequent thermonuclear explosion occurring in the universe and represent one type of phenomena responsible for heavier element nucleosynthesis. For this reason and others, a number of powerful X-ray observatories have been used to take large amounts of data on these bursts. The interpretation of these observations, however, is problematic due to the lack of a complete understanding of the nuclear physics at the base of these phenomena [1].

Among the various processes occurring in X-ray bursts, the most important is the rp-process. It is dominated by (p, γ), (α, p) reactions and β-decays. Critical nuclear data is needed related to these processes such as: nuclear masses, β-decay rates and reaction rates. There have been major strides made for the first two parameters. However, as most of the nuclei participating in the rp-process do not exist as stable nuclei, most of the reaction rates, so far, have only been estimated based on theory [2].

As with any nuclear reaction network, some reactions are more important than others. Several have been suggested for X-Ray bursts following different model calculations. One such reaction that we chose to research is the radiative proton-capture reaction $^{27}Si(p, \gamma)^{28}P$. The goal is to determine its rate using a re-accelarated radioactive beam of ^{27}Si from the Cyclotron Institute T-Rex upgrade and the MDM spectrometer.

However, until such a beam is available we intend to study the mirror reaction $^{27}Al(n, \gamma)^{28}Al$ with the purpose of using the properties of the mirror nucleus ^{28}Al in the estimation of the reaction rate. A secondary motivation is to look for new structure information on ^{27}Al and ^{28}Al. The asymptotic normalization coefficients will be obtained from the DWBA analysis of the measured angular distributions of the transfer reaction $^{27}Al(^{13}C,^{12}C)^{28}Al$. For that we need to know the optical potential parameters for the elastic scattering channel.

For that purpose, in the last year we have done two experiments. Both times, we used a beam of ^{13}C at 12 MeV/u on targets of ^{27}Al of different thicknesses (100 μg/cm^2, 270 μg/cm^2 and 800 μg/cm^2) and measured the elastic and inelastic scattering at a total angular range of 4 to 42 degrees in the laboratory system. The primary beam was accelerated by the K150 cyclotron at Texas A&M University. Then the reaction products were separated using the Multipole-Dipole-Multipole (MDM) spectrometer and were observed with the Oxford focal plane detector.

Preliminary results can be seen in the figures below. Fig. 1 shows the angular distribution of the cross-section in the lab system for the elastic scattering. Fig. 2 shows a comparison between the previous data and the distributions for two inelastic states where you can see the expected phase relationship. However, analysis is still ongoing as we are having issues resolving the peaks corresponding to the various excited states at larger angles where we sacrificed resolution for higher production rate by using a thicker target.

The measurement of the transfer reaction is planned for the second half of 2014.

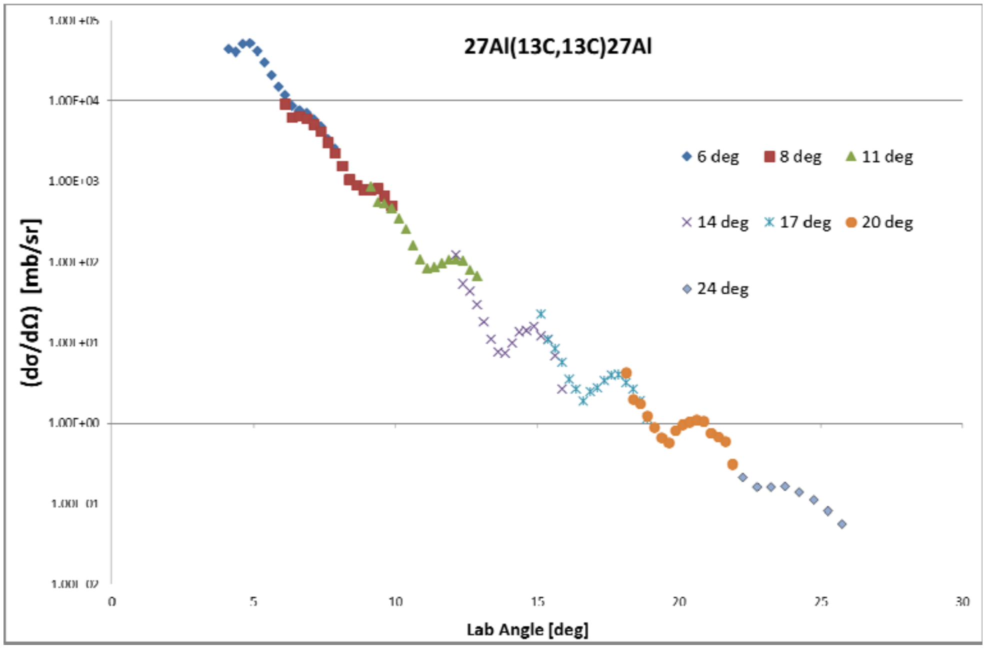

FIG. 1. Measured angular distribution of the elastic scattering cross section.

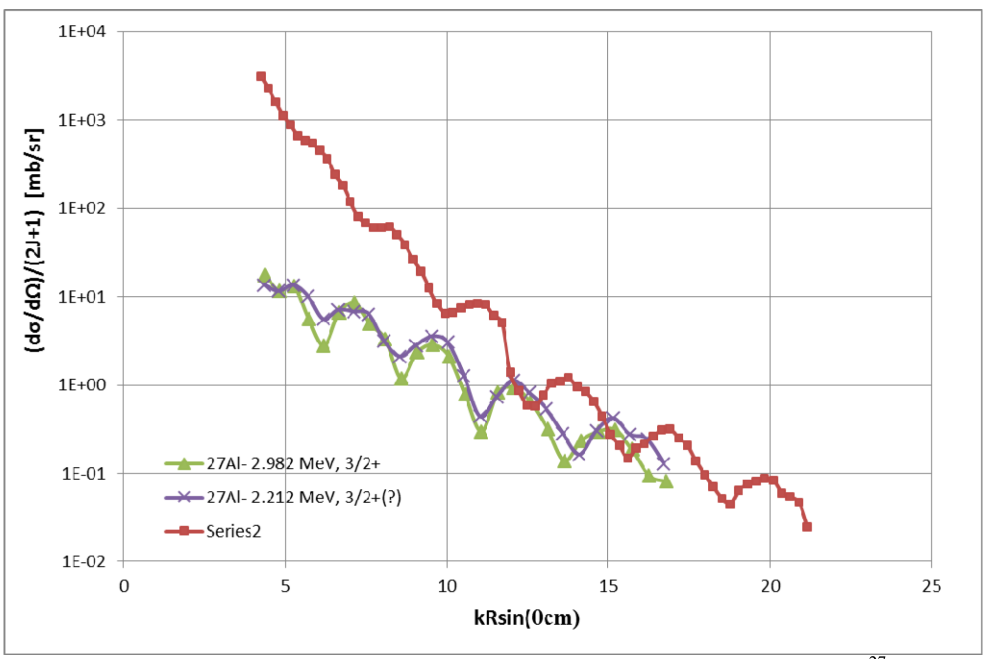

FIG. 2. Measured angular distributions for the elastic and inelastic scattering on ^{27}Al in the CM system.

[1] H. Schatz, Prog. Part. Nucl. Phys. **66**, 277 (2011).

[2] H. Schatz and K.E. Rehm, Nucl. Phys. **A777**, 601 (2006).