Extracting the ANC for $^{23}\text{Al} \rightarrow ^{22}\text{Mg} + p$ from Its Mirror System $^{22}\text{Ne} \rightarrow ^{22}\text{Ne} + n$

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The 1275 keV gamma-ray from the decay of the long-lived ($T_{1/2} = 2.61$ yr) $^{22}\text{Na}$ nucleus, supposedly synthesized during nova explosions via the rp-process in the Ne-Na cycle as in Fig. 1, was not observed in satellite gamma-ray telescopes such as COMPTEL. One suggested explanation is that the precursor $^{22}\text{Mg}$ can be depleted by the radiative proton capture reaction $^{22}\text{Mg} (p, \gamma) ^{23}\text{Al}$ [1]. The rate of this reaction is not precisely known. We plan to determine this rate with an indirect method using transfer reactions [2]. The normal candidate is a proton transfer reaction, but since the radioactive $^{22}\text{Mg}$ beam is not easily available, the $(^{22}\text{Mg}, ^{23}\text{Al})$ reaction is replaced by the neutron transfer reaction $(^{22}\text{Ne}, ^{23}\text{Ne})$. The structure of the ground state and first exited state in $^{23}\text{Ne}$ is studied and then transposed to the corresponding states of the mirror nucleus $^{23}\text{Al}$. The analysis will be done by extracting the asymptotic normalization coefficients (ANCs) using the charge symmetry and following the same procedure as in $(^7\text{Li}, ^8\text{Li})$ reaction [3].

**Figure 1.** Section of the chart of nuclides representing nuclear reactions and $\beta$-decays included the rp-process (NeNa cycle). The stable nuclei in the cold cycle have been shaded.

Two experiments using a 264 MeV $^{22}\text{Ne}$ beam from the K500 superconducting cyclotron were carried out so far. The MDM spectrometer was used to study detailed angular distributions for the elastic scattering and for the neutron transfer reaction $^{12}\text{C} (^{22}\text{Ne}, ^{23}\text{Ne})^{12}\text{C}$. The bombarding $^{22}\text{Ne}^{14}$ beam impinging on a 100 $\mu$g/cm$^2$ $^{13}$C target located in the target chamber. The Oxford detector was filled with pure isobutane gas at 50 torr. The detector consists of an ionization chamber to measure the energy loss inside...
the ionization chamber, four resistive wires to determine position at various depths in the chamber, and a plastic scintillator sitting 42 mm behind it to determine the residual energy. An angle mask consisting of five opening slits 0.77° apart and 0.1° wide was used to perform the position and angle calibration by comparing the elastic scattering of $^{22}\text{Ne}$ beam on a 300 µg/cm$^2$ $^{197}\text{Au}$ target with Raytrace calculations. During measurements a 4° x 1° window was used to accept the reaction products in the spectrometer, and the position in the focal plane and target angle are reconstructed using raytracing. A new acquisition ROOT code was written and checked to replace the code Goosy (used before on the VAX-VMS acquisition system which was retired recently).

In the first experiment, in September 2003, we tested our ability to measure the elastic scattering of $^{22}\text{Ne}$ on $^{13}\text{C}$ and the neutron transfer reaction. The results showed that we can clearly separate $^{22}\text{Ne}$ from $^{23}\text{Ne}$, but that special care is needed at larger angles due to their close bp. We determined that we need to enlarge the entrance window of the Oxford detector to ensure full efficiency of the detector at large angles. Another experiment was performed in May 2004. We succeeded to make elastic scattering on $^{12}\text{C}$ and $^{13}\text{C}$ targets and transfer reaction measurements on $^{13}\text{C}$ target at four MDM positions, equivalent to the angular range $\theta_{\text{C.M.}} = 3^\circ-32^\circ$. The preliminary angular distribution for neutron transfer to the ground state in $^{23}\text{Ne}$ is shown in Fig. 2. More measurements need to be done for full elastic scattering angular distribution, which will determine the optical potential parameters that will be used in DWBA calculations.

![Figure 2](image)

**Figure 2.** The yield of the reaction $^{13}\text{C}(^{22}\text{Ne},^{23}\text{Ne})^{12}\text{C}$ measured at 3, 5 and 7 deg. The x-axis represents the angle in channels. Preliminary.