Resonance states in ^{22}Mg for reaction rates in the rp-process

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Explosive nuclear hydrogen burning at high temperature conditions on the surface of accreting white dwarfs is dominated by the hot CNO cycles [1]. Explosive hydrogen burning on the surface of accreting neutron stars leads to considerably higher temperatures and break-out from the hot CNO cycles triggers the rp-process [2, 3]. Network calculations are well capable of qualitatively reproducing characteristics of these phenomena. Their auantitative interpretation, however, requires a better understanding of the nuclear processes during these explosive events by the measurement of reaction rates and structure of unstable, proton rich nuclei [4]. Even though new facilities are now able to directly measure relevant reaction rates by using radioactive beams and reversed kinematics, these challenging measurements will also benefit from level structure information with precise excitation energies in the resonance regions of interest.

Motivated by the need of spectroscopic data to better understand the rp-process, we developed a new experimental method using the Grand Raiden magnetic spectrometer to study proton rich nuclei with ^{4}He induced reactions [5]. The separation of the beam and the reaction products at 0° in a magnetic spectrometer is based on differences in their magnetic rigidity Bρ. For the (^{4}He,^{6}He) reaction, the Bρ difference is about 5% with the beam being less rigid. In order to stop the beam and integrate the current, a new Faraday cup was installed inside, near the exit of the frst dipole of the spectrometer. The reaction products continue to travel through the spectrometer and are measured in a focal plane detector system. Three plastic scintillators, 1 mm, 10 mm, and 10 mm thick, mounted behind the two vertical drift chambers allowed particle identification, time of flight measurements, and light particle rejection. Typical beam currents were 200 nA. For best vertical scattering angle definition, the spectrometer was used in overfocus mode which allows reconstruction of the vertical component of the scattering angle from the measured vertical position in the focal plane.

For good resolution in momentum and horizontal scattering angle component, full dispersion matching was applied [6]. The energy spread in the 0.7 mg/cm^2 target, the large Q-value, and limitations in the angle difinition have limited the best resolution to 50 keV so far. The measured energy spectrum of the ^{24}Mg(^{4}He,^{6}He)^{22}Mg reaction at 206 MeV and 0°, shown in Fig. 1 was used to determine excitation energies of high-lying states. The spectrum is corrected for several spectrometer aberrations and represents the data of

scattering angles smaller than 1° so that states with low angular momentum transfer are enhanced. The resolution is about 55 keV in Full Width at Half Maximum (FWHM) and allows the identification of levels up to about 12 MeV in the excitation energy. In order to calibrate the momentum spectrum, all well separated known low-lying levels in ^{22}Mg and ground states of ^{14}O and ^{10}C from oxygen and carbon contaminations were used at two magnetic field settings to calibrate the complete focal plane. The calibration is linear with a small quadratic term. The standard deviation of all 22 calibration levels from the calibration is 8 keV. The backgrounds from oxygen and carbon were separately measured with a Mylar (oxygen and carbon) and a pure carbon target, and were subtracted by normalizing to the yields of ^{14}O and ^{10}C ground states. Detailed nalyses includind spin and parity assignments are in progress refering angular distributions at forward three angles.

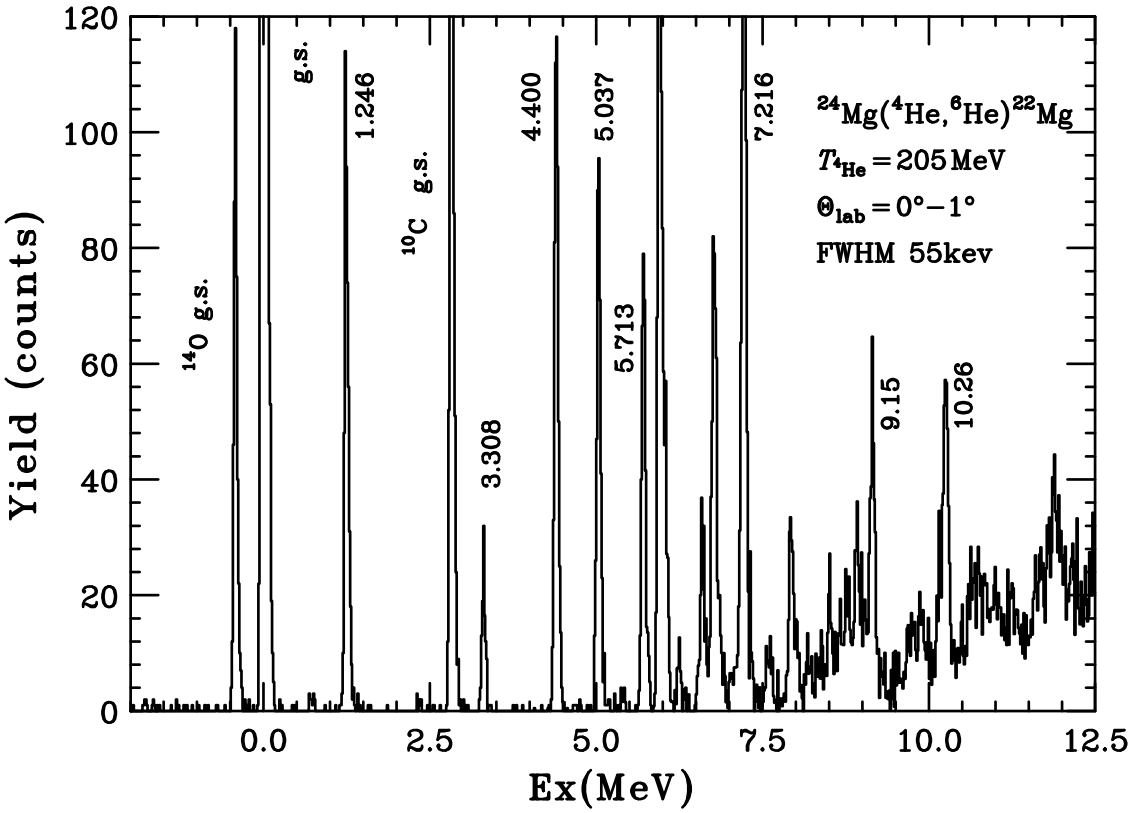

Figure 1: ^{22}Mg spectrum with angle cut 0 - 1° and a resolution of 55 keV.

References

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