E415

Stellar neutron sources and the s-process in massive stars (II)

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Running Time: A total of 7 days running time is requested of which 2½ days are needed for cyclotron optimization (momentum spread), beam line matching, and spectrometer setup, 2½ days for production runs (including the time needed for mode changes), one day for normalization using a ^{16}O target and background measurements on Be and C backings and one day for ^{6}Li elastic scattering.

Beam Line: Dispersive WS beam line and Grand Raiden Spectrometer in three modes (0° mode, Faraday cups behind Q1 and in scattering chamber).

Beam Requirements: Particle type and energy: ^{6}Li of 110 MeV
Beam intensity and energy spread: A maximum of 100 pnA is required,
Beam energy spread of the order of 100 keV or better.

Other requirements: Single turn halo-free beam, fully dispersion-matched beam on GR target.

Special Equipment required: Only existing and standard GR and focal plane equipment is needed.

Target Budget: implanted ^{22}Ne target will be prepared at the University of Bochum (no costs)
Be and C backings ($1200) have been purchased by Notre Dame

1 Summary of the Proposal

• **Proposed Experiment**: Measurements of (^{6}Li, d) on ^{22}Ne with astrophysical motivation are proposed using the WS course and Grand Raiden(GR). The ^{6}Li beam of 110 MeV will be provided by the coupled cyclotrons. The beam energy will allow to inject a $^{6}Li^{2+}$ beam from the ion source to provide a beam intensity of 100 pnA. GR will be used in three Faraday cup modes including the 0° mode with a Faraday cup inside dipole D1. This experiment is part of an astrophysics program at RCNP. It aims at resonance states above the α-threshold around 10 MeV excitation energy and is only possible with a high-resolution spectrometer since a resolution of ≤40 keV is required to resolve high-lying excited levels in the final nucleus.

• **Targets**: The ^{22}Ne target will be produced by ion implantation into a thin Be backing. For implantation energies of ≤ 160 keV a target thickness of ≈20 keV can be achieved for a ^{6}Li beam of 110 MeV, a significant improvement compared to a previous experiment (E379), where a gas cell with Aramid entrance and exit windows has been used (see discussion in Sect. 3). A ^{16}O target (Ta_2O_5) is needed for cross section normalization. In addition, a thin (100 μg/cm^2) C target will be used during dispersion matching.

• **Apparatus and Beam Properties**:
The WS course in dispersive mode and the Grand Raiden spectrometer with the standard VDC focal plane detector system will be used. A stack of two 10 mm thick ΔE plastic scintillator will provide energy loss and timing signals for particle identification.

• **Beam time Request**:
The total beam time request of 7 days will be used as follows:
a) 2 ½ days for beam preparation, detector and particle identification verifications, ion-optical setup and dispersion matching as well as energy calibration of the focal plane.
b) 3 ½ days for measurements with the ^{22}Ne target, the normalization of the cross section using a ^{16}O target and for background measurements.
c) 1 day to measure ^{6}Li elastic scattering at angles ≥ 6°.

2 Scientific Motivation

Potential stellar neutron sources for the s-process in massive stars are associated with α-capture reactions on light nuclei, such as ^{13}C and ^{22}Ne. The reaction ^{22}Ne(α,n) is of particular importance for the neutron production in massive Red Giant stars during core helium burning and in AGB star during helium shell burning. The cross section of this reaction at stellar energies as well as of the competing capture reaction ^{22}Ne(α,γ) are dominated by the contribution of low energy, natural parity resonances [1]. Considerable effort has been made in the past to measure the low energy resonances in ^{22}Ne(α,γ) [2] and ^{22}Ne(α,n) [3] to determine their impact on the channel branching and the overall efficiency of the neutron sources in the stellar environment. There are a number of low energy resonances which have not yet been measured because of the extremely small cross sections. Therefore only limited experimental information is available on these states