Contribution ID: **133** Type: **Poster**

The energy levels of 21Ne and the s-process in rapidly rotating metal poor stars

Thursday, 23 September 2021 15:30 (2 hours)

Observations of Ultra Metal Poor stars such as HD 221170 [1] show that the abundances of elements heavier than silver can be reliably predicted by models of nucleosynthesis. However, elements between iron and silver have much higher observed abundances than predicted by models which only consider the 'normal' r- and s-processes. A potential solution for these underestimates is an extension of the s-process to rapidly rotating metal poor stars. Whether or not these stars contribute significantly to the abundances of the lighter heavy elements depends on several nuclear reactions; of specific interest is the ratio of 17O(α,n)20Ne to 17O(α,γ)21Ne [2]. This ratio is important as it determines the efficiency of the s-process in these stars. However, the cross section is too low to measure directly which means we must calculate the rate based on the parameters of the relevant states.

When calculating the rates of these reactions, the spin-parities of nuclear energy levels are important as rates of reaction depend upon them. Several states within the Gamow window in neon-21 have unknown spin-parities and this is a significant source of uncertainty in the model predictions [3]. In order to address this, an experiment in direct kinematics was conducted using the Enge split-pole spectrograph at the Triangle Universities Nuclear Laboratory (TUNL) [4]. A second experiment was later carried out in inverse kinematics at Argonne National Laboratory (ANL) using the HELIOS spectrometer. The aim of these experiments was to determine the unknown spin-parities relevant for nuclear astrophysics as well as constraining the neutron widths of the relevant states, via a study of the 21Ne(d,p) reaction; in both direct and inverse kinematics. The angular distribution for each state was determined and compared with Distorted-Wave Born Approximation predictions. The astrophysical motivation behind the experiment, results of the TUNL experiment and details of the ongoing analysis of data from HELIOS will be presented.

This material is based upon work supported by the U.S. Department of Energy, Office of Science, Office of Nuclear Physics, under Contract Number DE-AC02-06CH11357 and under Grant No. DE-SC0017799 and Contract No. DE-FG02-97ER41041. Also, from the Fonds de la Recherche Scientifique-FNRS under Grant No IISN 4.4502.19, the ChETEC COST Action (CA16117), supported by COST (European Cooperation in Science and Technology), the IReNA AccelNet Network of Networks, supported by the National Science Foundation under Grant No. OISE-1927130 and from the World Premier International Research Centre Initiative (WPI Initiative), MEXT, Japan. This research used re- sources of ANL's ATLAS facility, which is a DOE Office of Science User Facility.

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Session Classification: Poster Session 2

Track Classification: Nuclear Astrophysics