UNIVERSITY OF NOTRE DAME
DEPARTMENT OF PHYSICS

NUCLEAR SEMINAR

Monday, March 6

From neutrino oscillations to stellar nucleosynthesis: Recent measurements of the $^{13}C(\alpha,n)^{16}O$ reaction at ND and ORNL

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The $^{13}C(\alpha,n)^{16}O$ reaction is of broad interest to both nuclear physics and applied nuclear science communities. Ranging from the s-process and stellar nucleosynthesis, to a dominate background source for large scale reactor and geo-neutrino detectors, and also constraining the important $^{16}O(n,\alpha)^{13}C$ cross section needed for advanced reactor modeling and materials recycling[1]. This talk will focus on two recent measurements of the $^{13}C(\alpha,n)^{16}O$ reaction ranging from 0.4 to 6.5 MeV performed at the University of Notre Dame and Oak Ridge National Laboratory. An emphasis will be given to the enabling advances in neutron detection technologies which made these measurements possible.

The $^{13}C(\alpha,n)^{16}O$ reaction serves as the dominant source of the neutrons for the slow neutron capture (s-process). Approximately half of the elements from Fe to Bi along the line of β-stability are synthesized via stellar nucleosynthesis in asymptotic giant branch stars. Previous measurements are thought to have exhausted above-ground attempts to measure this important cross section near the Gamow window[2]. Presently, there is a worldwide effort at many current and future underground laboratories to continue these measurements in a low-background environment. In this study, we will present on a recent above-ground measurement using a novel dual readout liquid scintillator approach performed at the Multicharged Ion Research Facility (MIRF) located at Oak Ridge National Laboratory. The use of such detectors permits a quasi-spectroscopic approach where events can be gated according to their recoil ion spectrum measured in the liquid scintillator bars. This effectively improves the signal to background by allowing for discrimination based on kinematics. Preliminary results from the recent measurement campaign at MIRF will be presented as well as a discussion on the advantages and challenges of this approach.

In addition to its astrophysical importance, the $^{13}C(\alpha,n)^{16}O$ reaction serves as a background in measurements of reactor and geo-neutrinos. In the detection of reactor and geo-neutrinos, the large organic liquid scintillator detectors used for such measurements naturally contains approximately 1.1% ^{13}C. Alpha emitting radionuclide impurities present in the liquid such as ^{210}Po can induce $^{13}C(\alpha,n)^{16}O$ reactions which are often indistinguishable from a true antineutrino signal [3]. The 2.2 MeV Q-value of the $^{13}C(\alpha,n)^{16}O$ reaction permits neutron production from the population of the ^{16}O ground state as well the higher excitation states over the range of alpha energies present from the radionuclide impurities. A neutron spectroscopic study of the $^{13}C(\alpha,n)^{16}O$ reaction between E_α = 3.5 - 7.5 MeV performed at the University of Notre Dame Nuclear Science Laboratory will be presented. Results showing the contributions of ground and excited state components to the total cross section will be given and their implication to reactor and geo-neutrino measurements will be discussed.

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[1] http://www.oecd-nea.org/dbdata/hprl/tmp//hprl-20170301-030304.html
[2] M. Heil, et al., Phys. Rev. C 78 025803 (2008)
[3] S. Harissopulos, et al, Phys. Rev. C 72, 062801 (2005)

4 pm – 5 pm

Nuclear Science Laboratory

124 Nieuwland Science Hall

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All interested persons are cordially invited to attend

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Refreshments will be served prior to the seminar in room 124