International Nuclear Physics Conference INPC2013: 2-7 June 2013, Firenze, Italy

Virtual Neutron Method applied to the study of $^{17}O(n,\alpha)^{14}C$ reaction

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The reaction ^{17}O$(n,\alpha)^{14}$C was studied using virtual neutrons coming from the quasi-free deuteron break-up in the three body reaction ^{17}O$+d \rightarrow \alpha+^{14}C+p$. This technique, called virtual neutron method (VNM), extends the Trojan Horse indirect method to neutron-induced reactions [1,2].

The reaction is interesting for both nuclear energy and nuclear astrophysics. In fact, in nuclear reactors the neutron induced reactions on ^{14}N and ^{17}O are the dominant sources of the radioactive isotope ^{14}C ($T_{1/2}$=5730 yr) [3]. In nuclear astrophysics, this reaction takes place in the nucleosynthesis of heavier elements in various astrophysical scenarios [4,5], and it could also help to explain anomalies in ^{18}O/^{16}O and ^{17}O/^{16}O ratios found in asymptotic giant branch stars and in circumstellar Al_2O_3 meteorite grains [6].

For incident neutron energies from thermal up to a few hundred keV, the cross section of this reaction is characterized by the presence of several narrow resonant states in the ^{18}O compound nucleus. Direct measurements [7-9] have shown the population of two out of three expected excited states at energies 8213 keV and 8282 keV and the influence of the sub-threshold level at 8038 keV. The 8125 keV state of ^{18}O would be populated by f-wave neutrons, but due to the high orbital momentum barrier, the cross section is too low for direct measurement. The reaction rate calculated at the astrophysical relevant temperatures (T$\in [0.01-1.3]\cdot 10^9$ K) by using the available data sets [7-9] differ by a factor 2-2.5, with a consequent change in the abundance ratios for some elements (e.g. ^{22}Ne, ^{26}Mg) [4].

In the present experiment the ^{18}O excited state at $E^* = 8.125$ MeV is observed in VNM experiments and the angular distributions of the populated resonances have been measured for the first time. The results unambiguously indicate the ability of the method to overcome the centrifugal barrier suppression effect and to pick out the contribution of the bare nuclear interaction. The astrophysical consequences of the present results will be discussed in the presentation.

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