SEARCH FOR THE 180-keV RESONANCE IN ^{17}O$(p,\gamma)^{18}$F

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Observations of the ^{17}O/^{16}O isotopic abundance ratio in the atmospheres of red giant stars are a sensitive test for models of stellar mixing and convection. Measurements of the ^{17}O/^{16}O and ^{18}O/^{16}O ratios in pre-solar meteoritic grains have been used to determine the age of the Galaxy, as well as to test stellar mixing models. Interpretation of these isotopic ratio measurements is confused by uncertainties in the rates of the ^{17}O$(p,\alpha)^{14}$N and ^{17}O$(p,\gamma)^{18}$F nuclear reactions. One significant source of uncertainty is a resonance in ^{17}O$+p$ at a center of mass energy of 180 keV, corresponding to a known 2^- level in ^{18}F at an excitation energy of $E_x = 5786$ keV. The total width, as well as the proton, gamma and alpha partial widths, of this state are uncertain, which results in a change to the ^{17}O$(p,\alpha)^{14}$N and ^{17}O$(p,\gamma)^{18}$F reaction rates by as much as a factor of 100 in the relevant temperature range $T = (80 - 400) \times 10^6$ K.

We have performed measurements of the ^{17}O$(p,\gamma)^{18}$F cross section at Triangle Universities Nuclear Laboratory using a proton beam at energies near the 180-keV resonance. The highly-enriched ^{17}O targets that were used consisted of an oxidized layer of Ta_2O_5 on a tantalum substrate. The oxide layer was sufficiently thick to stop the incident protons. The γ-ray yield was measured using a large (140%) high-purity germanium detector in close geometry to the target.

The 5785-keV state of interest decays by gamma emission primarily to the lower energy 937-keV (3^+) and 1080-keV (0^-) states in ^{18}F. In particular we searched for the 4848-keV and 4705-keV primary gamma transitions to these lower lying states. Measuring the capture gammas allows us to distinguish resonant capture from the 5785-keV state from direct capture (or capture from lower energy resonances) by the detected γ-ray energy. The yield from the 180-keV resonance is also expected to be larger than the yield from other resonances or direct capture.

A portion of a γ-ray energy spectrum taken at a proton beam energy of 220-keV is shown in Fig. 1. The location of the expected 4705-keV and 4848-keV capture γ-ray lines are indicated. We found no evidence for either transition. Analysis is still in progress, but no other ^{18}F γ-ray lines are apparent in the data. We do observe resonant capture to states in ^{19}F from the small amount of ^{18}O in the target. Preliminary results for the (p,γ) resonance strength of the 5785-keV state indicate that $(\omega\gamma)_{p\gamma} < 3$ μeV for a 2σ upper limit. The 180-keV resonance does not contribute substantially to the ^{17}O$(p,\gamma)^{18}$F reaction rate with this upper limit on the resonance strength. It is possible that this state could still contribute to the ^{17}O$(p,\alpha)^{14}$N reaction rate if $\Gamma_\alpha \gg \Gamma_\gamma$, but this is unlikely based on theoretical expectations. Additional measurements are planned next year which will place firm limits on the strength of the 180-keV resonance in ^{17}O$(p,\alpha)^{14}$N.

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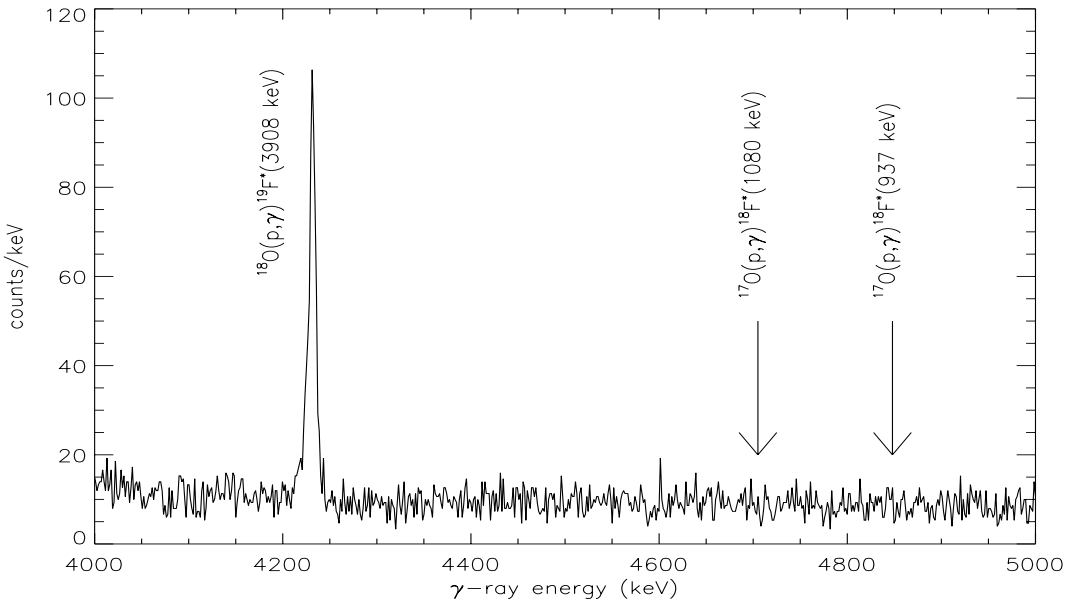

Figure 1: Gamma-ray energy spectrum taken with a 220-keV proton beam on a thick Ta_2O_5 target that was highly enriched in ^{17}O. The integrated charge on target was 0.5 C.