COULOMB EXCITATION OF ^{19}Ne: PRELIMINARY RESULTS AND CONSEQUENCES

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A significant uncertainty in the evolution from the hot CNO cycle to higher-Z burning in explosive astrophysical burning processes (e.g. x-ray bursters, novae) is that the relevant nuclear reactions are not well understood at the low energies encountered in the stellar environment. One of these reactions is α capture on ^{15}O to give ^{19}Ne and break out to subsequent proton capture reaction (*rp*-process). The study of this reaction motivates current and proposed radioactive beam development projects. The reaction rate is dominated by the 4.033 MeV $3/2^+$ state in ^{19}Ne, and since the gamma width of this state is large, i.e. $\Gamma_\gamma >> \Gamma_\alpha$, the astrophysical reaction rate depends only on the alpha width Γ_α of this state. This state decays primarily by gamma decay but has a very small α branch. Several groups are attempting to measure the branching ratio $\Gamma_\gamma/\Gamma_\alpha$ [1]. The goal of our experiment was to measure the gamma width, Γ_γ, so that this information along with the measured α-γ branching ratio could be used to calculate Γ_α.

The experiment was a standard secondary-beam Coulomb-excitation experiment [2]. A 100 MeV/u ^{20}Ne beam impinged on a Be production target. ^{19}Ne fragments with a nominal energy of 55 MeV/u were selected with the A1200 separator. A total of 9.3×10^9 particles were incident on a 518 mg/cm^2 Au target. Beam particles deflected by <5 deg were detected in a phoswich scintillator for particle identification by time-of-flight and ΔE. Gamma rays were detected with the NaI barrel, at the time comprising 28 active position-sensitive detectors; their gains were matched out-of-beam with standard sources. The in-beam and high-energy gain stability was confirmed with "off-prompt" γ rays (i.e., time correlation with the beam indicated that they originated from reactions with the phoswich detector or from room background). The Doppler-shift correction was fine-tuned with lines from the γ decay of a 1.536 MeV $3/2^+$ state in ^{19}Ne [3].

In addition to the 4.033 MeV γ line from the $3/2^+$ state of primary interest, it was also expected that a line at 4.362 MeV should be observed from a higher-lying $5/2^+$ state. Both states would be populated by E2 virtual photons. Other lines from E1 excitations were also possible, as well lines from lower-lying states or from branches from ~4 MeV states to ~1.5 MeV states. At relative high E_γ, the γ spectrum for a single ~4 MeV line would show as much yield in the first- and second-escape peaks as in the total-absorption photopeak. In order to analyze the γ data in detail, spectra from GEANT simulations of isotropic center-of-mass-frame emission of all expected lines were fitted to the measured γ histograms [3]. An example of such a best-fit over a limited range of the spectrum is shown

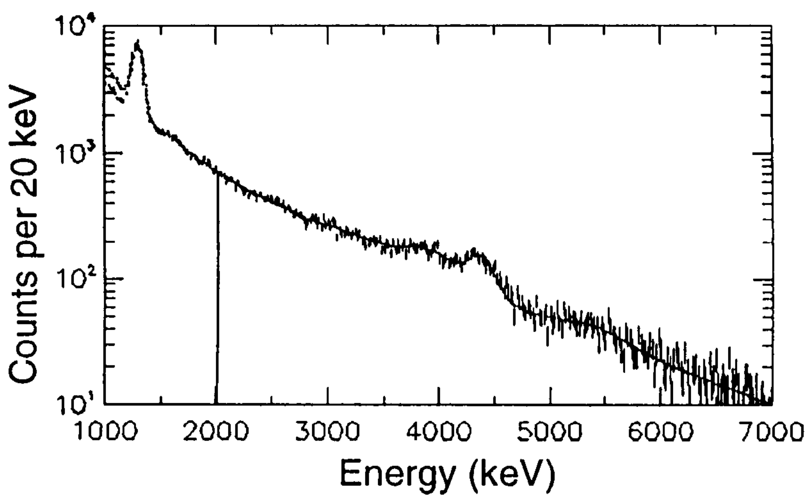

Figure 1. ^{19}Ne spectrum (data points) and best-fit function (range 2000 to 7000 keV) comprising exponential backgrounds and GEANT simulated spectra as described in the text. Dominant features are the 4362 keV line from the $5/2^+$ 4.6 MeV state and a 1298 keV line from the $3/2^+$ 1.6 MeV state.

in Figure 1. In this case, simulated spectra for lines from a single state were summed with the appropriate branching ratios as reported in Table of the Isotopes Vol. 8, and the overall normalizations of these summed spectra were fit to the data. The fit includes two exponentially-decaying backgrounds and a Gaussian at ~5.3 MeV. This latter structure may be unresolved decay from a number of >5 MeV states for which no γ data is currently known. A simulated fixed-source ^{88}Y spectrum is compared to out-of-beam calibration data in Figure 1. There are some problems with the simulation in the Compton edge, but the yields in the photopeaks are consistent within the statistics of the simulation.

We find that there is no statistically significant yield in the 4.033 MeV state. Preliminary results for this and other states are reported in Table I. The limit of 0.4 e^2fm^4 is much less than 60±30 e^2fm^4 one would estimate from the lifetime of the analog state at 3.901 MeV in ^{19}F [3] assuming pure electric quadrupole decay. If instead the decay of the ^{19}F state is pure M1, the B(M1) for the ^{19}Ne analog state would be $(3\pm2)\times10^{-2}$ μ_N^2, which is consistent with the upper limit of B(M1)<0.57 μ_N^2 calculated from the cross section. We conclude that M1 decay dominates the decay of theses analog states and that the B(E2) is negligibly small. Detailed analyses are in progress. This work was supported by the National Science Foundation under contract PHY-9528844. G.H. also acknowledges support from the University of Kansas General Research Fund.

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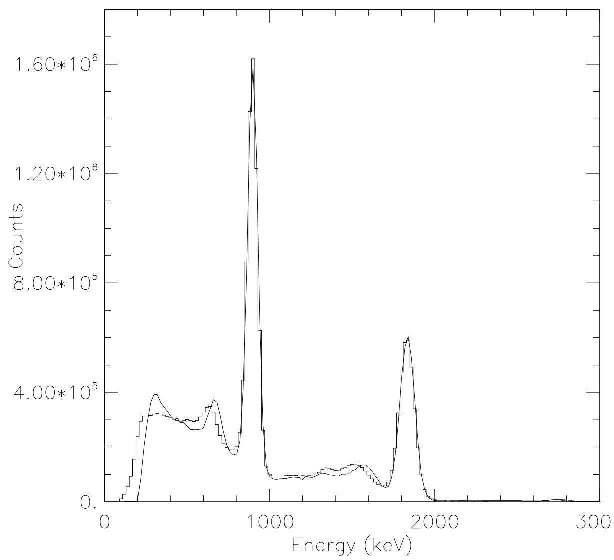

Figure 2. ^{88}Y source spectrum (histogram) and GEANT simulation (curve). This is not a fit; there are no free parameters. The simulation was normalized for source strength and live time during the calibration run.

References

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Table I. Preliminary cross-sections for ^{197}Au(^{19}Ne,γ^{19}Ne)^{197}Au @ E_{ave}=41 MeV/u and B(E2) assuming no mixing. Errors are 1σ and purely statistcal; the upper limit is 2σ.

J^π	E (MeV)	σ (mb)	B(E2) (e^2fm^4)
$3/2^+$	1.536	24.1(3)	81(1)
$3/2^+$	4.033	<0.01	<0.4
$5/2^+$	4.600	4.3(3)	20(2)