Investigation of the Two Proton Decay of ^{17}Ne $^\diamond$

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It has already been reported [1] that the experimental evidence for the long-searched two proton decay (2p-decay) mode of the first excited state in ^{17}Ne reported in [2] could not be confirmed in a new experiment designated to increase energy resolution as well as statistics and to allow a clearer separation from background processes. This experiment was described in the previous annual report [1]. Fig. 1 shows the final 2p-decay energy spectrum of ^{17}Ne following the Coulomb excitation of the radioactive ^{17}Ne beam with (60A*MeV) on a ^{197}Au target.

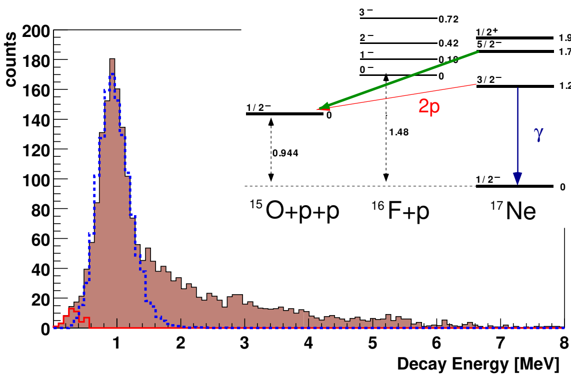

Fig. 1: Decay Energy Spectrum

The peak around $\simeq$ 900 keV corresponds to sequential 2p-decays from the $\frac{5}{2}^-$ state in ^{17}Ne to the ground state of ^{15}O. The dashed line represents the Monte Carlo simulation performed to reproduce the data. The simulation included the decay mechanism, the involved states, kinematic processes such as Coulomb deflection in the target and angular straggling of the decay products in the detectors, the geometry of the setup, and the measured detector resolutions and beam properties. Decays from the higher - lying $\frac{5}{2}^+$ state in ^{17}Ne were included in order to get a proper estimate of the tail of the peak. The energy of the $\frac{5}{2}^-$ state was varied in steps of 10 keV and than the χ^2 minimization method was used to determine the energy of the $\frac{5}{2}^-$ at 1874($\pm$ 80) keV. At low energies the simulation underestimates the data. These counts, indicated by the solid line in fig. 1 could in principle correspond to decays from the first excited state in ^{17}Ne. However, breakup reactions in the detectors created a peak in that region with a factor of 100 more intensity, which was removed by analysis conditions for the energy loss and the interaction point as described in [1]. Thus, it seems more likely that those counts around $\simeq$ 300 keV correspond to background reactions. Hence, the experiment is in agreement with an observation of less than one count of a simultaneous 2p-decay from the $\frac{3}{2}^-$ state in ^{17}Ne. The simulation was further used to extract the efficiencies and the resulting cross section for the excitation of the $\frac{5}{2}^-$ state of $\sigma_{\mathrm{exp},2p,\frac{5}{2}^-} = 30.5(\pm 4.5)$ mbarn. In addition the non-observation of 2p-decays from the $\frac{3}{2}^-$ state could be used to finally determine the cross section for the excitation of the $\frac{3}{2}^-$ state from a previous γ-decay experiment [3] to $\sigma_{\mathrm{exp},\gamma,\frac{3}{2}^-} = 12.0^{+5.3}_{-3.9}$ mbarn . Using the virtual photon method [4] those cross sections could be used to determine the B(E2) values to $B(\mathrm{E2},^{17}\mathrm{Ne},\frac{1}{2}^- \rightarrow \frac{3}{2}^-) = 67^{+30}_{-22}$ e^2 fm^4 and $B(\mathrm{E2},^{17}\mathrm{Ne},\frac{1}{2}^- \rightarrow \frac{5}{2}^-) = 126\pm19$ e^2 fm^4.

In addition a limit on the lifetime of the 2p-decay of the $\frac{3}{2}^-$ state in ^{17}Ne could be set to $\tau_{2p} > 143^{+69}_{-58}$ ps. This is in agreement with theoretical models (see. [3,5].

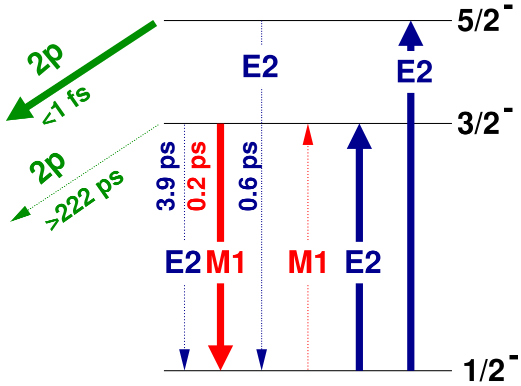

Fig. 2: Excitation and Deexcitation of the lowest state in ^{17}Ne

The B(E2) values calculated with the Weak Coupling model as described in [3] overpredict the B(E2) by a factor of 2. The same effect can be seen in the mirror system, leading to a break-down of the weak coupling model for those cases. New calculations in the full $(p_{1/2},d_{5/2},s_{1/2})^n$ model space were performed and B(E2) values were extracted as shown in Tab. 1. The new shell model calculations are in better agreement with the experiment. Details of the calculations can be studied in [6].

transition	theory	experiment
$B(\mathrm{E2},^{18}\mathrm{Ne},0^+ \rightarrow 2^+)$	256e^{2}fm^4	266(25)e^{2}fm^4
$B(\mathrm{E2},^{17}\mathrm{Ne},\frac{1}{2}^- \rightarrow \frac{3}{2}^-)$	105e^{2}fm^4	67^{+29}_{-22}e^{2}fm^4
$B(\mathrm{E2},^{17}\mathrm{Ne},\frac{1}{2}^- \rightarrow \frac{5}{2}^-)$	155e^{2}fm^4	126($\pm$19)e^{2}fm^4

Table 1: Comparison of calculated and experimental B(E2) values

References

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