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THE UNUSUAL STRENGTH OF THE
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The lifetime of the 5.14 MeV excited state of ^{22}Ne was investigated by use of the electronic timing, recoil distance and Doppler shift attenuation techniques. A mean life $\tau = 1.2 \pm 0.3$ ps was obtained, corresponding to a transition strength of 9.8×10^{-6} W.u. for the E1 decay of this state.

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In their recent review on electromagnetic transition strengths between bound states for A < 45 nuclei, Endt and Van der Leun [1] mentioned some transitions of unusual strength for which one might suspect one or more of the input data used for deriving their strength. Unusually weak appears the 5.14 → 1.27 MeV, $2^- \rightarrow 2^+$, transition in ^{22}Ne, with $(1.4 \pm 0.2) \times 10^{-8}$ W.u. In fact this transition is 150 times weaker than the next weakest E1 transition, and 7×10^6 times weaker than the recommanded upper limit value for this type of transition. In this letter we report a study of the lifetime of the 5.14 MeV level, for which a value $\tau = 0.84 \pm 0.08$ ns has been previously published [2].

The particle-gamma delayed coincidence technique was used in order to remeasure the lifetime of this state. Protons from the ^{19}F $(\alpha, p\gamma)$ ^{22}Ne reaction at $E_\alpha = 9.9$ MeV were detected in a silicon surface-barrier counter, located at an angle of 90° with respect to the beam axis at a distance of 3 cm from the 200 μg/cm² FLi target deposited on a 1 mg/cm² Au backing. A 20 mg/cm² Al absorber prevented the scattered α-particles from reaching the sensitive area of the detector. The overall energy resolution of the detection chain was good enough to permit the separation of the proton group corresponding to the 5.14 MeV level from the protons feeding the doublet at 5.34 + 5.36 MeV. The decay γ-rays were detected at 90° to the beam direction in a 2 cm diam. by 2 cm long NE-102 plastic scintillator mounted on a XP 1020 photomultiplier tube. Fast signals from the particle detector and from the anode of the photomultiplier were amplified and fed into discriminators which provided the timing signals to start and stop a time-to-amplitude converter. Two time spectra corresponding to the selection of the protons feeding the 5.14 and 4.46 MeV states respectively were recorded simultaneously. A common 20 % wide γ-ray energy window was set at the Compton edge of the 1.27 MeV γ-rays coming from the deexcitation of the first excited state. This was possible since both investigated states decay with large branching ratios [3] to this state which has a lifetime $\tau = 4.9 \pm 0.3$ ps [9] , short as compared to the time resolution of the system. The 4.46 MeV state has a lifetime $\tau < 23$ fs [4] and hence the shape of the time spectrum from this state was a measure of the system response to a prompt decay. The two experimental time spectra shown in fig. 1 had similar shapes. From the slope of these curves only an upper limit $\tau \leq 140$ ps could be obtained for the mean life of the 5.14 MeV state. This limit is in disagreement with the previously reported value $\tau = 840 \pm 80$ ps. It should be mentioned that in the earlier measurement, where the same reaction was used, a Na (I) scintillation counter detected the 0.69 MeV γ-rays from the 5.14 → 4.46 MeV transition resulting in a time resolution of 2 ns FWHM. Furthermore the proton groups leading to the 5.14 MeV state and to the 5.34 + 5.36 MeV doublet were not resolved in the proton spectrum and the satelite peaks present in the time spectrum were interpreted as a result of the large walk with proton energy of the electronic timing.

A lower limit $\tau > 12$ ps for the lifetime of the 5.14 MeV state has been given by Warburton et al. [5] , who analysed in the singles gamma spectra from the same reaction the Doppler shift of the double escape peak of the 5.14 → 1.27 MeV transition. Consequently the lifetime of this state was determined using the recoil distance method. The apparatus used was similar to the one described in Ref. [6] . Gamma spectra from a Ge (Li) counter located at 0° in respect to the beam direction were recorded in coincidence with the protons backscattered in an annular Si detector for different target-stopper distances. Protons corresponding to the feeding of the 1.27 and 5.14 MeV states were selected. The analysis of the 1.27 MeV line, corresponding to the deexcitation of the first excited state whose lifetime is well suited for this technique, provided a check for the measurement. In fig. 2a are presented the γ-peaks observed for a target-stopper distance d = 14 μm. Both stopped and shifted peaks of the 1.27 MeV γ-rays are present, whereas mainly the shifted peak of the 0.69 MeV line from the 5.14 → 4.46 MeV transition is observed. In fact a weak intensity of the stopped peak of this γ-ray is present. This recoil-distance measurement result yielded an upper limit $\tau \leq 2$ ps. for the lifetime of the 5.14 MeV state.

Finally the standard Doppler shift attenuation technique was applied, the ^{22}Ne recoiling ions ($v/c = 1.7$ %) being stopped in a 10 mg/cm^2 Au foil. The 0.69 and 1.27 MeV γ-lines observed at 0° and 90°, in coincidence with the protons feeding the 5.14 MeV state detected at 180°, are shown in fig. 2 b. The centroid shift analysis of the 0.69 MeV γ-ray peak leads to an attenuation factor $F = 0.16 \pm 0.03$, corresponding to a lifetime $\tau = 1.2 \pm 0.3$ ps for the 5.14 MeV state The theoretical electronic and nuclear stopping cross sections of Lindhard et al. [7] were used for the calculation of the $F(\tau)$ curve.

Using the reported branching ratio value [4] and the present lifetime result, the E1 strength of the 5.14 $\longrightarrow$ 1.27 MeV transition is found to be equal to 9.8×10^{-6} W.u. Although it remains weak, the strength of this transition is then no longer unusually weak and lies inside the histogram [1] of isospin allowed E1 transition strengths.

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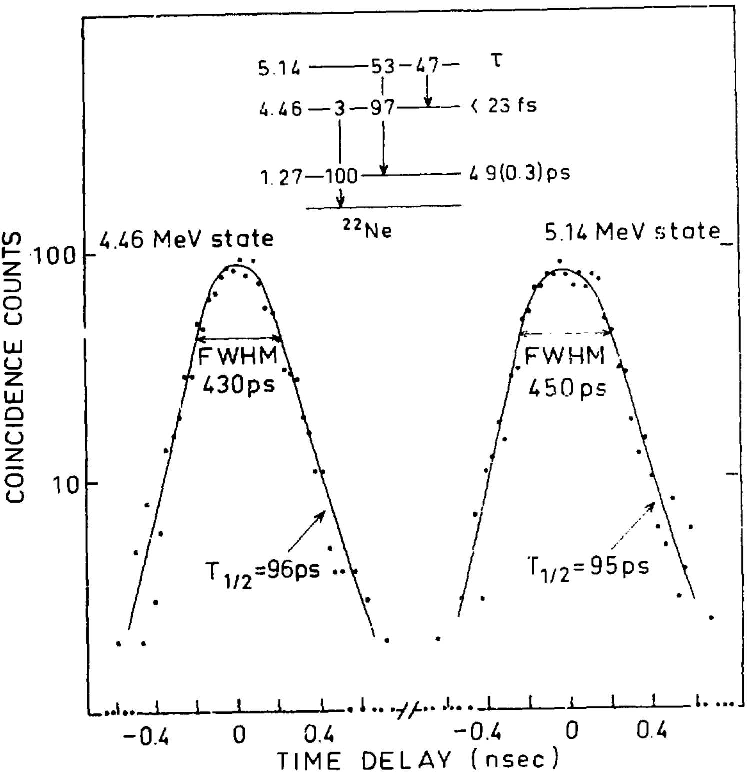
Figure captions

Fig. 1 The experimental delay curves for the 4.46 and 5.14 MeV levels in ^{22}Ne. An arbitrary zero time is used.

Fig. 2 Partial Ge(Li) detector spectra showing the 0.69 and 1.27 MeV peaks in coincidence with the protons feeding the 5.14 MeV state

a) at 0^{o} at a recoil distance of 14 μm (RDM)

b) at 90^{o} and 0^{o} in the gold backing (DSAM).



5.14
53
47
τ
4.46
3
97
< 23 fs
1.27
100
4.9(0.3) ps
^{22}Ne
4.46 MeV state
5.14 MeV state
100
10
COINCIDENCE COUNTS
FWHM
430ps
FWHM
450 ps
$T_{1/2}$=96ps
$T_{1/2}$=95ps
−0.4
0
0.4
−0.4
0
0.4
TIME DELAY (nsec)

Fig. 1.

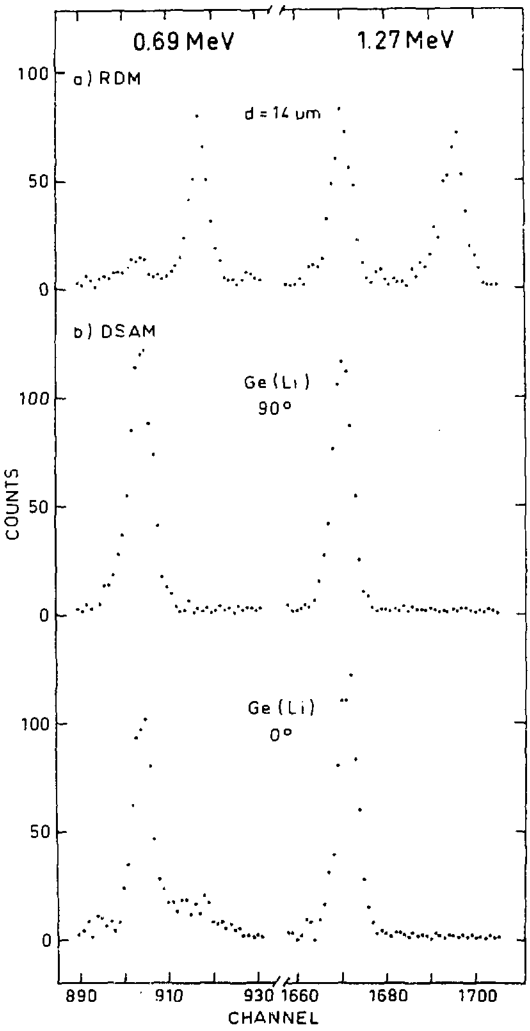

0.69 MeV
1.27 MeV
a) RDM
d = 14 μm
b) DSAM
Ge (Li)
90°
Ge (Li)
0°
COUNTS
0
50
100
890
910
930
1660
1680
1700
CHANNEL

Fig. 2.