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Doppler Shift Attenuation Measurements on ^{57}Fe and ^{57}Co (*).

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Summary. — Lifetime measurements by the Doppler shift attenuation method for levels in the nuclei ^{57}Fe and ^{57}Co, populated via the reactions ^{55}Mn(α, p$n\gamma$)^{57}Fe and ^{55}Mn(α, 2nγ)^{57}Co, respectively, are reported. The relative γ-ray intensities and the branching ratios for levels in the two nuclei are also presented. In ^{57}Fe, mean lifetime values of $\tau = (0.20 \pm 0.09)$ ps and (0.26 ± 0.10) ps are obtained for the levels at 1007.0 keV and 1356.8 keV, respectively, for which no lifetime information existed previously and values of $\tau = 0.08 \pm 0.03$, $0.54^{+0.30}_{-0.15}$ and (0.16 ± 0.06) ps are determined for the levels at 2355.7, 3269.1 and 6185.6 keV, respectively, for which only the limits of lifetimes were reported earlier. For the 2455.2 keV level in ^{57}Fe a lower limit of 2 ps is obtained for its mean life. In ^{57}Co lifetimes of eight levels with $J^\pi \leqslant 19^-/2$ have been measured and compared with the earlier reported values. The results of lifetime measurements and reduced transition probabilities for both the nuclei are discussed and compared with the available shell model calculations.

PACS. 23.20. – Electromagnetic transitions.

1. – Introduction.

The lifetimes and electromagnetic properties of the first four excited states of the ^{57}Fe nucleus have been extensively studied earlier and reported in the literature (¹). The lifetime information for the higher excited states is inconclusive both from the experimental and the theoretical point of view. Recent

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(*) To speed up publication, the authors of this paper have agreed to not receive the proofs for correction.

(¹) *Nucl. Data Sheets*, **20**, No. 3 (1977).

results of shell model calculations of electromagnetic properties of states above the yrast $J^\pi = 7^-/2$ state at 1007 keV are reported (^{2}) to be differing widely from the experimentally known properties. Also, there is a reported (^{3}) evidence of the existence of a $\Delta J = 2$ positive-parity band built upon a $J^\pi = 9^+/2$ level at 2455 keV and extending up to 8323 keV ($25^+/2$) level. There is a lack of lifetime information for the 1007 keV level and many higher-energy levels including some belonging to the positive-parity band for which only the limits of lifetimes have been reported (^{3}). With these points in view we have undertaken measurement of lifetimes and γ-ray branchings in ^{57}Fe. Concurrently, the lifetimes and γ-ray branching for some levels up to $J^\pi = (19^-/2)$ in ^{57}Co have also been measured in this work. This has been attempted in view of the fact that the previous lifetime measurements in ^{57}Co were confined to low-spin states, excepting the measurements reported by BENDJABALLAH *et al.* (^{4}) and recently, for the 4.81 MeV $17^-/2$ state by KEVELOH *et al.* (^{5}). The present results for the γ-ray transition probabilities are compared with the available model calculations.

The present studies have been carried out by in-beam γ-ray spectroscopy in the reactions ^{55}Mn(α, pnγ)^{57}Fe and ^{55}Mn(α, 2nγ)^{57}Co at $E_\alpha = 25$ and 28.6 MeV. Besides the lifetime measurements, the relative intensities of the γ-rays observed in these reactions are also presented along with the level schemes of ^{57}Fe and ^{57}Co.

2. – Experimental procedure.

Prompt γ-rays from natural manganese target irradiated with 25 and 28.6 MeV α-particles were studied with a 111 cm^3 Ge(Li) detector at the Variable Energy Cyclotron Centre, Calcutta. A natural manganese target of 8 mg/cm^2 thickness deposited on a 300 μg/cm^2 thick mylar foil was mounted at the centre of a reaction chamber with the mylar foil facing the incident α-particle beam. The transmitted beam through the target was stopped on a tantalum beam dump, positioned about 2 metres away from the target, and shielded by paraffin and lead blocks. The Ge(Li) detector, placed outside the reaction chamber at a distance of 18 cm from the target, was surrounded by 50 cm thickness of lead to shield against the background radiation.

(^{2}) R. VENNINK, J. KOPECKY, P. M. ENDT and P. W. M. GLAUDEMANS: *Nucl. Phys. A*, **344**, 421 (1980).

(^{3}) A. M. NATHAN, J. W. OLNESS, E. K. WARBURTON and J. B. MCGRORY: *Phys. Rev. C*, **17**, 1008 (1978).

(^{4}) N. BENDJABALLAH, B. DELAUNAY, J. DELAUNAY and T. NOMURA: *Nucl. Phys. A*, **280**, 228 (1977).

(^{5}) C. KEVELOH, H. P. HELLMEISTER, K. P. LIEB, J. B. MCGRORY and I. P. JOHNSTONE: *J. Phys. G*, **7**, L117 (1981).

No collimating apertures were used in the beam line inside the experimental area. Instead, a highly parallel beam of α-particles, about 4 mm in diameter, obtained by proper adjustment of the quadrupoles before the reaction chamber, was allowed to irradiate the target. This procedure effectively eliminated the unwanted background arising from the use of slits or apertures. Typical beam currents of about 1 nA were used. The incident beam on the target was monitored by detecting the scattered α-particles with a silicon surface-barrier detector mounted inside the reaction chamber.

The γ-ray spectra were studied at 90° and 125° with respect to the beam direction, at two beam energies. The background spectra without beam, and with beam on a 300 μg/cm^2 thick mylar foil, were measured in separate runs. The spectra were recorded on ND 620 8 K channel analyser and periodically transferred to magnetic tape for subsequent analysis. The efficiency calibration of the Ge(Li) detector was performed with standard sources of ^{133}Ba, ^{152}Eu and ^{207}Bi under identical conditions and geometry as during the experiment.

3. – Analysis.

The lifetimes were determined by the Doppler-shift attenuation (DSA) method. The target thickness was sufficient to stop 95 % of the recoils produced in the reactions studied. The recoiling nuclei were confined within a narrow cone centred about the z-axis (beam axis). The centroid shift of the Doppler-broadened γ-ray lines with respect to the unshifted ones was betermined from the the γ-ray spectra recorded at 125° and 90°, respectively. The lifetimes were extracted from a comparison of the experimental attenuation factors, $F(\tau)$, properly modified in order to take into account the feeding time of the preceding γ-rays, with the theoretical attenuation factor *vs.* mean life curve. The theoretical attenuation factors were obtained following the method of Warburton *et al.* (⁶), where the z-component of the ion velocity (v_z) is assumed to vary with time according to the following analytical form:

$$-M_1 \frac{\mathrm{d}v_z}{\mathrm{d}t} = K_e \left(\frac{v_z}{v_0}\right) + K_n \left(\frac{v_z}{v_0}\right)^{-1},$$

where M_1 is the mass of the moving ion and $v_0 = c/137$. The first term, $K_e(v_z/v_0)$, corresponds to electronic stopping and the parameter K_e is obtained using the relevant stopping power information (⁷). The parameter K_n corresponds to nuclear stopping and is evaluated incorporating the multiple ion-aton collision

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(⁶) E. K. WARBURTON, J. W. OLNESS and A. R. POLETTI: *Phys. Rev.*, **160**, 938 (1967).

(⁷) L. C. NORTHCLIFFE and R. F. SCHILLING: *Nucl. Data Tables*, **7**, No. 3-4 (1970).

corrections following the procedure developed by BLAUGRUND (8). These parameters K_e and K_n are used in calculating the theoretical $F(\tau)$.

Since the reaction mechanism in the present experiment does not permit a pre-selection of the state under study, corrections due to population of the state of interest by cascades from higher states are taken into account. If several levels each with mean life τ_i and direct population ν_i ($i \geqslant 2$) decay to a level with mean life τ_1 and direct population ν_1, the observed Doppler shift for the latter level depends on (9)

$$\overline{F(\tau_1)} = \nu_1 F(\tau_1) + \sum_i \frac{\nu_i}{\tau_i - \tau_1} [\tau_i F(\tau_i) - \tau_1 F(\tau_1)] ,$$

where $\nu_1 + \sum_i \nu_i = 1$. The initial velocities and hence the $F(\tau)$ curves for all the levels are taken to be same within errors.

We have extended this formalism to include also the effects of feeding by γ-γ cascades, where a level with τ_j and ν_j feeds another level with τ_i and ν_i, which finally decays to the state of interest with τ_1 and ν_1. In this case the observed Doppler shift depends on

$$\begin{aligned}\overline{F(\tau_1)} = {} & \nu_1 F(\tau_1) + \sum_{i \geqslant 2} \frac{\nu_i}{\tau_i - \tau_1} [\tau_i F(\tau_i) - \tau_1 F(\tau_1)] - \\ & + \sum_{\substack{j \geqslant 3 \\ i \geqslant 2 \\ j > i}} \frac{\nu_j}{(\tau_j - \tau_i)(\tau_j - \tau_1)(\tau_i - \tau_1)} [\tau_j^2(\tau_i - \tau_1) F(\tau_j) - \tau_i^2(\tau_j - \tau_1) F(\tau_i) + \\ & + \tau_1^2(\tau_j - \tau_i) F(\tau_1)] ,\end{aligned}$$

where the sum of all the ν's is normalized to unity.

The direct population ν's were obtained from the intensities of the relevant γ-rays taking into account the appropriate branching ratios.

Besides, there are feedings due to unknown transitions which are not observed experimentally due to their weak intensities. This is referred to as « side feeding ». The amount of side feeding to a level is obtained as the difference of intensities between known γ-transitions from the level and those to the level. The side feeding time is not known but it has also been accounted for in the manner described in ref. (4). The good agreement of our measured mean lives for some of the low-lying states of ^{57}Co (subsect. **4**.1), for which lifetime values were known previously, supports the procedure of analysis.

The recoil velocities of ^{57}Co and ^{57}Fe have been calculated following the method outlined in ref. (4), under the assumption that the reactions proceed via the formation of a compound nucleus. The corrections to the experimental

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(8) A. E. BLAUGRUND: *Nucl. Phys.*, **88**, 501 (1966).

(9) R. A. I. BELL, J. L'ECUYER, R. D. GILL, B. C. ROBERTSON, I. S. TOWNER and H. J. ROSE: *Nucl. Phys. A*, **133**, 337 (1969).

$F(\tau)$ values due to the escape of about 5% of the recoils from the target have been estimated by the method of ref. (10). The spread in the recoil velocity due to the initial spread in the projectile energy (≈ 200 keV) and the target thickness are not expected to yield significant errors. The recoils due to the emission of particles and γ-rays from the compound or residual nucleus are difficult to estimate accurately, but their effect on the calculated lifetimes has been previously shown to be small (4). The effect of possible errors in the recoil velocity due to these factors are nevertheless included by doubling the errors on the lifetime values reported here.

4. – Measurements and results.

A typical γ-ray singles spectrum with 28.6 MeV α-particles on natural manganese target, observed at 90° to the beam direction, is shown in fig. 1. Prominent γ-ray lines identified as belonging to ^{57}Co and ^{57}Fe are shown labelled

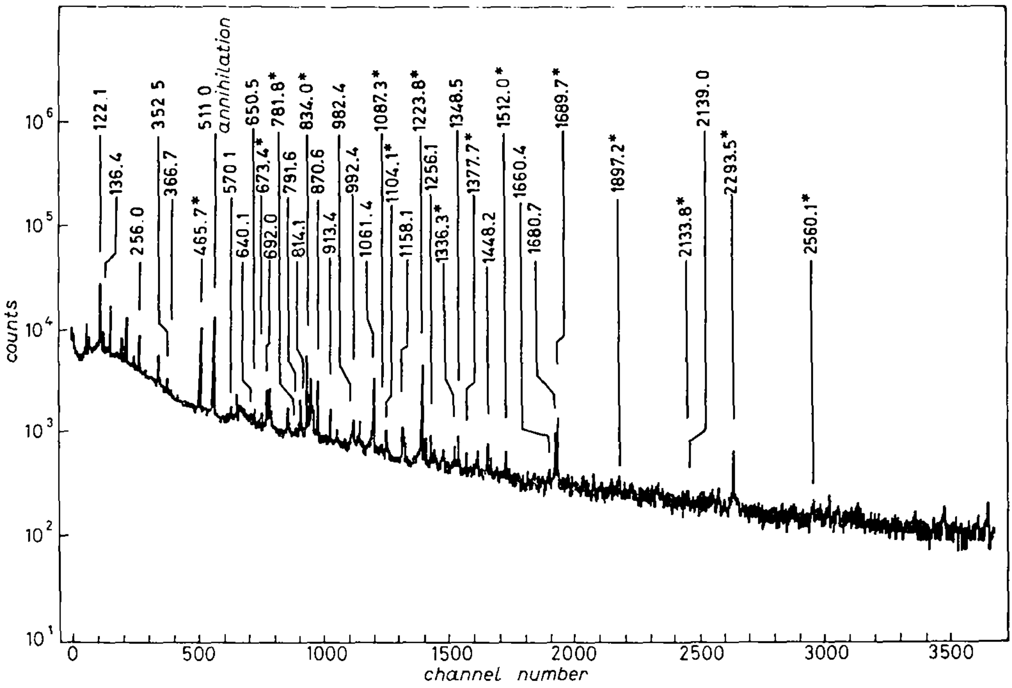

Fig. 1. – In-beam gamma-ray spectrum from the bombardment of natural manganese target with 28.6 MeV α-particle recorded at 90° with respect to the beam direction. Only the prominent γ-ray lines belonging to ^{57}Fe and ^{57}Co, the latter marked with asterisk (*), are labelled. The energies are given in keV.

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(10) E. J. Hoffman, D. M. Van Patter, D. G. Sarantites and J. H. Barker: *Nucl. Instrum. Methods*, **109**, 3 (1973).

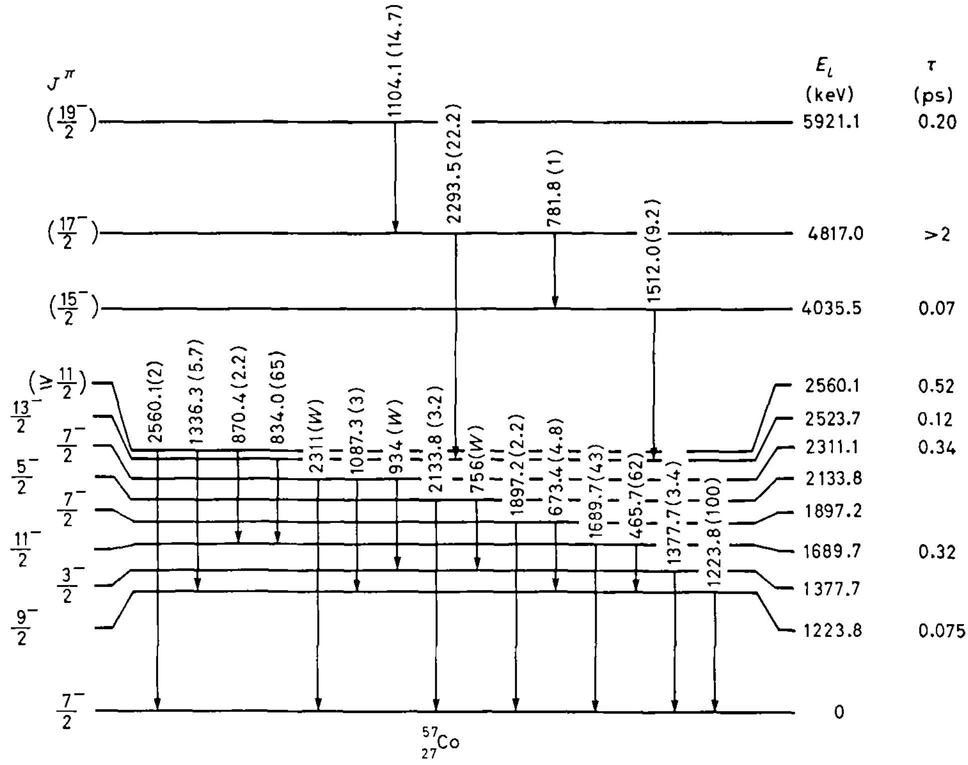

Fig. 2. – Level scheme of ^{57}Co showing the γ-ray transitions observed in the present work. The relative γ-ray intensities at 125°, in the reaction ^{55}Mn(α, 2nγ)^{57}Co at $E_\alpha =$ = 28.6 MeV, are given in parentheses. The estimated errors in the intensities are (5 ÷ 10)% for the relative intensity values in the range (100 ÷ 5) and higher for the weaker γ-rays. The symbol (*W*) indicates relative intensity values < 1. The relative intensity of the 870.4 keV transition is estimated from the reported (^{1}) branching ratio with respect to the 1336.3 keV γ-ray. The spins and parities of levels up to 2560.1 keV are taken from ref. (^{1}) and those for the higher levels from ref. (^{4}).

in the figure. We present below some of the results obtained for these two nuclei in this investigation.

4·1. ^{57}Co. – The level scheme of ^{57}Co indicating the level energies, γ-ray transitions, their relative intensities and branching ratios obtained in the present work via the reaction ^{55}Mn(α, 2nγ)^{57}Co is shown in fig. 2. Three high-spin states with $J^\pi = 15^-/2$, $17^-/2$, and $19^-/2$ have been reported by BENDJABALLAH *et al.* (^{4}) via the reactions ^{48}Ti(^{12}C, p2n)^{57}Co and ^{54}Fe(α, p)^{57}Co. The $19^-/2$ state was reported to be weakly populated in the former reaction and not observed in the latter reaction. All the three levels are well populated in the ^{55}Mn(α, 2nγ)^{57}Co reaction in the present work. The results of lifetime measurements of these levels and five other levels in ^{57}Co are presented along with the previous results in table I*a*). Typical Doppler-broadened line shapes for

γ-transitions depopulating the levels at 5921.1, 2523.7 and 1223.8 keV are shown in fig. 3*a*). The present results are in good agreement with the previous reports except in the case of the 2523.7 keV ($13^-/2$) level for which the present result agrees with that of ref. (⁴) but not with ref. (¹¹). For the mean life of the 4817.0 keV ($17^-/2$) level, a limit of $\tau > 2$ ps is assigned on the basis of very small Doppler shift with $F(\tau) < 0.05$ observed in this case.

TABLE I. – *Results of lifetime measurements of levels in* ^{57}Co *and* ^{57}Fe.

a) ^{57}Co

J^π	Level energy (keV)	Mean life (ps)			
		Present	Previous		
			ref. (¹¹)	ref. (⁴)	ref. (⁵)
$9^-/2$	1223.8	0.075 ± 0.035	$0.075^{+0.09}_{-0.011}$	0.085 ± 0.030	—
$11^-/2$	1689.7	0.32 ± 0.12	0.35 ± 0.03	0.32 ± 0.10	—
$7^-/2$	2311.1	0.34 ± 0.14	$0.275^{+0.075}_{-0.055}$	—	—
$13^-/2$	2523.7	0.12 ± 0.05	$0.38^{+0.07}_{-0.06}$	0.16 ± 0.06	—
$(\geqslant 11/2)$	2560.1	0.52 ± 0.21	$0.73^{+0.15}_{-0.13}$	—	—
$(15^-/2)$	4035.5	0.07 ± 0.03	—	$0.10^{+0.06}_{-0.07}$	—
$(17^-/2)$	4817.0	> 2	—	$1.5^{+4.0}_{-0.5}$	14.3 ± 0.3
$(19^-/2)$	5921.1	0.20 ± 0.07	—	$0.17^{+0.08}_{-0.07}$	—

b) ^{57}Fe

J^π	Level energy (keV)	Mean life (ps)		
		Present	Previous	
			ref. (¹²)	ref. (³)
$7^-/2$	1007.0	0.20 ± 0.09	—	—
$7^-/2$	1356.8	0.26 ± 0.10	—	—
$11^-/2$	2355.7	0.08 ± 0.03	$\leqslant 0.60$	< 0.2
$(9^+/2)$	2455.2	> 2	—	—
$(13^+/2)$	3269.1	$0.54^{+0.30}_{-0.15}$	—	$1.5 \div 5$
$(17^+/2)$	4525.2	0.27 ± 0.09	—	0.55 ± 0.2
$(21^+/2)$	6185.6	0.16 ± 0.06	—	< 0.2
$(25^+/2)$	8324.6	< 0.2	—	< 0.2

4·2. ^{57}Fe. – The level scheme of ^{57}Fe showing the γ-ray transitions and relative γ-ray intensities observed in the present work in the reaction ^{55}Mn(α, p$n\gamma$)^{57}Fe at 28.6 MeV projectile energy and a detection angle of 125° to the beam direction, is given in fig. 4. Two recently reported (³) high-spin states at 6185.6 keV ($21^+/2$) and 8324.6 ($25^+/2$) are observed to be populated, besides the previously known (¹) lower-lying states. Also the 814.1 keV γ-ray transition depopulating

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(¹¹) R. DAYRAS, M. TOULEMONDE, B. ČUJEC, B. HEUSCH, J. N. MO and I. M. SZÖGHY: *Nucl. Phys. A*, **173**, 49 (1971).

(¹²) Z P. SAWA: *Phys. Scr.*, **6**, 11 (1972).

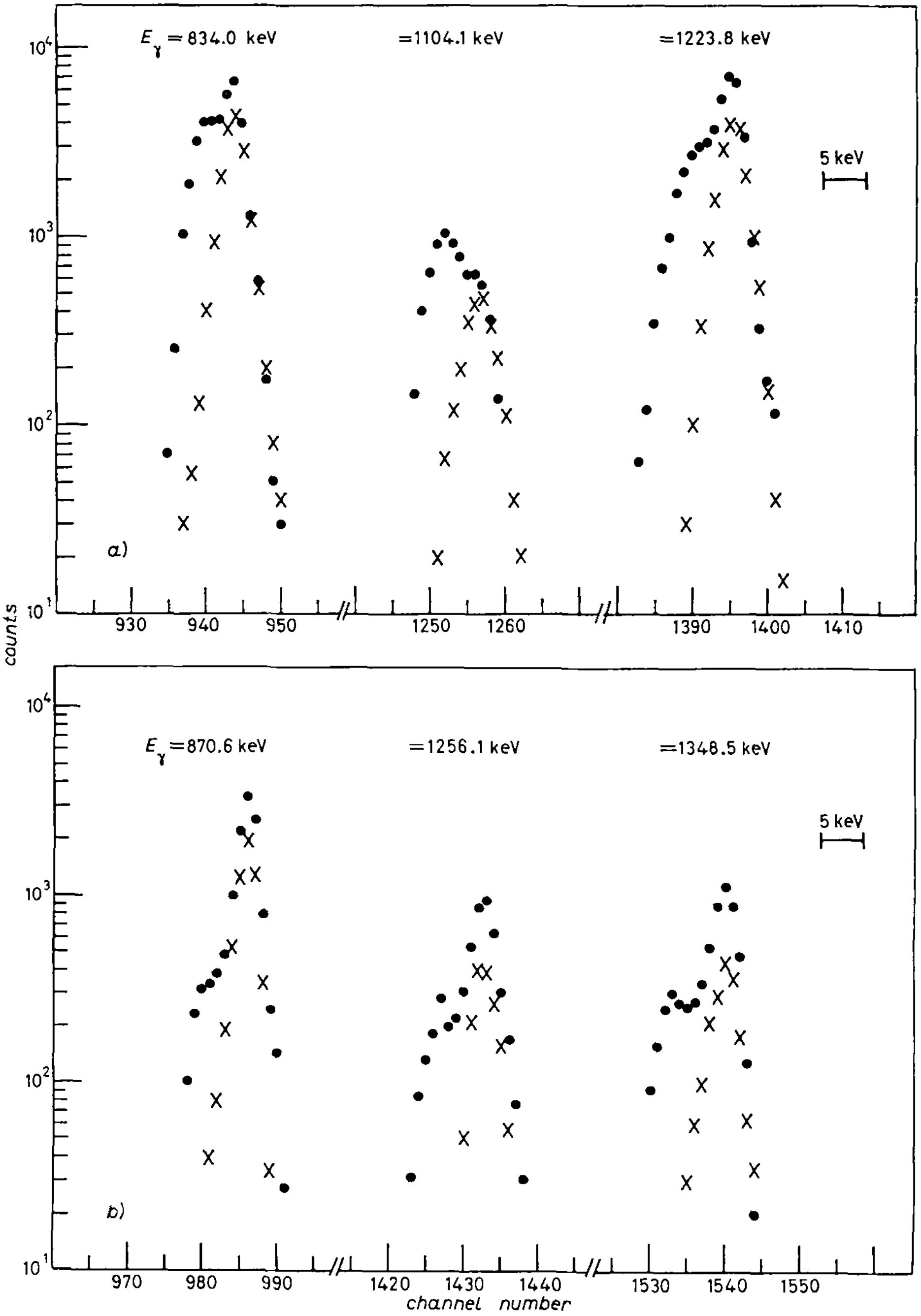

Fig. 3. – Typical Doppler-broadened peaks (dots) observed at 125° and the corresponding unshifted peaks (crosses) at 90° with respect to the beam direction for *a*) 834.0, 1104.1 and 1223.8 keV γ-rays of ^{57}Co, and *b*) 870.6, 1256.1 and 1348.5 keV γ-rays of ^{57}Fe.

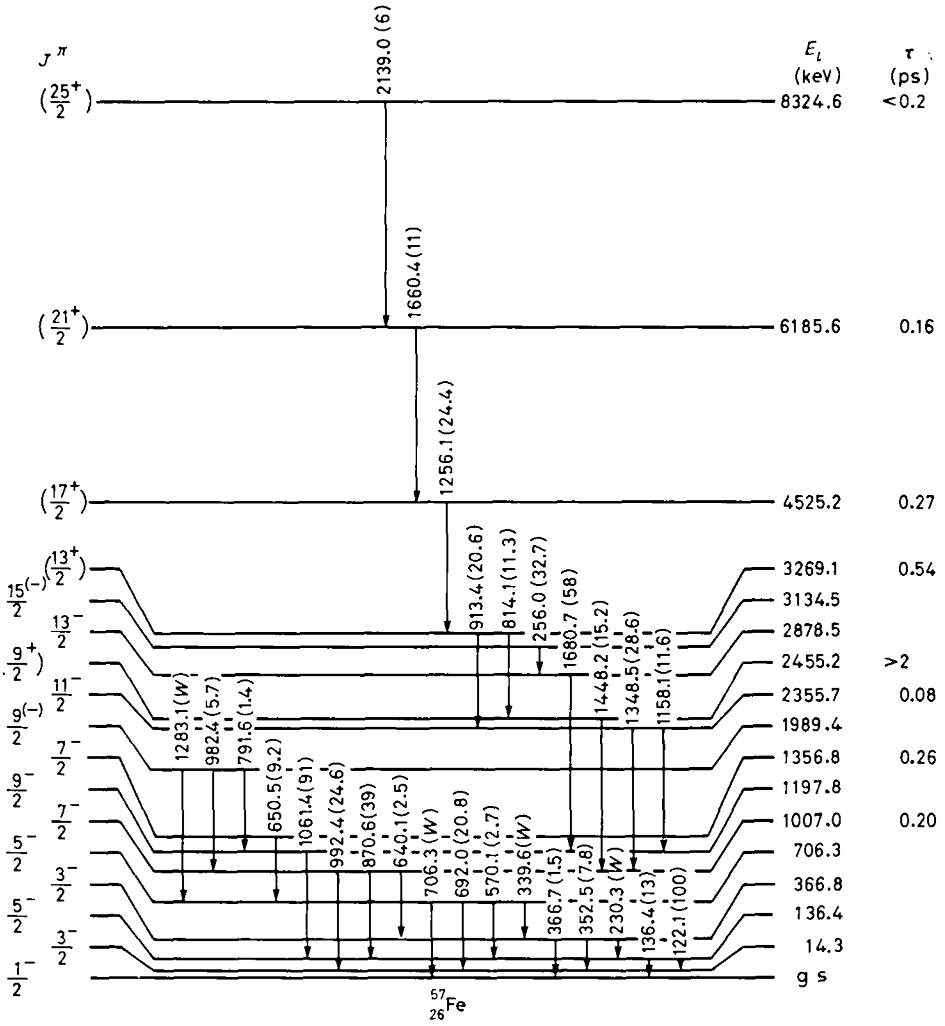

Fig. 4. – Level scheme of ^{57}Fe. The relative intensities of the γ-rays observed in the reaction ^{55}Mn(α, pnγ)^{57}Fe at 125° with respect to the beam direction and 28.6 MeV projectile energy are given in parentheses. The estimated errors in the intensities lie within (5÷10)% for relative intensities in the range (100÷10) and within (10÷15)% for the weaker γ-rays excepting those labelled (*W*). The symbol (*W*) indicates relative intensity values <1. The J^π values for levels up to 3134.5 keV are taken from ref. (^{1}) and those for the four higher-lying levels from ref. (^{3}).

the 3269.1 keV level, first reported in ref. (^{3}), is observed in this work. The branching ratio obtained for the 1158.1 and 1348.5 keV transitions depopulating the 2355.7 keV level is in disagreement with the result of ref. (^{3}) but agrees with the value reported in ref. (^{12}). Other branching ratios are in fair agreement with the previously published data (^{1}).

A few Doppler broadened and the corresponding unshifted γ-ray line shapes are shown in fig. 3*b*), and a summary of the results of lifetime measurements of levels in ^{57}Fe is presented in table I*b*). The lifetimes of the 1356.8 and 1007.0 keV levels were not known previously. The measurement of the mean life of the 1356.8 keV level yields a value of (0.44 ± 0.10) ps when side-feeding corrections are not applied. We have adopted a value $\tau = (0.26 \pm 0.10)$ ps on applying corrections due to the side-feeding time. The lifetime of the 1007.0 keV level was determined from the Doppler shift in both 992.4 and 870.6 keV γ-rays de-exciting the level. In the case of the 870.6 keV γ-ray, however, a correction was necessary due to the presence of the close-lying 870.4 keV γ-ray, arising from the de-excitation of the 2560.1 keV level in ^{57}Co. The intensity of the 870.4 keV γ-ray is obtained from the adopted (1) branching ratio for this γ-ray with respect to the 1336.3 keV γ-ray which also de-excites the same level in ^{57}Co. From the observed intensity of the 1336.3 keV γ-ray and the measured lifetime of the 2560.1 keV level of ^{57}Co, the contribution of the 870.4 keV γ-ray of ^{57}Co to the observed Doppler-broadened 870.6 keV line is readily obtained. It is observed that the 870.4 keV line from ^{57}Co constitutes only about 10% of the total intensity of the composite peak. The adopted result for the mean life of the 1007.0 keV level given in table I*b*) is the mean of the lifetime values obtained from the analyses of both 870.6 and 992.4 keV lines at $E_\alpha = 25.0$ and 28.6 MeV.

The mean lives of the 2355.7 and 6185.6 keV levels have been determined to be (0.08 ± 0.03) ps and (0.16 ± 0.06) ps, respectively. Previously only upper limits of lifetimes were known for these two levels (table I*b*)).

The value of (0.27 ± 0.09) ps for the mean life of the 4525.2 keV level in this work agrees within the error limits with the earlier reported (3) value of (0.55 ± 0.2) ps (table I*b*)). It is noticed that the apparent mean life of this level without applying the feeding time corrections shows closer agreement with the result of ref. (3). Also, the significantly lower value of $0.54^{+0.30}_{-0.15}$ ps obtained in the present work for the mean life of the 3269.1 keV level compared to the previous (3) DSA result of $\tau > 1.5$ ps is attributed to strong feeding time effects observed for this level. Finally, for the levels at 8324.6 and 2455.2 keV, we report the limits $\tau < 0.2$ ps and $\tau > 2$ ps, on the basis of the observation of very large and very small Doppler shifts, respectively.

5. – Discussion.

5·1. ^{57}Co. – The location of the yrast states with $9^-/2 < J^\pi < 15^-/2$ in ^{57}Co is well predicted by shell model calculations (13,14) considering $(\pi f_{\frac{7}{2}})^{-1}$ $(\nu\, p_{\frac{3}{2}}, f_{\frac{5}{2}}, p_{\frac{1}{2}})^2$ configurations treating ^{56}Ni as an inert core. The agreement with experiment for low-spin states is however poor.

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(13) J. B. McGrory: *Phys. Rev.*, **160**, 915 (1967).

(14) H. Horie and K. Ogawa: *Nucl. Phys. A*, **216**, 407 (1973).

The transition probabilities for the γ-ray transitions originating from the yrast states at 1223.8 keV ($9^-/2$), 1689.7 keV ($11^-/2$), 2523.7 keV ($13^-/2$), 4035.5 keV ($15^-/2$) and 5921.1 keV ($19/2^-$) determined from the measured lifetimes and the γ-ray branching ratios in the present work, taking the $E2/M1$ mixing ratios from ref. (1,4), show enhancement of $B(E2)$ values by factors of 2 to 30 and retardation of $B(M1)$ values by factors of 2 to 10, with respect to the Weisskopf estimate. The experimental reduced transition probabilities are in good agreement with the theoretical results of Steward *et al.* (15) for transitions from states with $J^\pi \leqslant 15^-/2$ derived from calculations based on the intermediate-coupling model, considering the coupling of one proton $f_{\frac{7}{2}}$ hole to the vibrating ^{58}Ni core, with anharmonic features in the vibration of the core.

The $17^-/2$ state at 4817.0 keV de-excites to the yrast states at 4035.5 keV ($15^-/2$) and 2523.7 keV ($13^-/2$) by γ-ray emission. An upper limit of the intensity of the $17^-/2 \to 15^-/2$ transition, corresponding to 15% of the intensity of the $17^-/2 \to 13^-/2$ transition, was reported in ref. (4). The branching ratio for these transitions measured in the present work gives the intensity of the 781.8 keV γ-ray ($17^-/2 \to 15^-/2$) to be $(4.5 \pm 1.5)\%$ of that of the 2293.5 keV γ-ray ($17^-/2 \to 13^-/2$). Taking the reported meanlife of (14.3 ± 0.3) ps for the $17^-/2$ state from recoil distance measurements (5) and the γ-ray branching ratio obtained in the present work, we get estimates of the reduced transition probabilities $B(E2)$ and $B(M1)$ for the $17^-/2 \to 13^-/2$ and $17^-/2 \to 15^-/2$ transitions assuming them to be pure $E2$ and $M1$, respectively. The reduced transition probabilities thus obtained are

$$B(E2; 17^-/2 \to 13^-/2) = (0.061 \pm 0.002)\ \text{W.u.}$$

and

$$B(M1; 17^-/2 \to 15^-/2) = (2.0 \pm 0.6) \cdot 10^{-4}\ \text{W.u.}$$

Both the transitions are strongly retarded. These results are in good agreement with shell-model calculations of Keveloh *et al.* (5), using the effective interaction of Johnstone and Benson (16), giving $B(E2; 17^-/2 \to 13^-/2) = 0.053$ W.u. and $B(M1; 17^-/2 \to 15^-/2) = 3.9 \cdot 10^{-4}$ W.u.

5.2. ^{57}Fe. – Several shell-model calculations are available for energy levels of ^{57}Fe. However, detailed model calculations regarding the electromagnetic properties of the excited states of ^{57}Fe are not available. COMFORT *et al.* (17) and BOLOTIN *et al.* (18) discussed the electromagnetic properties of the low-

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(15) K. W. STEWARD, B. CASTEL and B. P. SINGH: *Phys. Rev. C*, **4**, 2131 (1971).

(16) I. P. JOHNSTONE and H. G. BENSON: *J. Phys. G*, **3**, L69 (1977).

(17) J. R. COMFORT, P. WASIELEWSKI, F. B. MALIK and W. SCHOLZ: *Nucl. Phys. A*, **160**, 385 (1971).

(18) H. H. BOLOTIN, A. E. STUCHBERY, K. AMOS and I. MORRISON: *Nucl. Phys. A*, **311**, 75 (1978).

lying states of ^{57}Fe. In recent shell-model calculations, with two proton holes in $1f_{\frac{7}{2}}$ subshell and neutrons in the $2p_{\frac{3}{2}}$, $1f_{\frac{5}{2}}$ and $2p_{\frac{1}{2}}$ subshells, VENNINK *et al.* (^{2}) investigated the electromagnetic properties in ^{57}Fe, considering two different effective two-body interactions, *viz.* Kuo-Brown interaction (HB) and surface-delta interaction (SD). Both interactions fail to reproduce the experimentally known properties of the levels above the yrast $J^\pi = 7^-/2$ state (1007.0 keV). For states below the yrast $J^\pi = 7^-/2$ state, the results for Kuo-Brown interaction deviate from the experimental results considerably more than for the surface-delta interaction. The experimental results obtained in the present work on the lifetime of the yrast $J^\pi = 7^-/2$ state at 1007.0 keV and the branching ratios of the γ-rays from that level, on comparison with the theoretical results show that the theoretical values (^{2}) for both KB and SD interaction deviate significantly from the present experimental results. As pointed out by the authors of ref. (^{2}), the model space in their calculations is probably too small for a reliable description of the higher-lying states, and that three-hole $(f_{\frac{7}{2}})^{-3}$ admixtures in ^{57}Fe may need to be considered. The discrepancy between the theoretical and the present experimental results for the 1007.0 keV state may be related to the restrictions on the model space used in the calculations.

Results of theoretical calculations on the electromagnetic properties are not available for levels above the 1007.0 keV level. However, an outstanding feature of the ^{57}Fe level structure is the appearance of a probable $\Delta J = 2$ positive-parity band built upon the $J^\pi = 9^+/2$ level at 2455.2 keV; the band members above the $9^+/2$ level being $13^+/2$ (3269.1 keV), $17^-/2$ (4525.2 keV), $21^+/2$ (6185.6 keV) and $25^+/2$ (8324.6 keV). As pointed out by NATHAN *et al.* (^{3}), there is a remarkable similarity of the level spacings and the $B(E2)$ values of the transitions between the members of the band in ^{57}Fe to those of the ground-state band in ^{56}Fe, suggesting the coupling of a $1g_{\frac{9}{2}}$ neutron to a ^{56}Fe core. From our measured lifetime values for the positive-parity states above the $9^+/2$ state in ^{57}Fe, assuming $E2$ multipolarity for the intraband transitions, we obtain the following $B(E2)$ values for the $13^+/2 \to 9^+/2$, $17^+/2 \to 13^+/2$, $21^+/2 \to \to 17^+/2$ and $25^+/2 \to 21^+/2$ transitions: $B(E2; J+2 \to J) = 105^{+40}_{-36}$, 68^{+34}_{-17}, 28^{+17}_{-8} and > 6.4 W.u., respectively.

All these $B(E2)$'s are strongly enhanced and lend support to the interpretation of the positive-parity states as arising from the coupling of a $1g_{\frac{9}{2}}$ neutron to a ^{56}Fe core.

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● RIASSUNTO (*)

Si riportano le misure di vita media mediante il metodo di attenuazione dello spostamento Doppler per livelli nei nuclei ^{57}Fe e ^{57}Co popolati mediante le reazioni ^{55}Mn$(\alpha, \mathrm{pn}\gamma)^{57}$Fe e ^{55}Mn$(\alpha, 2\mathrm{n}\gamma)^{57}$Co, rispettivamente. Si presentano anche le intensità relative dei raggi γ e i rapporti di diramazione nei due nuclei. Per ^{57}Fe si ottengono i valori di vita media di $\tau = (0.20 \pm 0.09)$ ps e (0.26 ± 0.10) ps per i livelli a 1007.0 keV e 1356.8 keV, rispettivamente, per i quali non esistevano precedentemente informazioni sulla vita media, e si determinano i valori di $\tau = 0.08 \pm 0.03$, $0.54^{+0.30}_{-0.15}$ e (0.16 ± 0.06) ps per i livelli a 2355.7, 3269.1 e 6185.6 keV, rispettivamente, per i quali si erano stati riportati precedentemente solo i limiti di vita media. Per il livello a 2455.2 keV nel ^{57}Fe si ottiene per la sua vita media un limite inferiore di 2 ps. Nel ^{57}Co le vite medie degli otto livelli con $J^{\pi} \leqslant 19^-/2$ sono state misurate e confrontate con valori riportati precedentemente. Si discutono i risultati delle misure di vita media e le probabilità di transizione ridotte per entrambi i nuclei e si confrontano con i calcoli disponibili del modello a strati.

(*) *Traduzione a cura della Redazione.*

Резюме не получено.