ENERGY LEVELS OF ^{53}Mn FROM THE β DECAY OF ^{53}Fe

by

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ABSTRACT

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The γ rays following the β decay of ^{53}Fe were investigated with high resolution detectors. Two unreported weak transitions were detected at the energies 1177 ± 1 keV and 2305 ± 1 keV. Log ft values were determined and spin and parity assignments made. On the basis of the results attained, a new decay scheme was proposed. Comparison with theoretical calculations are made.

R E S U M O

Os raios γ provenientes da desintegração β do
Fe^{53} foram investigados com detetores de alta resolução .
Duas transições fracas anteriormente não registradas foram
detetadas nas energias de 1177 ± 1 keV e 2305 ± 1 keV. Va
lores de log ft foram determinados para essas transições e
spins e paridades atribuidos aos níveis correspondentes .
Com base nos resultados obtidos, um novo esquema de desin-
tegração foi proposto e uma comparação com os cálculos teó
ricos foi efetuada.

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I. ·INTRODUCTION

The study of the levels of ^{53}Mn (magic number of
neutrons N=28) is of a considerable theoretical interest.
Investigations [1,2] on the levels of ^{53}Mn from the
β decay of ^{53}Fe lead to different conclusions about
the existence of an allowed β group feeding a level
between $\sim$1000 and 1500 keV, which was not observed
in other experiments [3-5] with nuclear reactions.

The aim of the present work was to explore the above
mentioned inconsistency and also search new β groups
in the decay of ^{53}Fe. The existence of these groups
is suggested by values of spin and parity assigned
to some levels of ^{53}Mn in nuclear reactions
measurements [3-5]. γ-rays spectroscopy techniques
allowing high resolution and great statistics are
employed.

II. EXPERIMENTAL PROCEDURE

The source of ^{53}Fe was obtained from the reaction
^{54}Fe $(\gamma,n)^{53}$Fe, resulting from the irradiation of
286 mg of Fe_2O_3 (enriched to 75-90% in ^{54}Fe) with
the Brehmsstrahlung beam produced in a linear
accelerator of electrons, operating with a 21 MeV
and 50 μA.

Measurements were perfomed with a 30 cm^3 Ge-Li
detector (resolution 3,4 keV FWHM for 1332 keV) and
the information obtained was coded and memorized in
4096 channels. A double stabilizer of zero and peak
was introduced in the chain with the aim of allowing
the sum of spectra without deterioration of the
resolution.

Twenty irradiations were perfomed; each one was followed by two consecutive measurements of an equal duration (15 minutes). The spectra of the first measurements for each irradiation and that of the second measurements were summed separately.

In order that the transitions proceeding from ^{53}Mn could be identified, relative intensities to the γ ray of 380 keV were determined for each period of observation and compared the one with another, for each transition.

With the purpose of searching weak transitions possibly existing in the region of 511 keV, two detectors were placed symmetrically to the source and an anticoincidence with 511 keV was performed.

III. DISCUSSION OF RESULTS

The spectrum resulting from 20 irradiations appears in figure 1. Two unreported weak transitions presenting the same period as the γ-ray of 380 keV were observed at 1177 keV and 2305 keV. The energy and relative intensities of these transitions are shown in table I.

Energy (keV)	Relative intensity to 380 keV(%)
380 $^{\pm}$ 1	100
1177 $^{\pm}$ 1	1,0 0,1
2305 $^{\pm}$ 1	0,15 ± 0,03

TABLE I

A third γ ray observed at the energy 890 keV was proved to be a sum effect by measurements with different geometries

The anticoincidence revealed no further transition.

The possibility of the γ ray of 1177 keV being the

second scape peak of a transition of 2199 keV (between
the levels 2571 keV and 380 keV) would be compatible
with the levels of ^{53}Mn previously known [3]. That
possibility was discarded because the non occurence
of a peak of 2199 keV in the spectrum obtained was
in disagreement with the ratio peak/second scape
(about 5) determined for the detector employed, in this
energy region.

Thus an energy level at 1177 keV was proposed and the
log ft of the β group feeding it was determined to be
5,8. This interpretation and the log ft value found
are in agreement with experimental results [4], stating
the existence of an allowed β group of end point energy
∿1570 keV.

The Gamma ray of 2305 keV was identified as the
transition from the level 2685 keV (7/2⁻) to the level
380 keV (5/2⁻).

All the γ rays following the β decay of ^{53}Fe were
positioned in the decay scheme proposed in the present
work. Log ft values were determined from the relative
intensities of the γ transitions obtained in this paper
and also from data indicated in reference [5], concerning
the relative abundance of the β groups feeding the
ground state and the level of 380 keV.

In figure II it is shown the decay scheme of ^{53}Fe
previously proposed [4,5](a), and the one we propose (b).

IV. COMPARISON WITH THEORIES

As Figure III shows the accuracy attained in shell model
calculations is apparent. Even some very simple models
based on $(f_{7/2})^n$ pure configuration describe very
successfully the first excited levels 380 keV (5/2⁻),
1230 keV (3/2⁻), 1440 keV (11/2⁻) and 1620 keV (9/2⁻).
The importance of configuration mixing is, however,
evidenced in the levels 1177 keV (5/2⁻, 7/2⁻ or 9/2⁻),

2272 keV (7/2⁻), 2405 keV (3/2⁻) and 2571 keV (5/2⁻ or 7/2⁻). As a whole the model which best reproduces the experimental levels up to 2500 keV is the one presented by Lips-McEllistrem [6] in calculations $\underline{a}^+$ $\underline{b}^{++}$ and $\underline{c}^{+++}$ of their paper. The comparison among these calculations favours calculation $\underline{c}$ which reproduces the experimental levels with greater accuracy, and predicts the first levels (11/2⁻) and (9/2⁻) in the right sequence. It is also noticeable the fact that the calculation $\underline{c}$ produces a level ∿1150 keV (5/2⁻), with a strong preponderance of the configuration $(f_{7/2})^4 f_{5/2}$, which has energy probability of corresponding to the level 1177 keV (5/2⁻, 7/2⁻ or 9/2⁻) proposed in the present work. Owing to the strong preponderance LIPS-McELLISTREM state to exist of the configuration $(f_{7/2})^4 f_{5/2}$ in the level ∿1150 keV (5/2⁻), this level cannot be antecipated by most of the calculations available, which, with a few exceptions, do not consider such configuration.

+ - The matrix elements of the residual interaction are taken as free parameters and fitted to·experimental data.

++ - The residual interaction is a surface δ interaction.

+++- The residual interaction is expressed with the matrix elements of Kuo-Brown[16].

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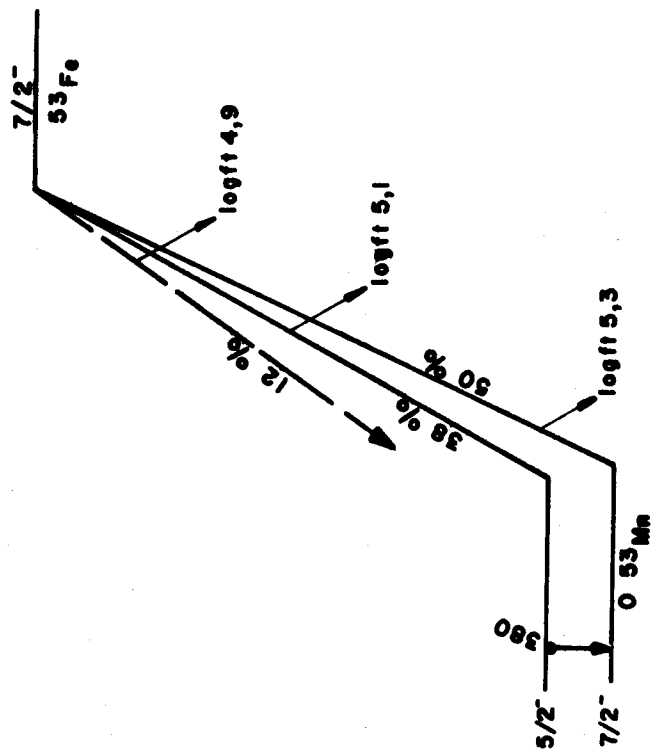16 - KUO,T.T.S. & BROWN,G.E.- Reaction matrix elements for the 0f-1p shell nuclei.   Nucl.Phys., 114A:241-79, 1968.
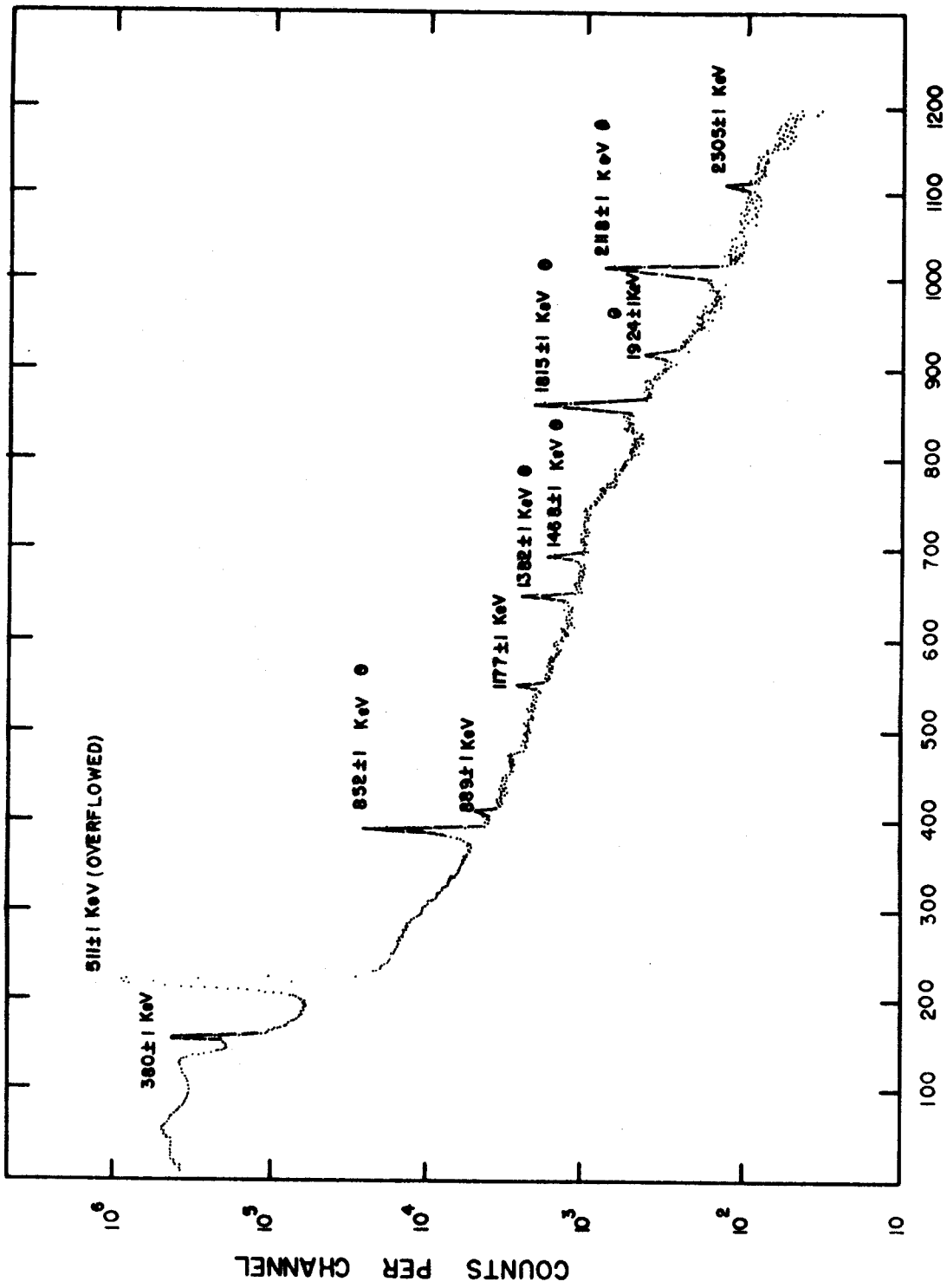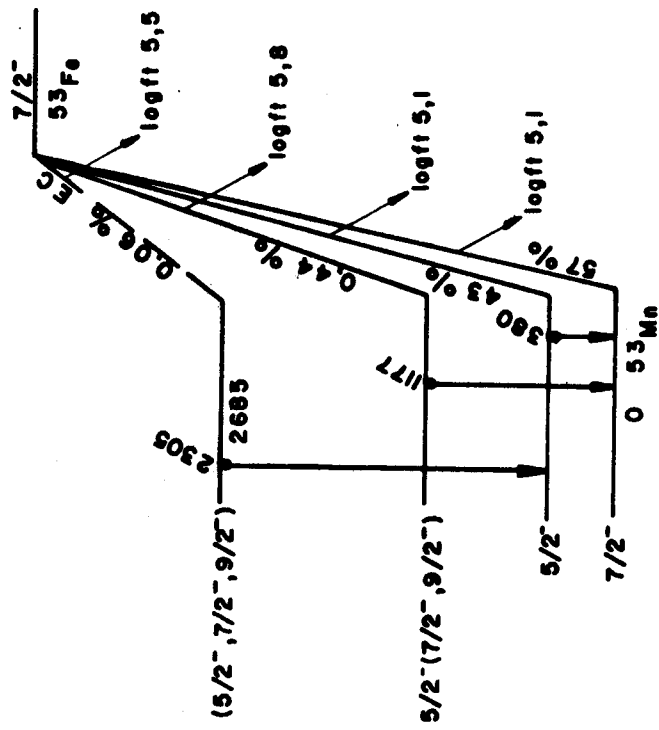
γ – RAY SPECTRUM FROM ^{53}Mn

FIGURE I

Θ LONG LIVIED TRANSITION

FIGURE II
DECAY SCHEME OF ^{53}Fe
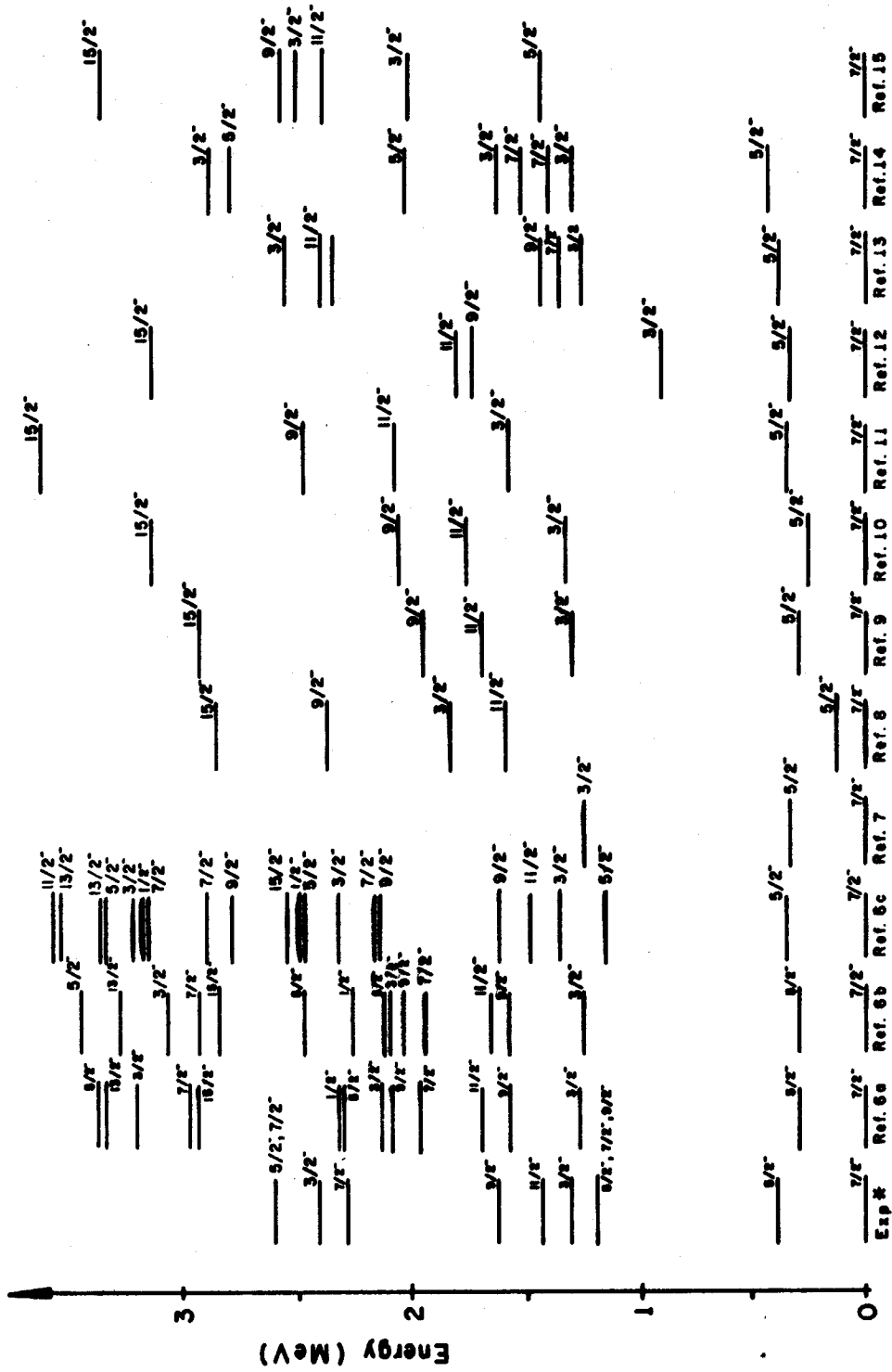
A) PREVIOUS PAPERS 4,5

B) PRESENT WORK

FIGURE III

Experimental and theoretical energy levels of ^{53}Mn

* REF. 6 AND PRESENT WORK