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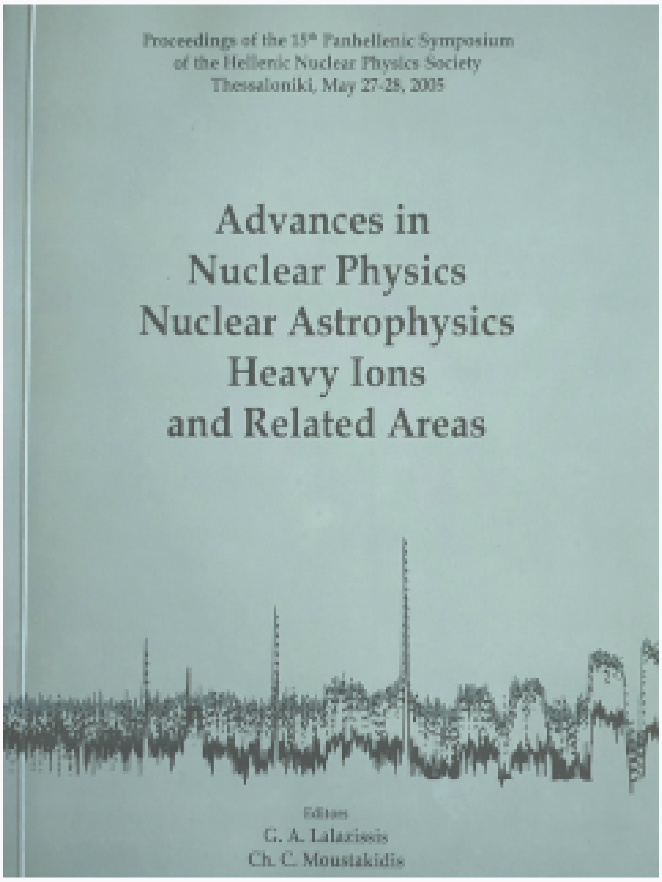

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Decay properties of high spin states in Mn

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Abstract

The electromagnetic decay properties of high spin states in ^{52}Mn have been studied through various experiments with the GASP and EUROBALL arrays plus the ISIS charged-particle detector, the Neutron-Wall and the Recoil Filter Detector. From γ-γ-particles coincidence measurements, spins and parities of these states have been determined and using the Doppler-shift attenuation method the mean life of some of these states have been determined. These results are compared with large scale shell-model calculations in the full *fp* shell.

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1 Introduction

The study of high spin states in N∼Z $f_{7/2}$ nuclei is of current interest. Recent important improvements both in the theoretical and experimental sides have allowed to understand different properties such as collective behavior, band termination, backbending and other related phenomena.

In the present work we report new experimental data on the odd-odd $N = Z+2$ nucleus ^{52}Mn. High spin states of both positive and negative parity have been observed up to an excitation energy of ≈16 MeV.

2 Experimental Procedure

The present data of ^{52}Mn were taken from several different experiments. Two of them were performed with the EUROBALL [1] spectrometer. In the first experiment it was combined with the 4π charged-particle detector ISIS [2] and the Neutron-Wall [3]. The reaction used was ^{28}Si(^{28}Si,3pn) at 110 MeV beam energy with a 850 μg/cm^2 Si target (enriched to >99.9%) evaporated on 15 mg/cm^2 of gold backing. For the second experiment, EUROBALL was combined with the Recoil Filter Detector (RFD) [4]. In this case the same reaction was used at a bombarding energy of 125 MeV, but the target was self-supporting with a thickness of 400 μg/cm^2. We also examined data obtained in two other experiments preformed with the 4π GASP γ-ray array [5] and the 4π charged-particle detector ISIS. The reactions used were ^{24}Mg(^{32}S,3pn) at 130 MeV bombarding energy and ^{28}Si(^{28}Si,3pn) at 115 MeV beam energy. In the first case the target was self-supported with a thickness of 400 μg/cm^2, while in the second a ∼ 800 μg/cm^2 ^{28}Si target (enriched to >99.9%) evaporated on a 13 mg/cm^2 of gold backing was used.

All of the above mentioned experiments were performed at the XTU Tandem accelerator of the Legnaro National Laboratory, except the thin target EUROBALL experiment which took place at the VIVITRON accelerator of IReS at Strasbourg.

3 The Level Scheme and Discussion

From previous works, the level scheme was known up to the 10^+ level at 4161 keV of excitation energy. In the present work we were able to extend the level scheme to much higher spins observing 25 new levels and 59 new γ-transitions, including a new negative parity structure. The spins and parities

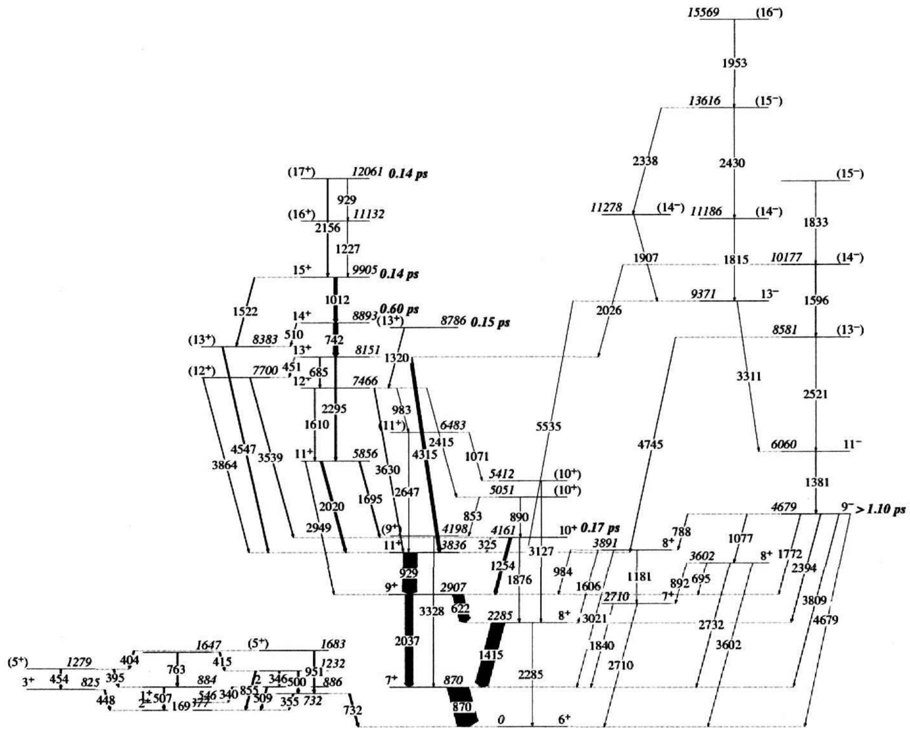

Fig. 1. *Level scheme of* ^{52}*Mn as obtained in the present work. In bold the lifetimes measured are marked.*

of the observed levels were assigned by angular distribution and Compton polarization measurements. The resulting level scheme is shown in Fig. 1. Also some lifetimes were measured, using the Doppler-shift attenuation method and they are marked in bold in the figure.

Large scale shell model (LSSM) calculations in the pf shell have been performed for ^{52}Mn with the code ANTOINE [6] using the KB3G [7] interaction. For the positive parity states the results are in very good agreement with the experiment as it can be seen in Fig. 2.

From the calculated fractional occupation numbers ($FON = \frac{Occupation\ Number}{2j+1}$, where j is the spin of each orbital) of the positive parity states, shown on the left panel of Fig. 3, we observe that up to the band termination (11^+_1 state) the neutrons act as spectators and the spin increment is generated mostly from proton alignment. This behavior reminds us that of ^{51}Mn above the $17/2^-$ states [8,9] and in fact comparing the level schemes for the states in question on the right panel of Fig. 3 we see that they are very similar.

The higher spins (starting from the 11^+_2 up to 16^+) are obtained promoting one neutron to higher subshells. A high degree of collectivity is observed for

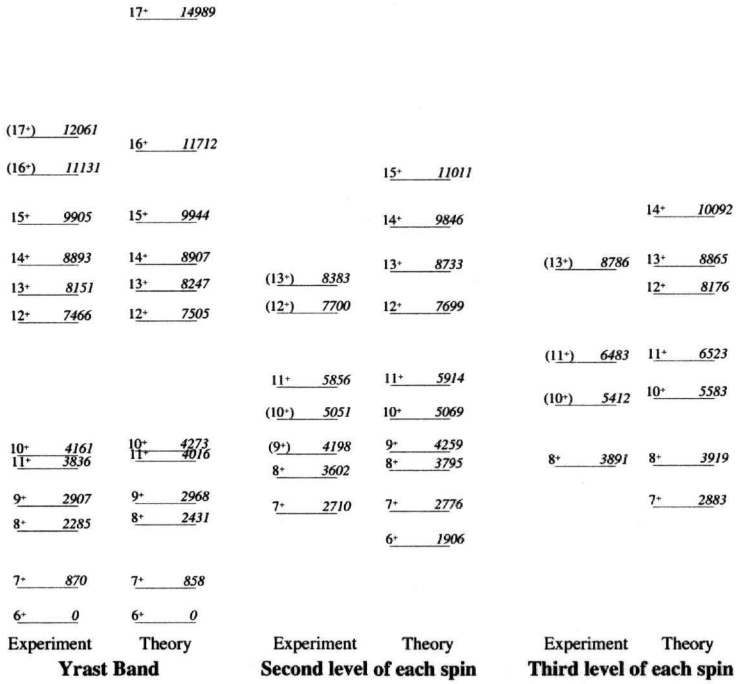

Fig. 2. *Comparison between experimental data and Shell-model calculations.*

the first states which then gradually reduces with increasing angular momentum. In fact for the highest spin states we observed very few $E2$ connecting

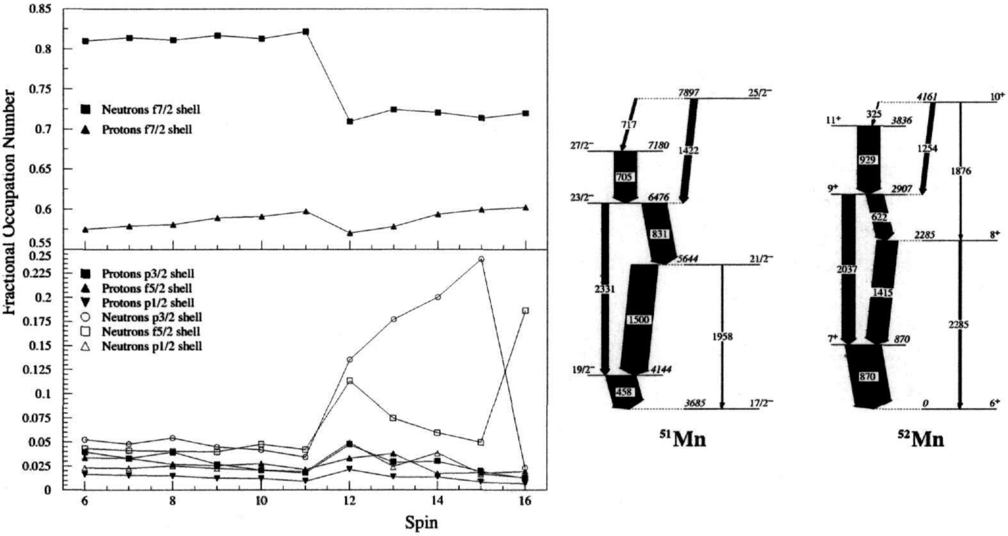

Fig. 3. *In the left panel we see the calculated fractional occupation numbers for the positive parity states of* ^{52}Mn *, while in the right one we see the comparison of* ^{52}Mn *to* ^{51}Mn *level scheme.*

transitions. The possibility of magnetic rotations was explored but the $B(M1)$ (experimental and theoretical) values do not behave as expected for this phenomenon.

Finally, a negative parity band was observed, which cannot be explained in the context of a $d_{3/2}$ hole. As in other neighboring nuclei (^{50}Mn [10] and ^{52}Fe [11]) it is believed that the configuration of the band-head (9^-) corresponds to the coupling of an octuple vibration to the ground state. For this reason the calculations are not in a good agreement with the experiment, as the shell space should be extended to the $g_{9/2}$ orbital, which for the time being is not possible. This hypothesis is enhanced from the fact that the excitation energy for these negative parity bandheads in the mentioned nuclei is very similar as it can be seen in Fig. 4.

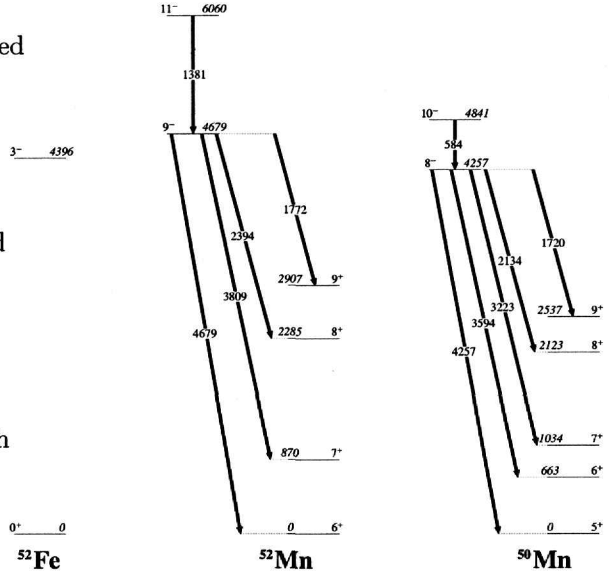

Fig. 4. *Negative parity bandhead energy comparison for nuclei in this mass region.*

4 Summary

In the present work a complete spectroscopic study of ^{52}Mn is presented. The level scheme is considerably extended and also some lifetimes were measured. Complete large scale shell model calculations were performed and found in very good agreement with the experimental data, apart from the negative parity structure. The bandhead of this structure is believed to originate from the coupling of the ground state with an octuple vibration.

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