DECAY PROPERTIES OF HIGH SPIN STATES IN ^{52}Mn AND ^{52}Fe *

M. Axiotis, A. Gadea, N. Mărginean, D.R. Napoli G. de Angelis, M. De Poli, T. Martínez

Laboratori Nazionali di Legnaro, Legnaro, Italy

S.M. Lenzi, C.A. Ur, F. Brandolini, D. Bazzacco, E. Farnea C. Rossi Alvarez, S. Lunardi

Dipartimento di Fisica and INFN, Padova, Italy

C.A. Kalfas

Institute of Nuclear Physics, NCSR Demokritos, Athens, Greece

A. Algora, D. Cano-Ott, E. Nácher, B. Rubio, J.L. Tain

Instituto de Física Corpuscular, Valencia, Spain

R. Borcea, J. Döring, M. Gorska, H. Grawe, M. La Commara, C. Mazzocchi, and E. Roeckl

Gesellschaft für Schwerionenforshung mbH, Darmstadt, Germany

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The electromagnetic decay properties of high spin states in ^{52}Mn have been carried out with the GASP and EUROBALL arrays combined with the charged-particle detector ISIS and the Neutron-Wall. From the coincidence measurements in these experiments new high spin states were placed in the ^{52}Mn level scheme. In a recent experiment performed at the on-line mass separator at GSI, the decay properties of the 12^+ yrast trap in ^{52}Fe have been investigated. Two E4 gamma branches to the 8^+ states in ^{52}Fe have been observed for the first time and the beta decay into high spin states in ^{52}Mn has been revisited.

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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 present new experimental and theoretical results for the structure of high spin states in ^{52}Mn (Section 2) together with the decay properties of the 12^+ yrast trap in ^{52}Fe (Section 3).

2. High spin γ-spectroscopy of ^{52}Mn

The present data of ^{52}Mn were taken in three different experiments, one performed with the 4π γ-array EUROBALL III combined with the light charged-particle detector ISIS [1] and the Neutron-Wall [2], while the other two were performed with the GASP [3] spectrometer plus the ISIS array. The reactions used was ^{28}Si on gold backed ^{28}Si target at 110 MeV (EUROBALL experiment) and 115 MeV (GASP experiment) and ^{32}S on a self supported ^{24}Mg target at 130 MeV (GASP experiment).

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 and also to observe a new negative parity structure. The spins and parities of the observed levels were assigned by angular distribution and Compton polarization measurements. The resulting level scheme is shown in Fig. 1.

Large scale shell model (LSSM) calculations for ^{52}Mn have been performed with the code ANTOINE [4] using the KB3G [5] interaction. For the positive parity states the results are in very good agreement with the experiment.

From the calculated fractional occupation numbers we observe that up to the band termination (11^+_1 state) the neutrons are spectators and the spin increment is generated mostly from proton alignment. 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 obtained for the first states which then gradually reduces with increasing angular momentum due to the alignment of nucleon spins. The 15^+ state corresponds to the fully aligned $(f_{7/2})^{11}\nu(p_{3/2})^1$ configuration, while for the 16^+ the calculated configuration is $(f_{7/2})^{11}\nu(f_{5/2})^1$.

Finally, a negative parity band was observed. As in other neighboring nuclei (^{50}Mn [6] and ^{52}Fe [7]) it is believed that the configuration of the band-head (9^-) corresponds to the coupling of an octupole 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.

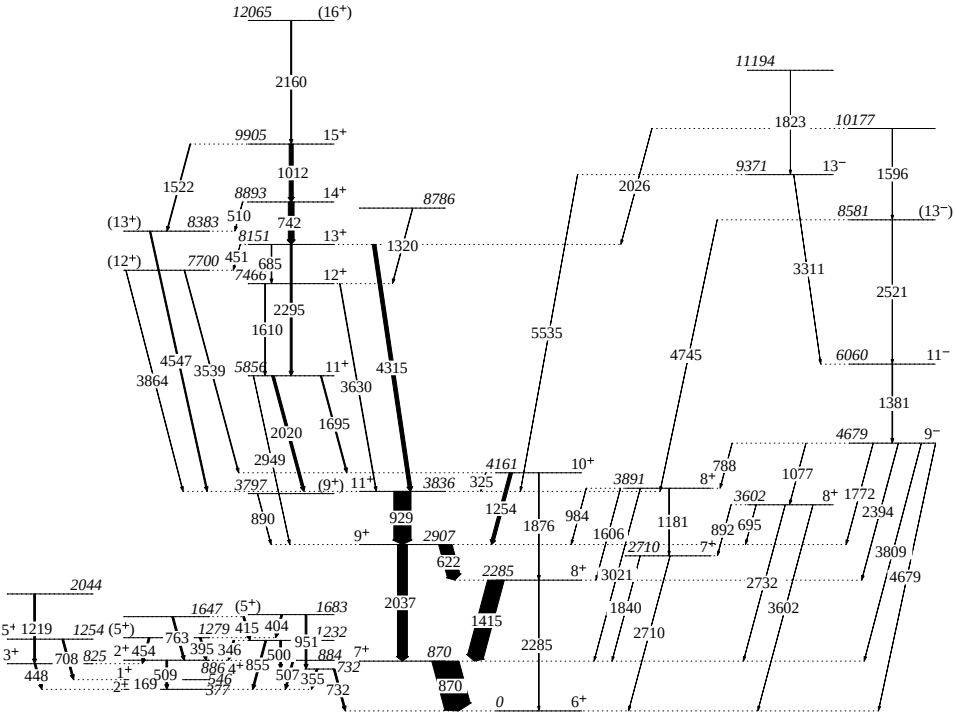

Fig. 1. Level scheme of ^{52}Mn as obtained in the present work.

3. Decay of the 12^+ yrast trap in ^{52}Fe

^{52}Fe is an interesting case to study because the spin inversion of the 10^+ with the 12^+ state, leads the 12^+ state to act as an yrast trap with a lifetime of 45.9 s. This isomer was only known from β^+-decay studies and its excitation energy was known with large inaccuracy [8]. From an experiment performed at the GSI on-line mass separator with ^{36}Ar beam of 209 MeV on $^{\mathrm{nat}}$Si target, using two composite germanium detectors (a Cluster [9] and a large Clover [10]), a 60% single Ge crystal and a plastic scintillator, we were able to observe two E4 γ-transitions from the 12^+ isomer into the two recently observed 8^+ states [7] (see Fig. 2). These decays determine the excitation energy of the 12^+ state to be 6957.5(5) keV.

The main decay channel of the 12^+ isomer is the β-decay process into ^{52}Mn. Only the 11^+_1 state of ^{52}Mn at an excitation energy of 3837 keV was known to be populated till now in this decay [8]. In the present work the decay to the second 11^+ state at excitation energy of 5856 keV was observed with probability of 0.5%, quite close to that predicted by LSSM calculations. In order to study better the population to these and other higher lying states we have performed a second experiment using the total

absorption technique. Although the analysis is not yet finished, the observed feeding is in good agreement with the theoretical predictions.

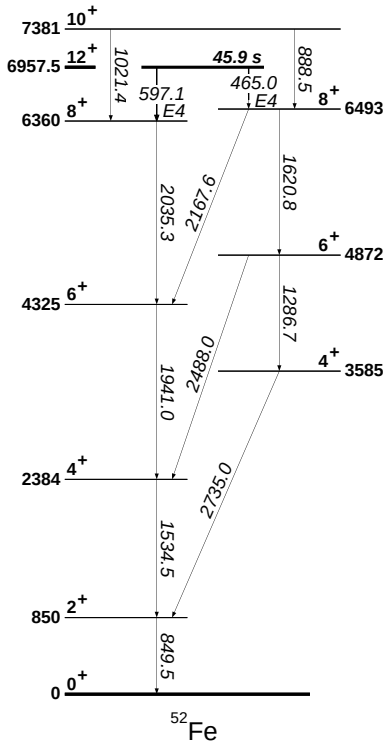

Fig. 2. Level scheme of ^{52}Fe showing the two E4 transitions decaying out of the 12^+ state.

4. Summary

In the present work we have extended considerably the existing level scheme of ^{52}Mn. We have also observed, for the first time, two E4 transitions decaying out from the 12^+ isomeric state of ^{52}Fe, allowing us to determine the excitation energy of that state. The β-decay of the 12^+ has been also analyzed. Further details will be given in forthcoming papers.

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