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Levels of two-particle and gamma bands in ^{192}Ir

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Abstract

Level scheme of the transitional doubly odd nucleus ^{192}Ir is analysed in detail up to about 530 keV energy using earlier published experimental data of neutron capture and particle transfer reactions. A number of new levels are proposed. Obtained ^{192}Ir level scheme is interpreted in terms of particle-plus-rotor coupling model. It is shown that the long-lived 241 year isomer of ^{192}Ir has spin-parity 11^-, just like the analogous states in neighbouring ^{190,194}Ir.

Keywords: ^{192}Ir neutron capture and transfer reaction data analysis; ^{192}Ir deduced levels, I^{π}; ^{192m_2}Ir isomer; ^{192}Ir rotational bands; Nilsson two-quasiparticle configurations; Gamma-bands; Gallagher–Moszkowski doublets

1. Introduction

For a long time ^{192}Ir was known as extremely complicated transitional doubly odd nucleus. However, in the beginning of 1990-ties two fundamental studies of ^{192}Ir levels were published.

In the paper of Kern et al. [1], two long-standing problems for understanding the ^{192}Ir nuclear structure were solved. The model independent level scheme of ^{192}Ir was developed resulting from the work of international team of 31 co-authors, and the ground state parity of ^{192}Ir was deduced to be positive. The level scheme, based on strong criteria, included 35 levels up to 531 keV energy. The established level scheme of ^{192}Ir was partially analysed using the rotor-plus-particle

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coupling (RPC) model and the Gallagher–Moszkowski (GM) rule. The 351.7 keV 2^+ gamma band of the 4^+ ground state was proposed.

Ground state parity was deduced from the orientation study of ^{192}Ir nuclei in Fe (see Subsect. 2.8 in [1], and references therein). Magnetic moment of the ^{192}Ir ground state was measured and the measured value was compared with theoretical predictions for three possible spin 4 configurations. Since there was no fit with a single structure, a strongly mixed proton–neutron configuration was assumed.

The above results solved difficulties for establishing the ^{192}Ir level scheme. The 56.7 keV E3 transition was placed between the ^{192m_1}Ir 1^- isomer state ($T_{1/2} = 1.45$ min), and the 4^+ ground state. Spins and parities 1^-, 2^-, and 3^- were assigned to the most of low-lying levels connected by M1, E2, and M1+E2 transitions.

Several years later, Garrett and Burke [2] published a study of ^{192}Ir levels using charged particle transfer reactions. This study contained excitation energies and transition strengths obtained from scattering of secondary particles measured by magnetic spectrometer. Impressive amount of data was published on (d, t), (d, p), $(^3\mathrm{He}, \alpha)$, (p, α) reactions. This work resulted in a partially alternative interpretation of the ^{192}Ir level structure differing in several important points from that proposed by Kern et al. [1].

Meanwhile, two large studies of the neighbouring ^{194}Ir nucleus have been published [3,4]. These studies have shown that there are two questions about ^{192}Ir which should be answered: (1) is ^{192}Ir structure more "deformed" than that of ^{194}Ir; (2) are there 11^- long-lived isomers in both ^{192}Ir and ^{194}Ir nuclei, as predicted by available proton–neutron configurations?

The aim of present work is to perform a consistent structure analysis of the ^{192}Ir low-lying levels from a viewpoint of today's experience. We include a reevaluation of the $K^\pi = 1^-$, 2^-, 3^- band heads and rotational levels since Ref. [1] contains no proposals for levels of the third 1^- band, and two expected 2^- bands. We search for all band heads predicted by the lowest proton–neutron configurations in the frameworks of RPC model, and, as far as possible, for additional rotational levels. Since ^{192}Ir is expected to be more "deformed" than ^{194}Ir [4] we will try to find more regularity in the level scheme of ^{192}Ir.

One of present authors (M.B.) made a report on the structure of ^{192}Ir at the CGS 9 Symposium in 1996 [5]. However, the ^{192}Ir level scheme proposed in that report was regarded as tentative since existence of several low energy levels, especially the 6^+ 13 keV, and the 6^- 16 keV level, was not registered in transfer reaction experiments.

The present paper has the following sections: (Section 2) analysis of available experimental data including the low-energy gammas and transition multipolarities, as well as the high energy gammas, ARC population rates, and transfer reactions; (Section 3) discussion covering bands and levels, the long-lived isomer ^{192m_2}Ir, and final comments, including structure comparison between low-lying level schemes of ^{190,192,194}Ir; (Section 4) conclusions.

2. Analysis of experimental data

2.1. Low energy capture gamma-ray spectra and ICC values

Kern et al. have presented a compact table of low energy radiation data in Table 2 of Ref. [1]. This table contains about 300 transitions with energies ranging from 19 to 633 keV. However, only 118 transitions have been placed in the level scheme of ^{192}Ir deduced in [1]. Many of the