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Isospin and F-spin symmetry structure in low-lying levels of ^{48,50}Cr isotopes*

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The low-energy level structure and electromagnetic transitions of ^{48,50}Cr nuclei have been studied using the interacting boson model with isospin (IBM-3). A sequence of isospin excitation bands with isospin $T = T_z$, $T_z + 1$ and $T_z + 2$ has been assigned, and compared with available data. According to this study, the 2_3^+ and 2_2^+ states are the lowest mixed symmetry states in ^{48}Cr and ^{50}Cr, respectively. In particular, the present calculations suggest that a combination of isospin and F-spin excitation can explain the structure in these nuclei. The transition probabilities between the levels are analysed in terms of isoscalar and isovector decompositions which reveal the detailed nature of the energy levels. The results obtained are in good agreement with recent experimental data.

Keywords: IBM-3, isospin, mixed symmetry states, ^{48,50}Cr isotopes
PACC: 2160F, 2740, 2100H

1. Introduction

The interacting boson model (IBM)[1−3] is capable of giving a simple yet realistic description of nuclear collective motions. In its original version (IBM-1), only one kind of boson is considered, corresponding to fully proton neutron symmetric states. The neutron–proton extension of the model (IBM-2), predicts a new class of states[4] having mixed symmetry in the proton and neutron degrees of freedom, and it has been successfully observed in various experiments.[5−7] The interacting boson model has been successful in describing various properties of medium and heavy nuclei.[8−11]

In lighter nuclei, the valence protons and neutrons fill the same major shell and isospin should be taken into account. In order to include the isospin, IBM has been extended to the interacting boson model with isospin (IBM-3).[12] In IBM-3 three types of bosons are included: proton–proton (π), neutron–neutron (ν) and proton–neutron (δ), which forms the isospin $T = 1$ multiplet. The ν, δ and π bosons have the isospin projections $M_T = -1$, 0 and 1, respectively. The wavefunctions can be classified by the $U_c(3) \supset SU(2)_T$ group,[12] where $SU(2)_T$ is the usual isospin group. Dynamical symmetries of the IBM3 have been studied in Refs.[13–18]. The $U_{sd}(6)$ of IBM-1 goes to the $U(18)$ group for IBM-3 as its dynamical symmetry group. The natural chains below $U(18)$ start with $U_{sd}(6) \times U_c(3)$, and they must contain $O(3)$ and $SU_T(2)$ as subgroups because the angular momentum and the isospin are good quantum numbers. The $U_c(3)$ charge symmetry was described in detail in Ref.[19]. The chains beginning with $U_{sd}(6) \times U_c(3)$ and satisfying the above requirement are the following:[13]

$$\begin{aligned} &U(18) \supset (U_c(3) \supset SU_T(2)) \times (U_{sd}(6) \supset U_d(5) \supset O_d(5) \supset O_d(3)), \\ &U(18) \supset (U_c(3) \supset SU_T(2)) \times (U_{sd}(6) \supset O_{sd}(6) \supset O_d(5) \supset O_d(3)), \\ &U(18) \supset (U_c(3) \supset SU_T(2)) \times (U_{sd}(6) \supset SU_{sd}(3) \supset O_d(3)). \end{aligned} \tag{1}$$

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