M1-E2 Mixing ratios and B(E2) values for transitions in ^{131}Xe

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Introduction

The accuracies of M1-E2 mixing ratios calculated from the experimental conversion coefficients α_i depend upon the accuracy with which the conversion coefficients are determined and also on the accuracy of the theoretical values. Recently a new calculation of ICCs by Band et al [1] , BRICC has been published. The calculations are based on the relativistic DF method in which the exchange interactions between bound electrons and free electrons receding to infinity during the conversion process are treated exactly. Gerl et al [2] showed that BRICC values are more closer to experimental values when compared to earlier theoretical values of Hager and Seltzer [3] and Rosel [4]. The availability of the BRICC values is expected to increase the accuracy with which the estimated quadrupole contents can be obtained.

The nucleus ^{131}Xe belongs to the group of odd-mass nuclei below the closed neutron shell at 82 neutrons. The positive-parity states in the light isotopes of xenon and barium represent a rich area for study. Several single-particle levels play important roles in determining the low-lying structure in these nuclei, and the couplings are strong . Hence, some mechanism in which these several fermion degrees of freedom can be treated must be employed when trying to describe these states .Kisslinger and Sorensen's pairing plus quadrupole interaction calculations [5] correctly reproduced the low energy levels of the odd-mass Xe isotopes. Cunningham [6] has reported the interacting Boson Fermion Model (IBFM) calculations for the energy levels and , mixing ratios and reduced transition probabilities for the ^{131}Xe nucleus. The ideal testing ground for any model predictions are the electromagnetic moments. The $^{125\text{-}133}$Xe nuclides would appear to be a particularly fertile ground for additional testing of IBFM calculations using the new core parameters in as much as the core Xe nuclides appear to have features that are reasonably well described by the O(6) limiting symmetry.

Experimental:

The radioactive ^{131}I source obtained from Bhabha Atomic Research Centre, Mumbai was investigated using 60 cc HPGe detector based gamma spectroscopy set up and a mini-orange electron spectrometer [8] for gammas and conversion electrons respectively with separate sources. Sources prepared by depositing liquid drops of a solution to a thin Mylar backing cannot be dried to give a homogeneous layer. Such effects are completely eliminated by first treating the backing foil with a thin layer of insulin. A drop of diluted insulin is placed on the foil and the excess insulin is removed by a dropper. Then, a drop of the source placed on it spreads immediately very uniformly. The deposit is then dried very slowly by slow evacuation in a desiccator. The sources were grounded with a thin layer of aquadag. The backing foils are 900 $\mu g/cm^2$ aluminized Mylar. The source thickness for the electron spectroscopy is of the order of 10 -100 $\mu g/cm^2$. Singles gamma spectra were recorded with counting periods lasting on an average 4.5 x 10^5 seconds per spectrum. Conversion electron spectra were recorded for a minimum of 10^5 seconds. Gamma and conversion electron spectra were analysed using the computer codes FIT and GMMAVISION. Twenty eight gamma transitions and 21 conversion electron lines have been analysed for the relative gamma and conversion electron intensities. Internal conversion coefficients have been determined using Normalised peak to gamma (NPG) method relative to the α_K value of

0.0192(11) for the most intense 364 keV gamma transition.` Table 1 shows the experimental α_K values for only the M1+E2 transitions along with their corresponding theoretical (BRICC) values for M1 and E2 multipolarities.

Table 1
Experimental and theoretical Internal conversion coefficients

E_γ (keV)	Internal Conversion Coefficients α_K		
		BRICC	
	Experimental	M1	E2
80.179	1.346 (78)	1.325	2.35
177.21	0.187 (11)	0.143	0.189
272.50	0.0456 (33)	0.0452	0.0468
318.07	0.0304 (32)	0.0302	0.0287
325.76	0.0285 (17)	0.0283	0.0266
364.48	0.0192 (11)	0.0213	0.0189
404.83	0.0151 (36)	0.0163	0.0139
722.90	0.00394 (25)	0.00394	0.00293

Mixing ratios have been determined for all the M1+E2 transitions, using the experimental α_K values and the corresponding BRICC values for M1 and E2 multipolarities with the formula:

$$\delta^2 = \frac{\alpha_{K,M1} - \alpha_{K,exp}}{\alpha_{K,exp} - \alpha_{K,E2}}$$

Table 2
Comparison of mixing ratios

E_γ (keV)	Transition	Mixing ratios $\|\delta\|$(exp)	
		Present	NDS'94
80.179 1	$1/2^+ \rightarrow 3/2^+$	0.0166 1	0.0165 5
177.21 1	$9/2^- \rightarrow 11/2^-$	4.05 24	4.3 4
272.50 2	$7/2^+ \rightarrow 5/2^+$	0.31 2	0.38 17
318.07 5	$5/2^+ \rightarrow 3/2^+$	0.109 11	0.11 8
325.76 2	$7/2^- \rightarrow 9/2^-$	0.221 13	0.23 4
364.48 1	$5/2^+ \rightarrow 3/2^+$	2.82 17	3.90 15
404.83 4	$3/2^+ \rightarrow 3/2^+$	1.01 24	1.0 9
722.90 4	$5/2^+ \rightarrow 3/2^+$	0.209 13	0.207 5

Table 2 shows the calculated mixing ratios for the transitions involved and a comparison with the NDS values. Using the experimentally determined mixing ratios δ^2 and the precise values of the life time of the given states, the reduced transition probabilities B(E2) have been calculated using the relation involving mixing ratio:

$$B(E2)\,(e^2 b^2) = \frac{0.56563 \times 10^2}{(1+\alpha)(1+\frac{1}{\delta^2})E_\gamma^5 T_{1/2}}$$

where $\alpha = \alpha_K + 1.33\alpha_L$, E_γ is in keV and $T_{1/2}$ in seconds.

Table 3
Comparison of experimental B(E2) values with IBFM predictions

E_γ (keV)	Experimental B(E2)		Theory
	Present	Palmer	IBFM
80.179	0.0024 (2)	0.0039 5	0.009
177.21	0.153 (13)	--	--
272.50	0.0059 (6)	0.004 2	0.003
318.07	0.374 (56)	<0.031	0.006
325.76	0.0014 (5)	--	--
364.48	0.111 (9)	0.10 1	0.08
404.83	0.144 (48)	0.057 4	0.065
722.90	0.023 (2)	0.013 1	0.019

Table 3 shows the experimental B(2) values calculated from the present mixing ratios and α values and the life times of the corresponding states from the literature. Also a comparison has been made among earlier measurements by Palmer et al, present work and the calculations based on Interacting Boson Fermion Model. It has been observed that the level structures of ^{131}Xe could well be understood in the frame work of IBFM. The computed energy spectra are in substantial agreement with the observed ones, as are the electromagnetic properties of the states.

References

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