On The Decay Of Cs^{132} TO Xe^{132}

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ÖZET :

Bu çalışmada Cs^{132} 'nin Xe^{132} 'ye bozunumundaki elektron spektrumunda en önemli dönüşüm çizgilerinin enerjileri hesaplanmıştır. Elektromagnetik geçişlerin çok kutuplu karışımları hakkında malumat edinebilmek için elektron spektrumu incelenmiştir. $_{55}Cs^{132}$ ve $_{54}Xe^{132}$ arasındaki kütle farkının tesbiti için gereken gözlemler tartışılmıştır.

SUMMARY :

In this work energies of the most prominent line in the electron specrum of the decay of Cs^{123} to Xe^{132} are calculated. The interpretation of the electron spectrum is made to yield information about the multipolarity of the electromagnetic transitions. The observation to be made to determine the mass difference between $_{55}Cs^{132}$ and $_{54}Xe^{123}$ is discussed.

INTRODUCTION :

The decay of Cs^{132} to Xe^{123} has a number of interesting features. In this work the most prominent Internal Conversion lines; the coefficients related to them; and the determinaion of masses of Cs^{123} and Xe^{132} were discussed.

THE PROMINENT INTERNAL CONVERSION LINES

The ciriterion to find the most prominent I.C. (Internal Conversion) lines is :

a) The probability of finding the K - shell electrons close to the nucleus is much grater than that of the L_1 , L_2 , L_3 etc. electrons.

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b) For the electrical multipole moments (I.C.) coefficients are inversely proportional to the $(l+5/2)$ th power of the energy of the transition. For magnetic multipole moments it is $(l+3/2)$.

c) I.C. coefficients increase with increasing multipole order «l» (and Z^3.)

All this show that conversion of K electrons for $(2^+ \rightarrow 0^+)$ is the most prominent line. However there is a weak contribution of M3 moment to $(4^+ \rightarrow 2^+)$ I.C. so :

$$(1^*)\ E_k^{(1)} = E_{(2^+ \rightarrow 0^+)} - B.E._k = 635.45 \text{ KeV}$$

$$(2^*)\ E_k^{(2)} = E_{(4^+ \rightarrow 2^+)} - B.E._k = 1295.45 \text{ KeV}$$

However new methods are developed. Yasuyiki Gono et. al. (1970) using iron - free β - ray spectrometer, could resolve the L_I L_{II} L_{III} lines, with some doupt in L_{III}. So we may expect

$(2^+ \rightarrow 0^+)$ $E_{L_1} = 644.55$ KeV
$E_{L_2} = 664.90$ KeV
$E_{L_3} = 665.22$ KeV
$(4^+ \rightarrow 2^+)$ $E_{L_1} = 1324.55$ KeV
$E_{L_2} = 1324.90$ KeV
$E_{L_5} = 1325.22$ KeV

To observe the Auger electrons one must overcome the noise due to the apparattus, also they should be separated from x - rays.

I.C. COEFFICIENTS

According to Weiskopfh or Evans, our excited Xe^{132} is a parity favored nucleus. This has the following selection rules: {Predominant radiation: $E\Delta I$}+{Weak admixure of: $M(\Delta I+1)$ if both I_a and $I_b \neq 0$} where $\Delta I = |I_a - I_b|$. Surely then according to the theory we have :

E2+M3 for $(4^+ \rightarrow 2^+)$ and E2 for $(2^+ \rightarrow 0^+)$, if there is no spin change in nucleus, above multipolarities exist and the I.C. coefficients are mostly due to electric quadropole moments and they are, to a good approximation given by :

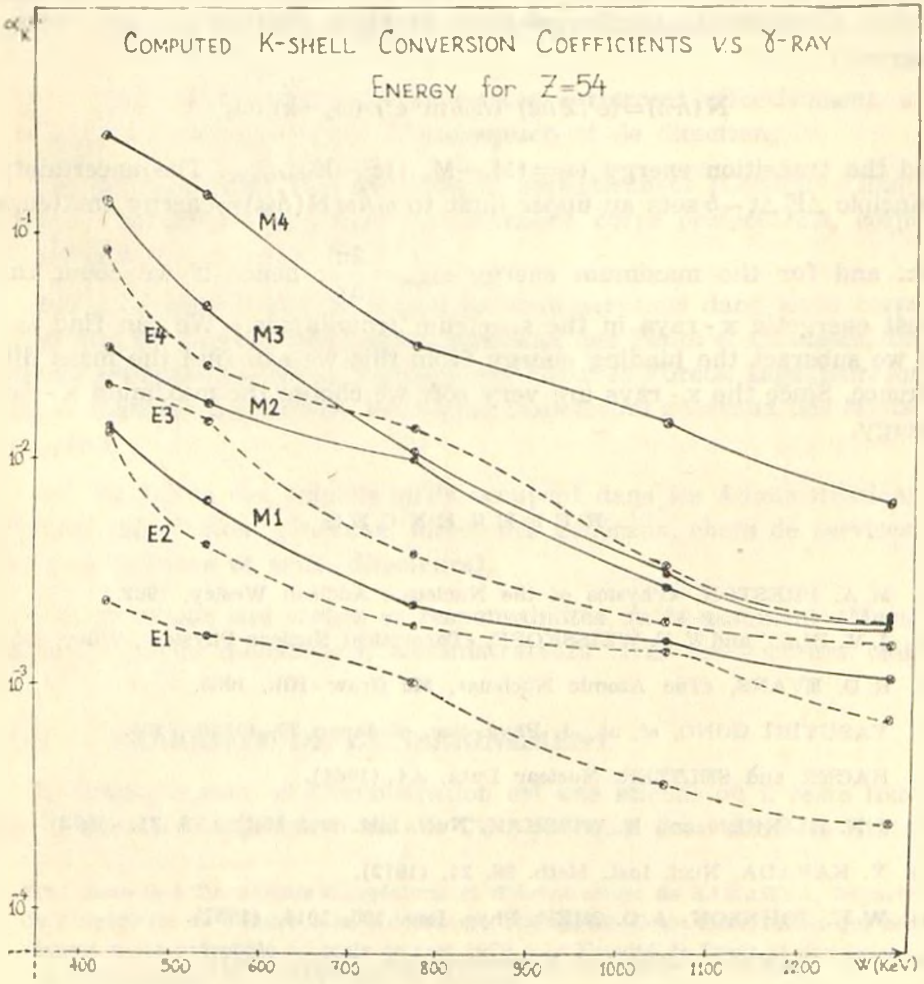
$$(\alpha_K)_{el.} \approx \frac{1}{l+1} Z^3 \left(\frac{1}{137}\right)^4 \left(\frac{2\,m_0\,c^2}{\omega}\right)^{l+5/2}$$

$$(\alpha_K)_{mag.} \approx Z^3 \left(\frac{1}{137}\right)^4 \left(\frac{2\,m_0\,c^2}{\omega}\right)^{l+3/2}$$

The values of these two I.C. coefficients are plotted as a function of energy of the γ transition ω, in the following graph. The best assignement of quadropole moments to our nucleus by using I.C. coefficients can be made; if one can measure the coefficients and compare with this graph. However one should be careful when he chooses the type of experiment for such a measurement; e.g. Comparison with x - rays or Auger electrons should be very hard (or needs, more theoretical calculations) since there is an electron capture process which may involve the x - rays or Auger electrons at the same enery as the I.C.; Absolute counting would be good enough if there were no internal pair production, and no efficiency problem; Coulomb excitation is applicable for fast E2 (in collective nuclei.) Hence the best method should be the use of magnetic spectrometer method. This method is explained in detail in the references, but the main trouble is that the angular distrubution of the pohoto electrons can not be controlled. This can be overcome to a certain extend if one adjusts the position of the absorber such that a γ source of known intensity gives a correct number of photo electrons. The theoretical values for L_1, L_2, L_3 ... lines by using iron - free β - ray spectrometer. In most cases the L lines are all mixed in one peak, then one can measure $\alpha_K/\alpha_L = N_K/N_L$ (or usually $\alpha_K/\alpha_{(L+M)}$.) But this also depends on the measurement of α_K. It is found that α_K/α_L increases as ΔI increases; In our case $\Delta I = 2$ which may give a good value of α_L.

New experimental techniques developed in 1971: J.V. Klinken and K. Wisshak (1972) inform that they could obtain reasonable transmission curves for symmetric configurations of magnet, with various source distances. For the determination of I.C. coefficients and K/L ratios these transmission curves are said to be very promising. Y. Kavada (1972) developed a method of source preparation for various thicknesses of sources which are important for the electron scattering in the source.

The exceedingly weak positron line on the spectrum represents a kind of pair production in which monoenergetic positrons are emitted. This happens as follows: (i) The $(4^+ \rightarrow 2^+)$ decays by I. C. thus leaving a hole in the K shell (most probably). (ii) At the same time a pair production due to a 1.33 MeV γ ray (emitted by another nucleus) happens. If the e^- in the produced pair has the proper energy to fill the hole in the K shell described in (i), or if the pair production happens near this hole such that the produced e^- is captured in the K shell vacancy, before an outer shell electron fills it; and if this process is very favorable by other nuclei for all pair creations then we observe positrons with a definite energy in coincidence with the 0.67 MeV γ - rays. Of course with a very weak probability. (Together with this line one may observe a continious spectrum of β^+ with an end point energy much less than 1.33 MeV.)



Cs^{132} AND Xe^{132} MASSES

Neglecting the recoil energy of the nucleus and the rest mass of the neutrino (<2 eV) the condition for the electron capture gives

$$M_{_{55}Cs^{132}} - M_{_{54}Xe^{132}} = T_{\nu} + T_{\gamma} \; .$$

We can observe T_{γ} but T_{ν} may hardly be observed. The atomic masses are usually obtained by using mass spectrometers. On the other hand, one can deduce the masses of Cs^{132} and Xe^{132} by finding the mass differences of the possible (n, γ) reactions between the neighbouring isotopes as W. H. Johnson and A. O. Nier did. Yet there may be another possibility. Consider the number of Bremstrahlung emitted per unit energy interval :

$$N(\hbar\omega) = (e^2/2\hbar c)\ (\hbar\omega/m^2 c^4)\ (\omega_0 - k)^2/\omega_0^2$$

and the transition energy $\omega_0 = (M_Z - M_{Z-1})c^2 - E_{\text{binding en}}$. The uncertainty principle $\Delta E\,\Delta t \sim \hbar$ sets an upper limit to $\omega\hbar\omega N(\hbar\omega)$ = energy emitted/$\hbar$ sec. and for the maximum energy $\omega_{max} = \dfrac{2\pi}{\Delta t}$; hence if we count the most energetic x-rays in the spectrum (counts/sec.) We can find ω_0. If we subsract the binding energy from this we can find the mass difference. Since the x-rays are very soft we choose the maximum x-ray energy.

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