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Gamma Radiation from I^{128}

By H. Bosch, R. Radicella, P. Reyes and T. Urstein*

I^{128} disintegrates by K capture and β^- emission to two stable isobars, Te^{128} and Xe^{128} respectively. To this disintegration is assigned[1] a half-life of 24.99 min, K capture representing $6.3 \pm 0.7\%$ of the β^- emission.[2, 3] According to Mims and Halban[3] the X ray which appears in the disintegration of I^{128} originates in the tellurium isotope.

Wapstra and others[4] have observed two gamma rays of 0.445 and 0.980 Mev, and Germagnoli *et al.*[5] one of 0.430 Mev. The β^- and γ radiation from the disintegration of I^{128} has been reviewed in detail by Benczer *et al.*,[6] who observed gamma rays having energies of 0.455, 0.540, 0.750 and 0.990 Mev. Gupta and Jha[7] have also investigated the gamma spectrum and found rays of 0.440 and 0.980 Mev.

We continued the investigation of I^{128} in view of the fact that as Xe^{128} is an even–even nucleus with neutron number between 36 and 88, one of the vibration zones—according to Sharff-Goldhaber and Weneser[8] and Wilets and Jean[9]—should exist at an energy approximately double that of the first excited level, three levels of character 0+, 2+ and 4+. Since β^- transitions of I^{128} are permitted at levels 0+ and 2+ of Xe^{128} (as will be seen later), we may hope to observe 0+ and 2+ levels of the triplet. The latter is of particular interest, since we are not certain of the position of the 0+ level with respect to the 2+ and 4+ levels of the triplet.[10] Recent theoretical work by Raz[11] indicates that the 0+ level has a greater energy than the 2+ and 4+ and that the 2+ level is always below the 4+ level. We find a single example in which the three levels[12] (Cd^{114}) appear, and a nuclide in which we found the 2+, 0+ succession (Pd^{106}) (Ref. 13). In the latter case the energies of the two levels coincide within experimental error.

EXPERIMENT

(*a*) *Preparation of the source.* We have used various methods for the preparation of the source in order to control the purity of the sample. I^{128} was prepared by the irradiation of ethyl iodide with thermal neutrons and the iodine was separated by the Szilard-Chalmers method. We also obtained the same isotope of iodine by irradiating resublimated iodine with thermal neutrons. Finally, we irradiated very pure NaI with thermal neutrons and separated the iodine from the activity. In three cases we followed the half-life of the total β^- activity with a scintillation spectrometer, using an anthracene crystal, which gave the same results. Figure 1 shows the disintegration curve of the total β^- activity.

(*b*) *Measurements.* For the measurement of the energies and the relative intensities of the gamma radiation, we used a scintillation spectrometer of one channel with crystals of different sizes. Final measurements were carried out with a NaI(Tl) crystal of 5 x 5 cm and a Du Mont 6364 photomultiplier. In order to estimate the pile-up of gamma rays we measured various spectra at different source–crystal distances.

Figure 2 shows a typical spectrum of the gamma rays of I^{128} after corrections for the disintegration half-life. In this figure we show the spectrum for low energies. We were able to establish the following energies, expressed in Mev: 0.0275 (X rays of Te), 0.445 ± 0.005, 0.530 ± 0.005, 0.740 ± 0.010 and 0.975 ± 0.015 Mev.

In order to reduce the pile-up to the order of 1 per 1000 between the gamma ray of 0.445 Mev and its Compton background and the pile-up of the same ray with that of 0.530 Mev, we set the source–crystal distance at 13 cm.

Table 1 shows the relative intensities of the various gamma rays.

Table 1. Relative Intensities of the Various Gamma Rays from I^{128} Disintegration

Energy (Mev)	*Relative intensity (in relation to the most intense)*
0.445	100
0.530	10
0.740	3
0.975	2

DISCUSSION

From the measurements carried out we may conclude that the disintegration of I^{128} produces four gamma rays, the energies of which are: 0.0275 (X rays of Te), 0.445 ± 0.005, 0.530 ± 0.005, 0.740 ± 0.010 and 0.975 ± 0.015 Mev.

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* Comisión Nacional de Energía Atómica, Buenos Aires.

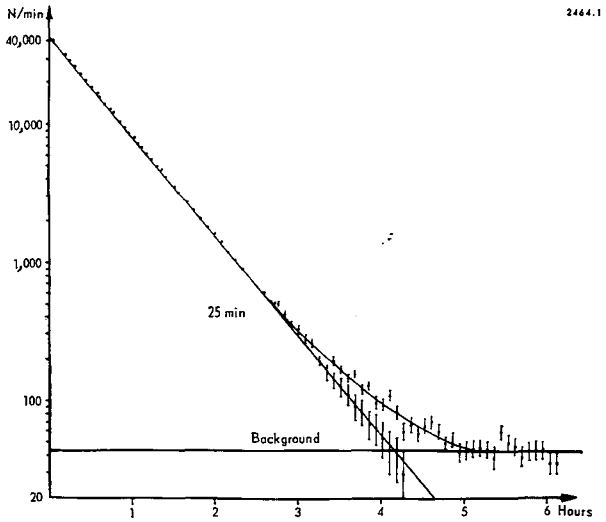

Figure 1. Decay curve of β^- activity of I^{128}

The ground level of the even–even nuclei has always the 0+ character.[10, 11] The first excited level, apart from a few exceptions, is of the 2+ character.[9, 11] We have represented in Fig. 3 the energies of the first excited level as a function of the number of neutrons in a series of Te and Xe nuclei. It seems logical to compare these energies, since the first excited state of all these nuclei has a 2+ character. This is not the case for the second excited states, the character of which is generally 2+ or 4+ and, occasionally, 0+ or odd.[9, 11]

From the results obtained by Temmer and Heydenburg[14] and from the curves of Fig. 3, we can assert that the gamma ray of 0.740 Mev corresponds to a transition between the two levels of tellurium. According to the same curves the gamma ray of 0.445 Mev corresponds to the transition between the first excited state and the ground state of Xe^{128}.

In accordance with the energies and relative intensities on the β^- radiation of the I^{128} obtained by other authors,[6] all the β^- transitions are permitted. As stated above, the characters of the ground state and the first excited state of Xe^{128} are 0+ and 2+

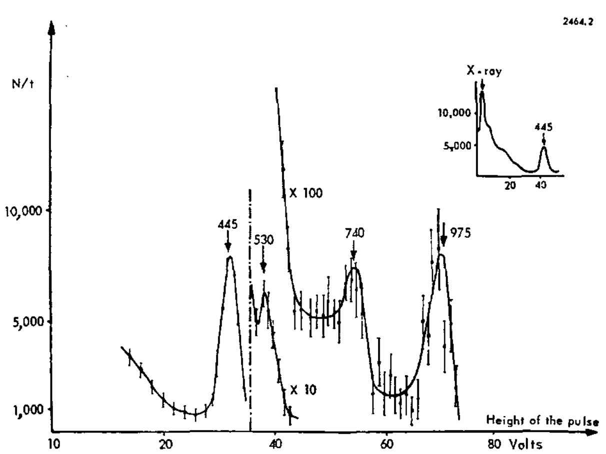

Figure 2. Gamma spectrum of I^{128} after correction for disintegration half-life

respectively; the character of the ground level of I^{128} is thus 1+. The latter may be accounted for by the model of layers if we assign a configuration of $d_{5/2}$ for the protons and $d_{3/2}$ for the neutrons. Accordingly, the character of the second excited level of Xe^{128} could be 0+, 1+ or 2+.

Generally, the second excited levels (collective levels) of the even–even nuclei have a 2+ or 4+ character.[9, 11] We did not observe the 1+ character for the second excited state of the even–even nuclei. This was established by Morinaga[15] who asserts that in the even–even nuclei the collective levels of odd parity have an odd spin. With this assumption we could exclude the 1+ possibility for the second excited level of Xe^{128}. Since the energy of the gamma ray of 0.975 Mev is 2.2 times 0.445 Mev and is the sum of 0.445 and 0.530 Mev, we could consider that this ray is a direct transition between the two. This corresponds to a transition between the second excited and the ground states; the possibility of character 0+ for the second excited level must, therefore, be rejected.

No line-splitting effect has been observed in the second excited state of Xe^{128}, even when the 0+ level could have been supplied by a permitted β^- transition. For the purpose of evaluating the energy and relative intensity of the possible gamma transition of the level 0+ to the first excited level 2+, we carried out an approximate computation of the various β^- transi-

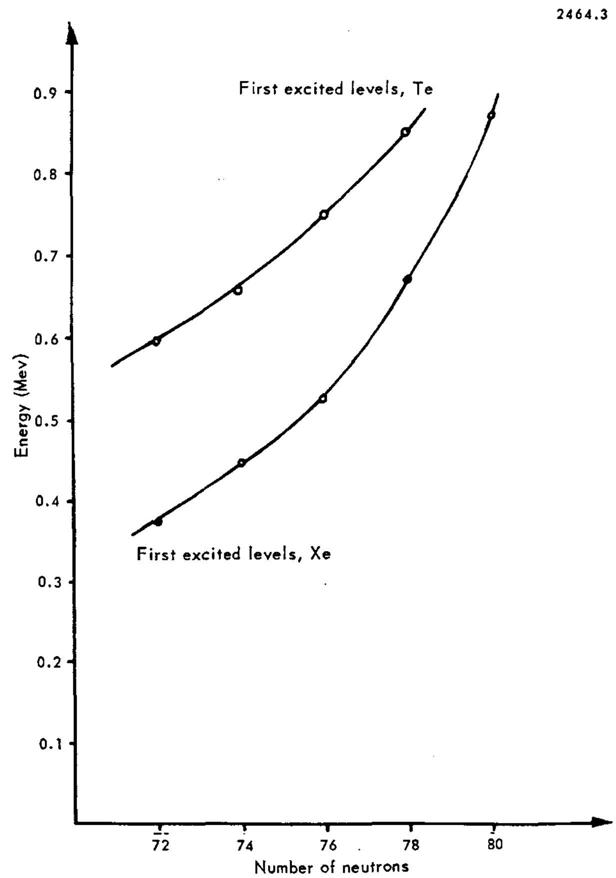

Figure 3. Energy of the first excited level of a series of Te and Xe nuclides, as a function of the number of neutrons

tions which would supply the 0+ level: if we assume a β^- transition at the second level 0+ with a log *ft* value of 6.5 to 7 and a gamma transition the intensity of which is at most 10% of that of 0.445 Mev, the energy would lie between 0.230 Mev and 0.440 Mev. If we now assume that this gamma transition has an intensity of at most 1% of that of 0.445 Mev, the energy would lie between 0.530 and 0.740 Mev. These evaluations are not in contradiction with the results of our experiments, since these energies and their relative intensities cannot be observed.

We shall, thereafter, endeavor to carry out an external conversion of the gamma rays from the disintegration of I^{128} and to observe the relevant lines of electrons in a β^- magnetic spectrometer of the "orange" type.

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