eγ DECAY

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A short report is given on the measurements of the eγ decay of ^{113}In, ^{137}Ba, ^{85}Rb, and ^{139}La, performed by our group in the "Rudjer Bošković" Institute.

eγ decay is a higher-order process, in which an atom in an excited nuclear state decays by simultaneous emission of two quanta, of an electron and a photon. The decay energy is shared amongst them in a continuous manner. This process is a nuclear counterpart of the radiative Auger effect.

The spins and parities of the initial and final states, multipolarities, and decay energies of the transitions we studied are

^{113}In	$1/2^- \rightarrow 9/2^+$	M4	393 keV
^{137}Ba	$11/2^- \rightarrow 3/2^+$	M4	662 keV
^{85}Rb	$9/2^+ \rightarrow 5/2^-$	M2	514 keV
^{139}La	$5/2^+ \rightarrow 7/2^+$	M1	166 keV

In the measurements, the double-coincidence (electron and photon pulses) and the triple-coincidence (electron, photon, and X-ray pulses) techniques were used. The data were recorded in three-dimensional pulse-height analyzers. The introduction of time dimension considerably improved the reliability of the measurements and made the analysis of data simpler.

Detailed measurements of the eγ decay of ^{113}In were made |1|. They include energy distributions, angular distributions, and an attempt to determine the low-energy part of the spectra. eγ decay involving K electrons (Kγ decay) was well resolved from higher-shell decays. Comparison shows that the experimental spectra for Kγ decay are in agreement with the theoretical spectra derived from the theory of Spruch and Goertzel |2|. In their theory Kγ decay is visualized as radiation of a photon by the conversion electron. Since the Feynman diagrams for the process are the same as the diagrams for the Compton effect, except for the replacement of the interaction of a free photon with a free electron, by the interaction of a nuclear virtual photon with a bound electron, they named the process the internal Compton effect (ICE).

In addition to the ICE mechanism, in which electronic intermediate states are involved in the process, "nuclear" eγ decay is also possible. The calculations, following the detailed theoretical analysis of Grechukhin |3|, have shown that in the investigated range of photon energies the ICE is the dominant process |1|. This is illustrated in the following table of integrated coefficients of Kγ decay:

	Spruch-Goertzel	Grechukhin	exptl.
$B_{K\gamma}$(35 to 105 keV)	1.09×10^{-3}	3.4×10^{-6}	1.11×10^{-3}

A comparison of the experimental data with the theoretical results of Spruch and Goertzel, Baumann and Robl |4|, and Chang and Falkoff |5| (internal bremsstrahlung in beta decay) is shown in fig. 1.

Along with the Kγ data the unresolved eγ decay from higher shells, the (L+M+N) decay, was measured, and it was concluded that also here electronic intermediate states are dominant.

In an earlier measurement |6| of the Kγ decay of ^{137}Ba,

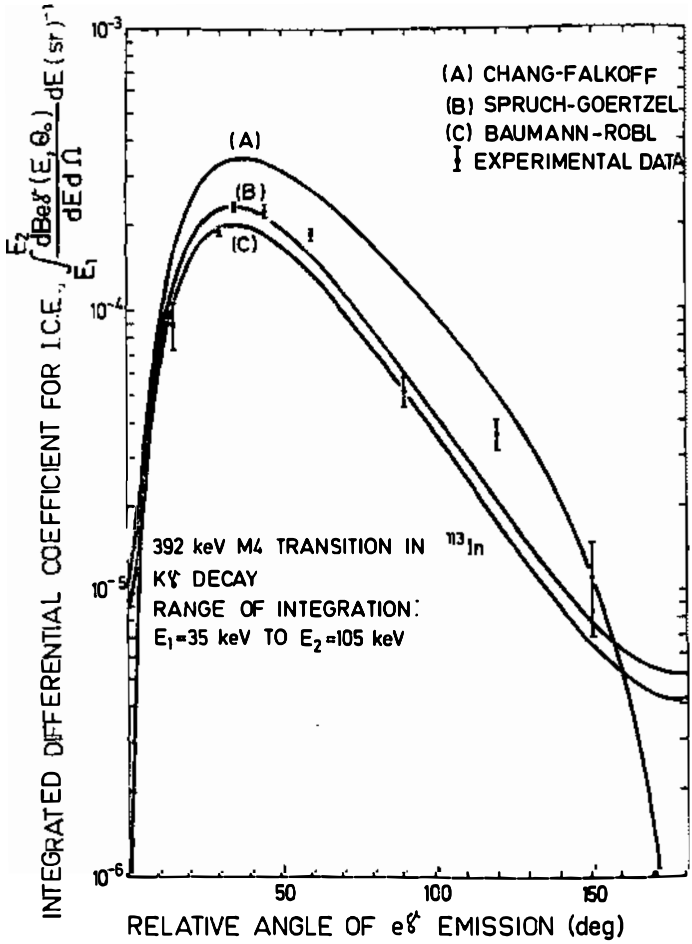

Fig.1. Comparison of the experimental values of probabilities of Kγ decay integrated per K conversion electron for the 393-keV M4 transition in ^{113}In as a function of relative angle of emission, with the values calculated from the theory of Chang and Falkoff, Spruch and Goertzel, and Baumann and Robl.

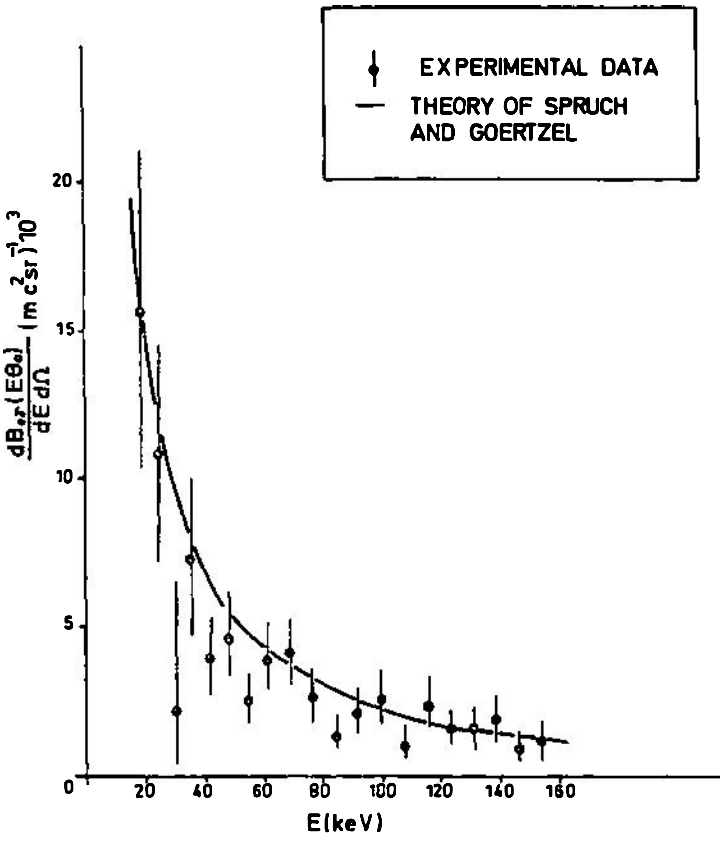

Fig.2. Differential probabilities of Kγ decay for the 662-keV M4 transition in ^{137}Ba per K conversion electron, as a function of photon energy, for a relative angle of emission of 27^{o}. The energy of the Kγ and K X-rays of barium are 32.2 and 36.4 keV, respectively.

in which a NaI(Tl) counter was applied to detect photons, an indication of disagreement with the theory of ICE was found in the low-energy range. For that reason the new technique of three-dimensional analysis of data and a high-resolution low-energy Ge(Li) detector were applied to determine the low-energy spectra of photons from the Kγ decay of ^{113}In at a relative angle of emission of 35^{o}, and from the Kγ decay of ^{137}Ba at 27^{o}. In both cases data below the K X-ray lines were obtained. The differential coefficients essentially agree with the theory of ICE. The data for ^{137}Ba are shown in fig. 2.

The eγ decay of the 154-keV state in ^{85}Rb was measured at relative angles of emission of 30^{o} |7| and 45^{o}. The data agree with the theory of ICE.

The same technique was applied to measure the eγ decay of the 166-keV state in ^{139}La at 30^{o}. The data are less accurate than those of the previous measurements, but it may be concluded that also for this M1 transition the theory of ICE is in agreement with the data.

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