E0 Conversion in ^{238}U in Heavy ion Collisions at Coulomb Barrier

M. Dębowski[1], A. Bałanda[1], F.W.N. de Boer[2], H. Bokemeyer[3], Th. W. Elze[2], J. Gerl[3], H. Hoogduin[4], J. van Klinken[4], P. Salabura[1], H.J. Wollersheim[3], H. Xie[3]

[1] Jagellonian University, Kraków
[2] Institut für Kernphysik, Universität Frankfurt
[3] Kernfysisch Versneller Institut, Groningen
[4] Gesellschaft für Schwerionenforschung, Darmstadt

We propose a Coulomb excitation study for E0 conversion in actinide nuclei. We expect the large amount of conversion electrons in transitions from $K = 0$ states with $\Delta I = 0$. By measurement of those electrons we can extend our knowledge about ^{238}U nuclear structure. Using standard γ-spectroscopy methods we can observe the ground-state rotational band up to spin 30^+ and the octupole band to spin 23^-, other collective bands are hardly seen[1,2]. In 1985 Venema et al.[3] measured excited levels in ^{232}U, ^{234}U and ^{232}Th in $^{232}Th(\alpha, xn)$ reactions. They used two mini-orange detectors. The strong presence of E0 conversions in $\Delta I = 0$ transitions has been observed (fig.1).

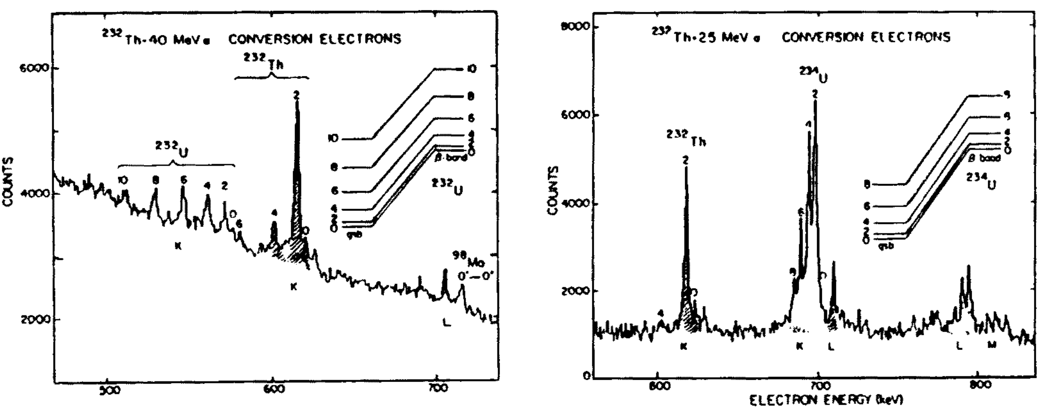

Fig.1 Prompt conversion electrons from $^{232}Th(\alpha, xn)$ reactions.

In nuclei, transitions between states with equal spin, parity and K-quantum numbers proceed predominantly through E2, M1 and E0 radiation. The contribution of E0 transition increases with Z. For instance, for excitation energy $0.5 - 1.0 MeV$, in nucleus with $Z \sim 80$, E0 transition probability increases as $\sim Z^{12}$, in contrast with E2 $\sim Z^{1.6}$ or M1 independent on Z. Also conversion coefficients for excitation energy $\sim 1.0 MeV$ for pure E2 transition is about three orders of magnitude smaller, than those coefficients for E2 and admixed E0 transitions. For example, α_{exp}(E0+E2) values for $\Delta I = 0$ transitions depopulating excited levels of two low lying $K = 0$ bands in ^{238}U are $6.7\pm^{7.0}_{3.0}$ and 4.4 ± 1.2 respectively[4]. Same transition in ^{232}Th has α_{exp} value of 17.0 ± 6.0[5]. These coefficients are incredibly high, one order of magnitude larger, than expected from nuclear structure of actinide nuclei ($\beta \sim 0.25$). If the conversion coefficients are spin independent or increase with spin, the main decay mode of excited levels of $K = 0$ bands is expected to be interband-conversion electrons more, than inband or interband γ-rays. Also $\Delta I = 0$ transitions from γ- to ground-state band have the E0 conversion contribution due to mixing with β-bands.

Up to now, we know two low lying $K = 0$ rotational bands with band heads $927keV$ and $995keV$, up to spin 4^+. The third $K = 0$ band has been found with band head $1482keV$[4,6] (see fig.2). Decay of that level will occur mainly through conversion electrons, but it is also possible to decay through Internal Pair Conversion. Although the branching ratio for this process is houndred times smaller, than for electron conversion, it is very interesting to measure the contribution of IPC to background in puzzling e^+-e^- peaks[7,8].

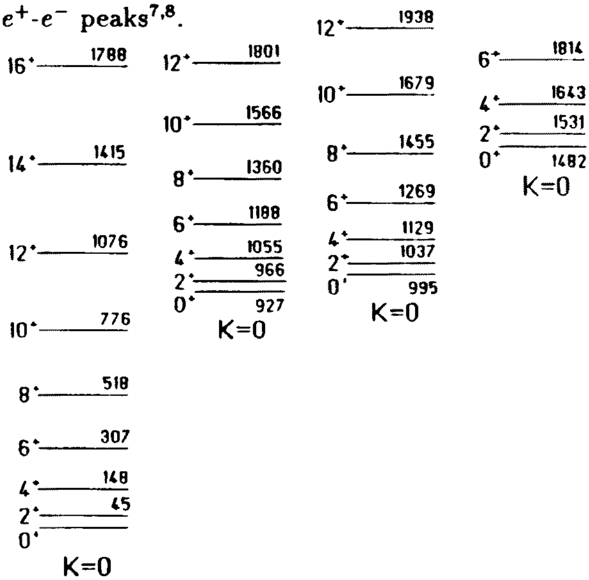

Fig.2 Decay scheme of ^{238}U.

We want to measure conversion electrons in very heavy systems under Coulomb barrier (e.g. $^{238}U +^{181} Ta$). In such experiments there is very high background of γ-rays and much higher, than in lighter systems δ-radiation ($\sigma_{\delta-electrons} \sim Z^2$). To suppress the background, we apply mini-orange energy filters. Doppler-broadening reduction, we can obtain moving our electron detectors with mini-oranges away from the target to reduce opening angle. For the opening angle of 1% of 4π, for $1MeV$ electrons Doppler-broadening is $\Delta E_D = 12keV$ to compare with $\Delta E_D = 140keV$ for 4π opening angle. The experimental setup looks as on fig.3.

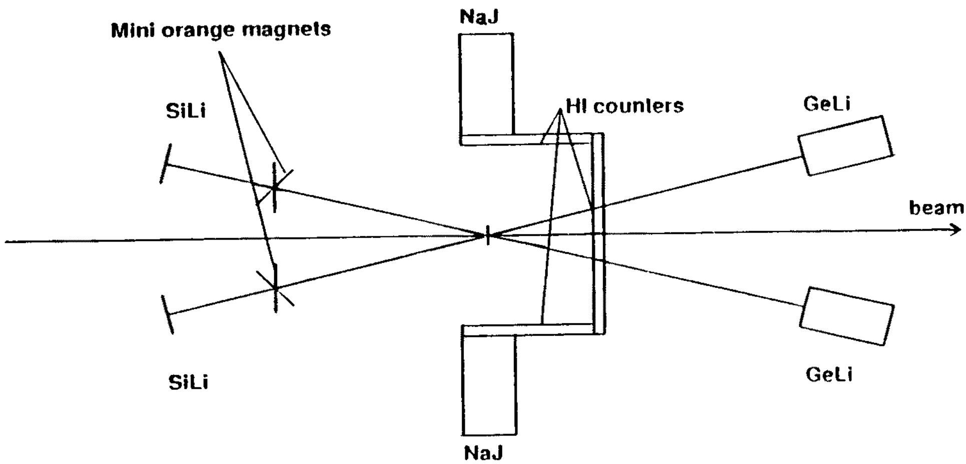

Fig.3 Experimental setup.

References

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