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RDDS lifetime measurement with JUROGAM + RITU

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Abstract. Lifetimes in ^{188}Pb were measured using the Köln plunger in combination with the RITU separator and JUROGAM. Four lifetimes were measured, from which the deformation of the prolate band was experimentally determined for the first time. The squared prolate mixing amplitude of the 2_1^+ state was deduced from the measured $B(E2)$ values.

PACS. 21.10.Tg Lifetimes – 27.70.+q $150 \leq A \leq 189$ – 23.20.Lv γ transitions and level energies

In recent years considerable theoretical and experimental effort has been devoted to the very exciting region of neutron-deficient lead nuclei where triple shape coexistence can be investigated at low excitation energies [1]. After the experimental establishment of spherical shapes in coexistence with oblate and prolate deformations many different theoretical approaches were made to explain this interesting phenomenon as well as related features like the interplay between the different nuclear structures. Aside from ^{186}Pb, where the lowest states have been attributed to the three different structures, a lot of experimental work has been focused on the even neighbour ^{188}Pb. A considerable amount of experimental information concerning the energy spectra was collected by many groups. Recently, G.D. Dracoulis *et al.* [2] published a rather detailed level scheme including well-developed bands built on the oblate and prolate band heads. These well-established bands, which were observed up to spin 14, reveal the stability of the coexisting deformed structures. Although our knowledge on the energy spectra is quite developed, the experimental data on absolute transition probabilities is very limited. Only one lifetime measurement has been performed so far, where the lifetimes of the 2_1^+ and the 4_1^+ states were measured [3].

We performed a plunger measurement using the Köln coincidence plunger device in combination with the RITU separator and the JUROGAM spectrometer at Jyväskylä [4]. This was the first time that a gas-filled separator was combined with a plunger. The set-up is shown in fig. 1. The reaction ^{108}Pd(^{83}Kr, 3n)^{188}Pb was used at a beam energy of 340 MeV in the middle of the target. The beam intensity on the target was 3 pnA. The current was limited by the single count rate ($\leq$ 10 kHz) of the Ge detectors. The standard stopper foil was replaced by a 2.5 mg/cm^2 gold degrader foil allowing the recoiling fusion products to enter into the RITU separator and to be identified with the focal-plane detectors [5]. In this way the weak reaction channel of interest was separated from a dominant fission background. Examples of recoil gated spectra are shown in fig. 2 measured at three different target-degrader separations. The thickness of the degrader foil was chosen such that the fully shifted component was separated from the degraded component, which originates

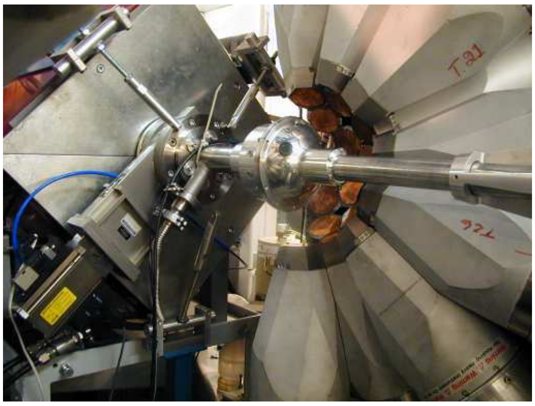

Fig. 1. RITU-JUROGAM-Plunger set-up.

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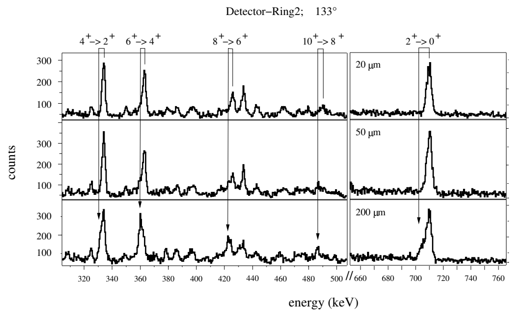

Fig. 2. Recoil gated γ spectra measured at different target-degrader separations.

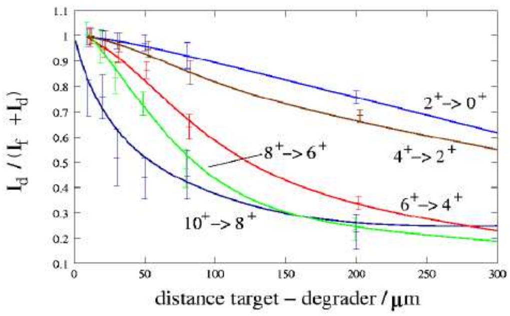

Fig. 3. Experimental decay curves of transitions in the yrast band. $I_{\mathrm{d,f}}$ denotes the intensities of the degraded and the fully shifted component, respectively.

from a γ emission after the recoiling nucleus has passed the degrader foil. Only 15 detectors of the JUROGAM spectrometer positioned at 157.6° (5 detectors) and 133.6° (10 detectors) with respect to the beam axis were used to separate the two components in the off-line data analysis. In total it was possible to measure four lifetimes. The corresponding decay curves are shown in fig. 3. No lifetime could be extracted from recoil gated $\gamma\gamma$-coincidence data because of insufficient statistics. Therefore, the results obtained depend on the assumptions made for the unobserved feeding. We assumed feeding times similar to those of the corresponding observed discrete feeding times. It has been shown in many cases (*e.g.* [6]), that this assumption is realistic whenever no special structure effects dominate the feeding pattern of the state of interest. This is valid for the feeding of the considered states except that of the 2_1^+ state. This strongly mixed state is populated up to 80% from the prolate 4_1^+ state, which is very slow ($\approx 18\,$ps) due to the low transition energy (340 keV) and the difference in the underlying nuclear structure. Therefore, we varied the feeding times for the unobserved feeding between 0.1 ps and 18 ps. The resulting value for the 2_1^+ lifetime varies between 5 ps and 12 ps including also the effect of the nuclear deorientation which has to be considered for low spin states.

In fig. 4 a partial level scheme of ^{188}Pb [2] is given together with preliminary $B(E2)$ values obtained from this work. Since the 8_1^+, 6_1^+, and 4_1^+ states are considered to be rather pure prolate deformed states and less mixed than the 2_1^+ state, it is possible to determine the nuclear deformation of the prolate band from the $B(E2;8_1^+ \rightarrow 6_1^+)$ and $B(E2;6_1^+ \rightarrow 4_1^+)$ values in a model-independent way for the first time. Using the relations

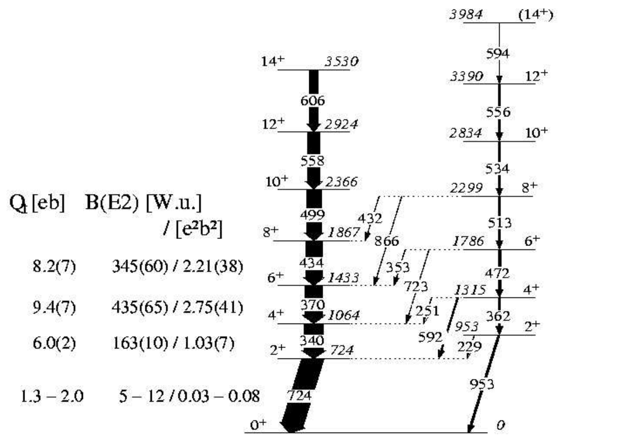

Fig. 4. Partial level-scheme of ^{188}Pb [2] and preliminary Q_{t} and $B(E2)$ values between yrast states.

$$B(E2;I \rightarrow I-2) = \frac{5}{16\pi} Q_0^2 \langle I020|I-20\rangle^2,$$
$$Q_0 = \frac{3}{\sqrt{5\pi}} Z R_0^2 \beta(1+0.16\beta),$$

we obtain $\beta = 0.286(14)$, which is in good agreement with the theoretical predictions [7,8,9,10]. The reduced transition strength observed for the $4_1^+ \rightarrow 2_1^+$ decay indicates the strong mixture of the 2_1^+ state. From the $B(E2;4_1^+ \rightarrow 2_1^+)$ value a squared prolate mixing amplitude can directly be determined using $Q_0 = 8.8(5)\,$eb, determined from the averaged $B(E2;8_1^+ \rightarrow 6_1^+)$ and $B(E2;6_1^+ \rightarrow 4_1^+)$ values. We find a value $a_{\mathrm{pro}}^2 = 0.42(10)$ which is somewhat smaller than the values given in [2,3], where different assumptions were made to extract the mixing amplitude.

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