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First results of the (n,γ) EXILL campaigns at the Institut Laue Langevin using EXOGAM and FATIMA

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Abstract. At the PF1B cold neutron beam line at the Institut Laue Langevin the EXILL array consisting of EXOGAM, GASP and LOHENGRIN detectors was used to perform (n,γ) measurements under very high coincidence rates. About ten different reactions were then measured in autumn 2012. In spring 2013 the EXOGAM array was combined with 16 $LaBr_3$(Ce) scintillators in the FATIMA@EXILL campaign for the measurement of lifetimes using the generalised centroid difference method. We report on the properties of both set-ups and present first results on Pt isotopes from both campaigns.

1. Introduction

During autumn 2012 and spring 2013 the EXOGAM spectrometer[1] and additional detectors were installed on the high intensity cold neutron guide PF1B of the Institut Laue Langevin (ILL) for the EXILL campaign. EXILL is partially a follow-up of a previous campaign using 8 EUROBALL capsule Ge

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detectors and a highly collimated cold neutron beam for (n,γ) measurements [2]. The EXILL campaigns, which took two reactor cycles of 49 days, used beside the (n,γ) also the (n,fission) reaction on ^{235}U and ^{241}Pu targets. Here we will only report on very first results from the (n,γ) reaction on ^{194}Pt and ^{195}Pt.

2. The used set-ups

The same collimator used in Ref [2] provided, at the target position, a 12-mm diameter cold neutron beam of 10^8n/(s.cm^2). Perpendicular to the beam 8 EXOGAM Clover detectors with their BGO shields were mounted in a ring while the additional detectors were mounted in the forwards and backwards directions under 45°. During the first reactor cycle and part of the second one, 6 shielded GASP Ge detectors and 2 unshielded LOHENGRIN Clovers were mounted in addition to EXOGAM. Digital data acquisition allowed to handle event rates up to 0.84 MHz. With this set-up we have measured gamma-rays from the ^{194}Pt(n,γ)^{195}Pt reactions. During 30 days of the second cycle 16 $LaBr_3$(Ce) scintillators from the fast-timing array (FATIMA) collaboration were combined with the EXOGAM detectors for fast-timing measurements. From this campaign we report on results with the ^{195}Pt(n,γ)^{196}Pt reaction.

3. First results for the ^{194}Pt(n,γ)^{195}Pt reaction

Three 96% enriched targets of masses 200,140 and 70 mg were irradiated for a total of 3 days. Of interest was the population of the 4 days $13/2^+$ isomer, which is populated with a thermal capture cross section of less than 0.1 barn. Gamma-ray cascades leading to this isomer after thermal neutron capture were first observed by D. D. Warner *et al.* in 1982 [3] and a $3/2^+,5/2^+ \rightarrow 5/2^+ \rightarrow 9/2^+ \rightarrow 13/2^+$ cascade was identified populating the isomer from the capture state. Using only the EXOGAM data, the population of the isomer could be corrected and extended as shown in Figure 1 [4]. The full analysis of these data is still ongoing.

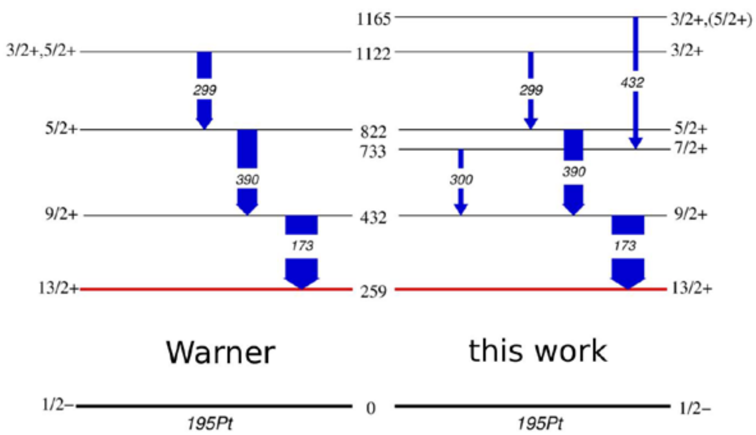

Figure1: Comparison between the Warner cascade and the extended cascade.

3. First results for the ^{195}Pt(n,γ)^{196}Pt reaction

Many years ago the even-even nucleus ^{196}Pt was proposed as an example of the SO(6)-limit of the Interacting Boson Model (IBM) [5]. When the Hamiltonian for N s,d bosons is composed by the linear combination of second order Casimir operators of the group chain: SO(3) ⊂ SO(5) ⊂ SO(6) ⊂ U(6), the quantum numbers classifying the irreducible representation (irrep) of these groups: L, v, σ, N are valid and the Hamiltonian is analytically solvable. The lowest states have $\sigma = N$. States at higher energies can have $\sigma = N-2, N-4, \ldots$. Recently, the need to test the SO(6) symmetry and not only the SO(5) properties in ^{196}Pt was stressed [6]. When testing the goodness of the description of an SO(6) nucleus one thus should look for properties involving states with different σ. One of these properties concerns the electric quadrupole transition operator. In the SO(6) limit, the E2 transition operator is a generator of SO(6). Now generators cannot act outside their irrep and the strict selection rule $\Delta\sigma = 0$ follows. In order to test this selection rule, absolute B(E2) values between $\sigma = N-2$ and $\sigma = N$ states need to be measured. This is not an easy task as the first $\sigma = N-2$ states in ^{196}Pt are at high energy and have low spins. They are not populated by standard in-beam reactions with ions, but well by neutron capture. It is, therefore, not an accident that Ref [5] relied on ILL data. In 1990 we made an attempt to measure the lifetime of the lowest $\sigma = N-2$ state at 1402.7 keV using the GRID method [6] at GAMS4 [7]. For this 0^+_3 state a lower lifetime limit of $\tau > 1.8$ ps could be established showing that the B(E2) towards the 2^+_1 was smaller than $0.034e^2b^2$ and, as such, at least an order of magnitude smaller than allowed transitions between states with $\sigma = N$. Using the FATIMA set-up at EXILL triple coincidences can be used in which a Ge gate selects the cascade of gamma-rays to be measured by the $LaBr_3$(Ce) scintillators. These fast signals can then be used for the generalised mirror symmetric centroid difference method [9,10] to measure lifetimes. The prompt response difference curve (PRD) was obtained using an ^{152}Eu source and transitions in ^{49}Ti after neutron capture. The method can be used to measure lifetimes down to about 10 ps. Figure 2 shows the time spectra of the 333-356 keV cascade gated by the 1978 keV transition in ^{196}Pt. The observed centroid difference between both spectra corresponds to 108.4(48) ps. Using the PRD curve a lifetime of τ = 50(5) ps is deduced which agrees very well with the literature value of 49.2(2) ps. Being confident that the method works, the lifetime of the 1402 keV 0^+ state was then measured. Again the 356 keV transition provided the decay signal for the fast timing. The feeding signal was obtained from the 566 keV transition feeding the 1402 keV state. The Ge gate was set on the 1048 keV transition of the decay towards the first excited state. The effective lifetime deduced from the centroid shift $\tau_{eff} = \tau_2 + \tau_0$ was 54(7) ps leading to an upper limit for the lifetime of $\tau_0 < 12$ ps. Using also the lower limit from [8] we find that 0.56 W.u < B(E2;$0^+_3 \rightarrow 2^+_1$) < 5 W.u and 0.05 W.u < B(E2;$0^+_3 \rightarrow 2^+_2$) < 0.41 W.u. Clearly no collective B(E2) values are found between the states, confirming the validity of the SO(6) symmetry.

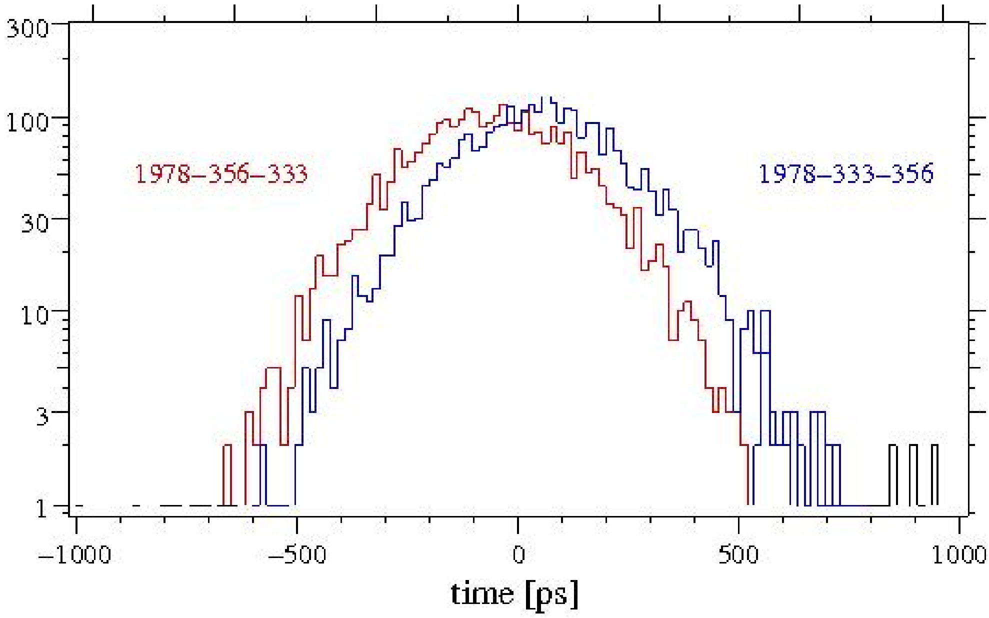

Figure 2: The binned time spectra using the 356 keV ground state transition as start for the TAC (left curve) and once as stop (right curve) (color online).

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Corrigendum: First results of the (n,γ) EXILL campaigns at the Institut Laue Langevin using EXOGAM and FATIMA Journal of Physics Conference Series 533 (2014)012026

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The lower limits on the B(E2) values in W.u should be: 0.75 W.u < $B(E2;0^+_3 \rightarrow 2^+_1)$ < 5 W.u and 0.06 W.u < $B(E2;0^+_3 \rightarrow 2^+_2)$ < 0.41 W.u. This small change doesn´t affect the conclusions.

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