New excited 2^+ and 3^- two-proton states in $^{210}_{84}$Po$_{126}$ populated by two-proton transfer

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Five new 2^+ levels have been established in the semimagic ^{210}Po nucleus from a ^{208}Pb(^{12}C, ^{10}Be) two-proton transfer experiment, performed at energies close to the Coulomb barrier at JAEA Tokai. A setup combining Ge, LaBr$_3$, and Si telescopes was used to detect both in-beam γ rays and ejectile residues. The new 2^+ states have been established by means of the transitions toward the 0^+ ground state which are present in the γ spectra produced by properly selecting the excitation energy in ^{210}Po after kinematical reconstruction. $(f_{7/2})^2$, $h_{9/2} \otimes f_{5/2}$, $(i_{13/2})^2$, $f_{7/2} \otimes p_{3/2}$, and $f_{7/2} \otimes f_{5/2}$ two-proton configurations are assigned to these states. In addition, a new 3^- level has also been established in this nucleus, very likely originating from the $f_{7/2} \otimes i_{13/2}$ configuration. Shell-model calculations strongly support these assignments.

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I. INTRODUCTION

With only two protons more than the doubly-magic ^{208}Pb nucleus, ^{210}Po is an ideal test bench for refining nuclear structure theories and models developed for the region around the doubly-closed magic shell ($Z = 82$, $N = 126$). In order to determine the effective two-body matrix elements to be used in realistic calculations, the most complete experimental information is therefore required. In particular, the identification of excited two-proton states can allow to extract the mixings between the involved configurations.

As one can expect, single-particle-type excitations of the two valence protons are responsible of almost all levels identified in ^{210}Po at low excitation energy. Actually, only the known 3^-_1 state located at 2387 keV has a collective nature and stands out in this landscape governed by valence protons. This 3^-_1 state was identified and its collectivity measured in the early 1970s, from the electron-capture decay of ^{210}At [1] and inelastic scattering reactions (p, p'), (d, d'), and (t, t') on ^{210}Po targets [2]. It is only above $\sim$3 MeV that particle-hole core excitations start to show up in addition to the proton configurations.

From proton transfer (stripping) reactions such as (^{3}He, d), (^{4}He, t), and $(t, 2n)$ on ^{209}Bi targets, most of the proton states have been characterized in the works of Groleau *et al.* [3] and of Mann *et al.* associating in-beam γ-ray and conversion-electron measurements [4].

However, it is worth noting that, because ^{209}Bi has its last proton on the $h_{9/2}$ orbit, the proton-stripping reactions populate preferentially states whose configuration contains this orbit, too. Thus, the $(h_{9/2})^2$, $h_{9/2} \otimes f_{7/2}$, $h_{9/2} \otimes f_{5/2}$, and $h_{9/2} \otimes i_{13/2}$ multiplets of states have been very well identified [5]. The states originating from the $\pi(f_{7/2})^2$ configuration are more difficult to be evidenced, their direct population being possible only through a small component of the wave function. Nevertheless, despite their weak production, Mann *et al.* succeeded in firmly identifying the 0^+, 4^+, and 6^+ members of this multiplet, thanks to their decay properties toward lower-lying states in ^{210}Po [4]. The 2^+ state of the $\pi(f_{7/2})^2$ multiplet is even more difficult to be identified; indeed, its deexcitation is expected to proceed entirely by a $E2$ transition to the ground state and therefore cannot be established by γ-γ coincidences. However, among the "orphan" single γ rays, Mann *et al.* mention in their paper the presence of three transitions with energies compatible to the one expected for this 2^+ state, the transition of 2867.9 keV being the best candidate.

The two-proton transfer to ^{208}Pb should enhance the population of configurations such as $\pi(f_{7/2})^2$ and $\pi(i_{13/2})^2$, with respect to the population of these orbits in the one-proton stripping reaction on ^{209}Bi. Such a $2p$-transfer reaction was already performed by Becchetti *et al.* using ^{12}C and ^{16}O beams, at energies $\sim$20 MeV above the Coulomb barrier, and many levels were established up to 8 MeV from the particle spectra [6]. In particular, a level at $E^* = 2.85(3)$ MeV was identified and proposed to be the 2^+ state of the $\pi(f_{7/2})^2$

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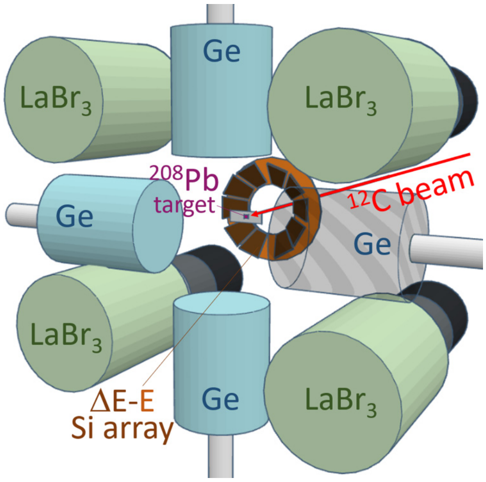

FIG. 1. Schemactic view of the experimental setup used in this work.

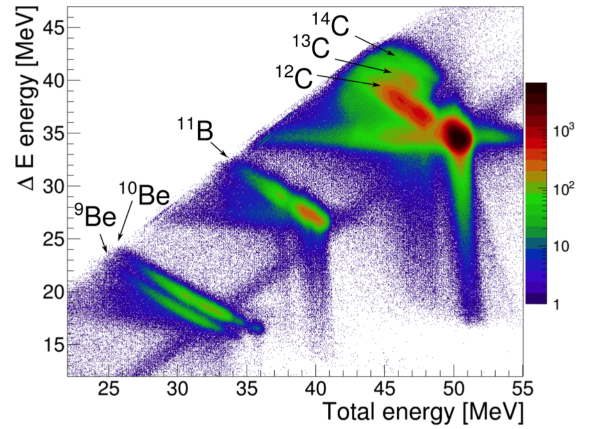

FIG. 2. ΔE-E spectrum for ejectiles measured by one pair of the ΔE-E Si telescopes at $E_{\text{beam}} = 63.7$ MeV. Beamlike identified reaction products are labeled.

multiplet. However, this level is not included in the latest data evaluation of the ^{210}Po nuclear levels [5].

More recently, the ^{208}Pb(^{12}C, ^{10}Be) two-proton transfer was studied by Kocheva and collaborators [7] at Coulomb barrier energy, aiming to lifetime measurements. The lifetimes of the 2_1^+, 2_2^+, 3_1^- states of ^{210}Po have been measured, and the $B(E2; 2_1^+ \to 0_1^+)$ reduced transition probability was notably revised to $B(E2) = 136(21)\, e^2\, \text{fm}^4$.

This paper reports on the localization of most of the two-proton 2^+ excited states expected in ^{210}Po, obtained with the ^{208}Pb(^{12}C, ^{10}Be) $2p$-transfer reaction. New results concerning the two-proton 3^- states present in this nucleus have also been obtained in this work.

II. EXPERIMENTAL METHODS AND DATA ANALYSIS

In our work, excited states in ^{210}Po have been populated by two-proton transfer using the ^{208}Pb(^{12}C, ^{10}Be) reaction. The target was composed of a 200-μg/cm^2 enriched ^{208}Pb material deposited on a thin 30-μg/cm^2 carbon layer. The ^{12}C beam was provided by the 18 MV tandem at JAEA Tokai. For the main purpose of the experiment, four beam energies have been studied: 58, 60, 62, and 63.7 MeV in the laboratory frame, slightly below and above the Coulomb barrier. In the analysis devoted to the study of the structure of ^{210}Po, the four data sets have been summed.

A schematic view of the experimental setup is displayed in Fig. 1. Ten segmented Si ΔE-E telescopes located at backward angles (122° to 141°) with respect to the beam direction were used to identify the light beamlike ejectile and determine the kinematics of the reaction on an event-by-event basis, as illustrated in Fig. 2. The excitation energy of the heavy targetlike partner was therefore fully reconstructed, with a Gaussian standard deviation of $\sigma \sim 230$ keV. It is worth mentioning that only the two telescopes having the lowest ΔE thickness (50 μm) were used in the ^{210}Po data analysis. Indeed, the eight other telescopes did not allow a complete characterization of the ^{10}Be ejectile, the larger ΔE thickness (75 μm) being enough to stop the ^{10}Be ions. This device was already used successfully to identify transfer channels, as described in Refs. [8,9].

In parallel, the γ rays were detected by four HPGe and four LaBr$_3$ detectors placed at 90° with respect to the beam axis. The LaBr$_3$ scintillator characteristics can be found in Ref. [10], these detectors having been used for the measurement of high-energy prompt γ rays emitted during the neutron-induced fission of ^{235}U. In this experiment, the absolute γ detection efficiency at 1.3 MeV was $\epsilon_\gamma = 6.8(2)\%$ [5.1(2)% for the LaBr$_3$ scintillators, and 1.67(2)% for the Ge detectors].

Time-stamped data recorded with a triggerless mode allowed us to perform the subsequent data analysis relying on coincidences between charged particles and γ rays. Of particular importance, coincidence matrices $(E^\star, E_\gamma)$ were built between the reconstructed excitation energy of ^{210}Po ($E^\star$) and the detected Doppler-corrected γ rays (E_γ). It is here worth noting that the γ-ray information from the Ge or LaBr detectors is not an ingredient of the reconstruction of the excitation energy which is fully obtained by the measurement of the ^{10}Be ejectile. Therefore the correlations contained in these matrices are physically meaningful. As an illustration, the $(E^\star, E_\gamma)$ matrix containing the γ rays detected by LaBr$_3$ is displayed in Fig. 3. The similar matrix containing the Ge information was also built.

III. EXPERIMENTAL RESULTS

A. Identification of excited 2^+ two-proton states in ^{210}Po

Excited 2^+ levels in ^{210}Po are expected to decay predominantly to the 0^+ ground state, as is the case for the 2_1^+ and 2_2^+ states, with 100% and 90% branching rates, respectively. Furthermore, contrary to the 2_1^+ and 2_2^+ states, the $\pi h_{9/2}$ orbit is not involved in the configurations of the next 2^+ two-proton states, and therefore the direct decay of these states to the ground state may be the unique decay mode to be observed. For each 2^+ state, the energy of the corresponding

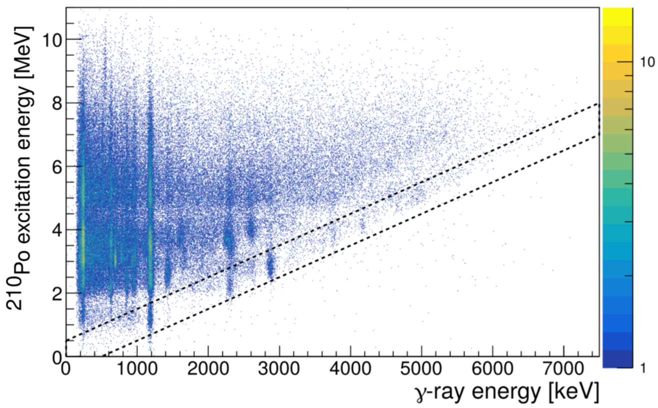

FIG. 3. Two-dimensional plot of the $[E^\star(^{210}\mathrm{Po}), E_\gamma]$ matrix, i.e., associated with a ^{10}Be identification in the Si telescopes (see text for details). The γ rays have been detected in the $\mathrm{LaBr_3}$ scintillators. The dashed lines are the contour limit of ± 500 keV around the $E^\star = E_\gamma$ line which is used to obtain the projected γ-ray spectrum shown in Fig. 4(a).

$E2$ transition is therefore identical to the level energy, which is nothing else than the excitation energy of the nucleus. Therefore, these γ rays should appear in the $(E^\star, E_\gamma)$ matrix displayed in Fig. 3, just on the $E^\star = E_\gamma$ diagonal line. By selecting the events within ± 500 keV around this line, we obtain the $\mathrm{LaBr_3}$ and Ge γ-ray spectra displayed in Figs. 4(a) and 4(b), respectively.

Combining the Ge information (more precise) with the $\mathrm{LaBr_3}$ information (more efficient, especially at high energy), the following transitions are identified: 1181(1), 2290(2), 2869(3), 3763(20), 4170(20), and 4943(50) keV. The three peaks of 3763, 4170, and 4943 keV can only be observed in the $\mathrm{LaBr_3}$ spectrum, being out of the energy range defined for the Ge detectors. The large width of the 4943-keV peak also suggests that it is actually composed of two unresolved peaks.

The first two peaks of 1181 and 2290 keV are the known $2_1^+ \to 0^+$ and $2_2^+ \to 0^+$ transitions in ^{210}Po, respectively. The other transitions, and especially the relatively strong one at 2869 keV, were not observed previously. One could wonder whether these transitions are correctly assigned to ^{210}Po. For that, it is worth mentioning that these spectra are particle gated, so that the charge selection provided by the Si telescopes definitely guarantees a correct Be assignment for the light ejectile. Only ^{9}Be ejectiles, and therefore ^{211}Po γ rays, could be envisaged; the corresponding $2pn$-transfer cross section is measured $\sim$3 times smaller than the $2p$-transfer cross section. The broad peak located around 2620 keV in the $\mathrm{LaBr_3}$ spectrum corresponds to the Compton edge of the 2869-keV transition and to the 2615-keV $3^- \to 0^+$ transition of ^{208}Pb, randomly coming from the huge background of quasielastic collisions of ^{12}C on ^{208}Pb.

The 2869-keV γ ray cannot be the $5^- \to 3^-$ transition in ^{208}Pb, since it is present neither in the $[E^\star, E_\gamma]$ matrix relative to ^{208}Pb nor in coincidence with the 2615-keV γ ray in the $[E_\gamma, E_\gamma]$ matrix. We can therefore safely conclude that the

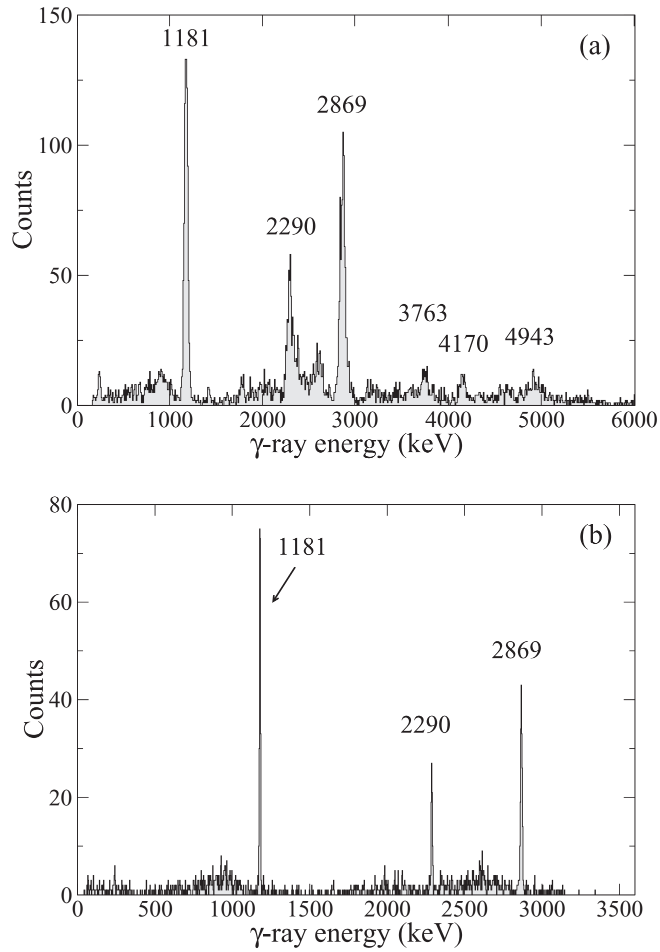

FIG. 4. γ-ray spectra obtained by slice of the $[E^\star(^{210}\mathrm{Po}), E_\gamma]$ matrix close to the $E^\star = E_\gamma$ line as defined on Fig. 3 in order to isolate the direct γ deexcitations toward the ^{210}Po ground state. (a) $\mathrm{LaBr_3}$ data and (b) Ge data.

2869-keV transition belongs to ^{210}Po and deexcites a level at 2869-keV excitation energy.

The 1181- and 2290-keV transitions which deexcite the 2_1^+ and 2_2^+ states to the ground state of ^{210}Po have to be distinguished from the other transitions. These two transitions can be observed in coincidence with a wide range of excitation energies of ^{210}Po. This is related to the fact that the 2_1^+ and 2_2^+ levels collect, in addition to their direct populations, almost all the deexcitation flows from higher-lying states before decaying to the ground state. This is not the case for the other newly observed transitions: The corresponding events are present only in a narrow excitation energy range around the $E^\star = E_\gamma$ line in the $[E^\star(^{210}\mathrm{Po}), E_\gamma]$ matrix. This suggests that the deexcited states are only directly populated in the reaction and decay toward the ground state. The intensities extracted from the spectra in Fig. 4 have therefore to be considered as the direct populations of the corresponding states. From the Ge spectrum in Fig. 4(b), the cross sections of the direct populations of the 2_2^+ and 2_3^+ states are measured to $\sim$70% and $\sim$150%, respectively, compared to the cross section to the 2_1^+ state.

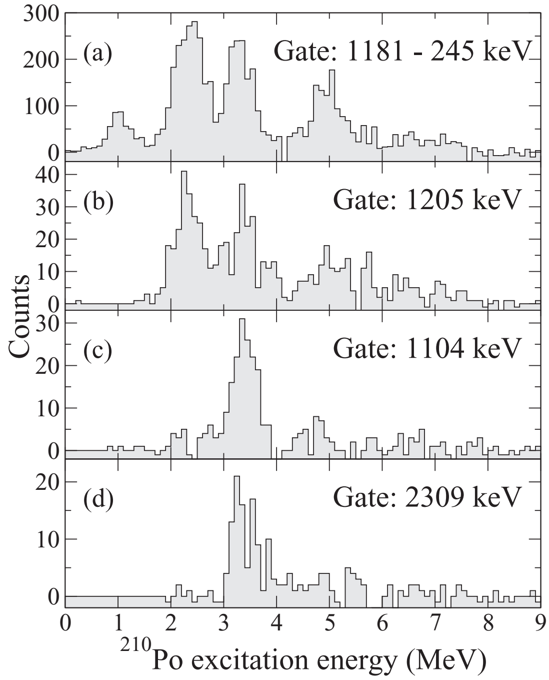

FIG. 5. ^{210}Po excitation energy distribution spectra obtained by slices of the $[E^\star(^{210}\mathrm{Po}), E_\gamma]$ matrix: (a) $LaBr_3$ gate on the $2_1^+ \to 0^+$ 1181-keV transition with subtraction of the feeding from the $4_1^+ \to 2_1^+$ 245-keV transition, (b) Ge gate on the $3_1^- \to 2_1^+$ 1205-keV transition, (c) Ge gate on the 1104-keV transition, and (d) Ge gate on the 2309-keV transition.

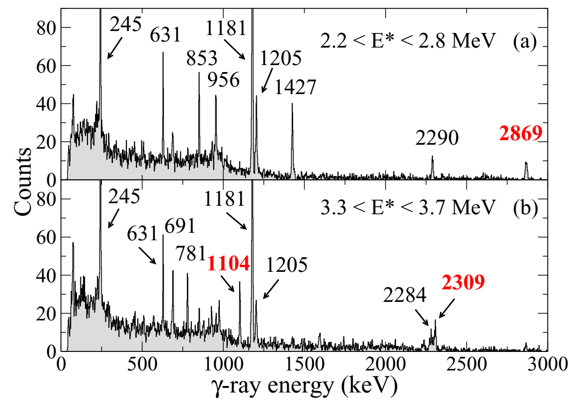

FIG. 6. γ-ray spectra obtained by slices of the $[E^\star(^{210}\mathrm{Po}), E_\gamma]$ matrix: (a) $E^\star \in [2.2, 2.8]$ MeV and (b) $E^\star \in [3.3, 3.7]$ MeV. For clarity, the spectra have been vertically expanded, and the peaks at 1181 keV ($2_1^+ \to 0^+$) and 245 keV ($4_1^+ \to 2_1^+$) are therefore cut. The new transitions observed in this work are labeled in bold.

B. Identification of the $\pi f_{7/2} \otimes i_{13/2}$ 3^- state in ^{210}Po

In the quest for the complete knowledge of the two-proton states of ^{210}Po, let us now consider 3^- levels. From two-proton configurations, 3^- states are present in two multiplets: $h_{9/2} \otimes i_{13/2}$ and $f_{7/2} \otimes i_{13/2}$. Experimentally, only the former is known, at 2846 keV, the latter being not reported until now [5]. According to our SM calculations detailed in the next section, their excitation energies are 2998 and 3577 keV, respectively. We have been looking for this missing 3^- state, guided by the following criteria: Its excitation energy should be close to $\sim$3500 keV, and its possible γ deexcitation should proceed mainly by a parallel decay toward the 2_1^+ state at 1181 keV (via a $E1 + M2$ transition of $\sim$2320 keV) and toward the 3_1^- collective state at 2387 keV (via a $M1$ transition of $\sim$1100 keV), as reported for the other two-proton $h_{9/2} \otimes i_{13/2}$ 3^- level.

In order to identify this $\pi f_{7/2} \otimes i_{13/2}$ 3^- state, we have proceeded as follows:

Firstly, we have analyzed the excitation energy spectrum of ^{210}Po obtained by gating on the 1181-keV $2_1^+ \to 0^+$ transition in the $(E^\star, E_\gamma)$ matrix, after having subtracted the contribution from the 245-keV $4_1^+ \to 2_1^+$ transition. So this spectrum selects the nonyrast levels decaying toward the 2_1^+ level and must therefore contain the missing 3^- one. This spectrum is displayed in Fig. 5(a). One can clearly observe the first peak at 1.1 MeV which is the direct population of the 2_1^+ state at 1181 keV. The second peak is broader and can be fitted by two Gaussians centered at $\sim$2.3 MeV and $\sim$2.6 MeV. A third peak is evidenced at $\sim$3.5 MeV and a fourth structure is visible at $\sim$5.1 MeV. Similarly, the excitation energy spectrum obtained by gating on the 1205-keV $3_1^- \to 2_1^+$ known transition is displayed in Fig. 5(b). The three observed structures (at $\sim$2.3, 3.5, and 5 MeV) are in common with those found in the spectrum obtained by gating onto the 1181-keV $2_1^+ \to 0^+$ transition [Fig. 5(a)], which indicates that states feeding the 3_1^- state are also among those feeding the 2_1^+ state.

Secondly, we have built the γ-ray spectra in coincidence with each of the peaks in the excitation energy spectra. Thus, the γ rays (registered by the Ge detectors) associated to the second structure between 2 and 3 MeV are displayed in Fig. 6(a). All γ rays observed in this spectrum are already known [5]. In particular, the two transitions of 1205 keV ($3_1^- \to 2_1^+$) and 1427 keV ($0_2^+ \to 2_1^+$) are clearly visible, which confirms that this second structure of Fig. 5(a) does contain the 3_1^- (at $E^\star = 2387$ keV) and 0_2^+ (at $E^\star = 2609$ keV) states decaying via these two transitions. It is also worth noting that the newly identified 2869-keV $2_3^+ \to 0^+$ transition is present in this spectrum, too. However, the 1664- and 459-keV γ rays deexciting the 3_2^- state at 2846 keV are not present in this spectrum. This will be discussed in the next section.

The γ rays associated with the $\sim$3.5 MeV excitation-energy peak are displayed in Fig. 6(b). In addition to all the already-known transitions, two new γ rays are observed, with energies of 1103.5(15) and 2309(2) keV. These two energies perfectly match with a unique level that would be located at 3490(2) keV and deexciting toward both the 2_1^+ and the 3_1^- states with 45(8)% and 55(8)% of the decay, respectively. It is worth pointing out that no low-spin level corresponding to this energy is known in the literature [5]. One level is reported at 3.477 MeV but it decays only to a 8^+ state. Two other levels stand at 3429 and 3525 keV, but they have well-established spins and parities of 5^- and 6^-. Furthermore, none of their known γ deexcitations are present in our γ-ray spectrum displayed in Fig. 6(b).

Thirdly, we have analyzed the excitation-energy spectra of the states associated with these two new γ rays, displayed in Figs. 5(c) and 5(d). Only the peak at $E^\star = 3.5$ MeV is observed when gating on either transition. Thus, the two transitions must be associated with the deexcitation of this level at 3.5 MeV. The two spectra also prove that this level is populated directly in the $2p$ stripping reaction.

IV. DISCUSSION

In this section we discuss now the spin and configuration assignments of the newly discovered states. Concerning the states decaying to the 0^+ ground state via γ emission (see Sec. III A), only spin values of 1, 2, or 3 may be considered *a priori*. Moreover, because of the reaction mechanism used in this work ($2p$ transfer) only natural-parity states ($\pi = +$ for even spins, $\pi = -$ for odd spins) can be directly populated [11]. The direct population of non-natural-parity states is only possible through a two-step process involving a ^{208}Pb excited state, which is unlikely. And indeed it is the case: The known 2394-keV $1^+ \rightarrow 0^+$ $M1$ transition is not present in the spectra, as its direct population is not allowed. Therefore, from an experimental point of view, the possible assignments to the newly observed states are 1^-, 2^+, or 3^-. One may also exclude 3^- assignments, since the deexcitations of all known 3^- levels in ^{210}Po do not populate directly the 0^+ ground state through $E3$ transitions but proceed through $E1$ transitions to the 2_1^+ level at 1181 keV.

In order to go further, we will now examine the shell-model (SM) calculations, which should well describe the expected low-spin states in ^{210}Po. Dedicated shell-model calculations for the $N = 126$ isotones ^{210}Po, ^{211}At, and ^{212}Rn were performed by Coraggio *et al.* using a realistic effective interaction, with an excellent agreement with the experimental findings [12]. We also performed shell-model calculations with the NuShellX code [13], using the "jj67pn" interaction and the "khp" model space, in which the proton valence orbits outside a ^{208}Pb core are successively: $0h_{9/2}$, $1f_{7/2}$, $1f_{5/2}$, $2p_{3/2}$, $p_{1/2}$, and $0i_{13/2}$. We performed the present calculations in order to extend the results published in Ref. [12], especially for the 2^+ excited states. In this full valence space, 92 states originating from 21 possible two-proton configurations are calculated: 62 with positive parity and 30 with negative parity. Among the negative-parity states, it is worth noting that there are no possible 1^- states from the two-proton configurations in the valence space. Among the positive-parity states, twelve 2^+ states are predicted. All of these 2^+ states are listed in Table I for the sake of completeness, bearing in mind that the considered valence space is certainly no more relevant for the highly excited 2^+_{8-12} calculated levels.

Combining both the present experimental and theoretical information, we are confident to safely assign 2^+ configurations for all the new states established by their $E2$ deexciting transitions to the ground state, as indicated in Table I. In particular, the 2^+ state of the $(f_{7/2})^2$ configuration is now clearly established at 2869 keV.

According to Ref. [3], the highest (2^+) level observed in ^{210}Po is located at 3792(4) keV, with a $h_{9/2} \otimes f_{5/2}$ assignment. Our results suggest a 3763(20)-keV energy for the $h_{9/2} \otimes f_{5/2}$ 2^+ state. In the original work of Groleau *et al.* [3], this (2^+) assignment was based on the ratio value of the cross sections measured at two angles, but the value reported at 40° seems questionable. It is not possible to conclude without further experimental investigations whether this is the same state.

TABLE I. Experimental (Ref. [5] and this work in bold) and calculated excitation energies of the 2^+ two-proton states in ^{210}Po. For each state, the main component of the SM configuration is displayed.

	$E^\star$ (keV)		SM configuration	
Level	SM	Expt.	main component	
2_1^+	1200	1181	$(h_{9/2})^2$	(96%)
2_2^+	2370	2290	$h_{9/2} \otimes f_{7/2}$	(94%)
2_3^+	2923	**2869(3)**	$(f_{7/2})^2$	(83%)
2_4^+	3848	**3763(20)**	$h_{9/2} \otimes f_{5/2}$	(63%)
2_5^+	4557	**4170(20)**	$(i_{13/2})^2$	(67%)
2_6^+	5164	**4943(50)**[a]	$f_{7/2} \otimes p_{3/2}$	(60%)
2_7^+	5228	**4943(50)**[a]	$f_{7/2} \otimes f_{5/2}$	(66%)
2_8^+	7111		$(f_{5/2})^2$	(93%)
2_9^+	7476		$f_{5/2} \otimes p_{3/2}$	(74%)
2_{10}^+	7530		$(p_{3/2})^2$	(69%)
2_{11}^+	7901		$f_{5/2} \otimes p_{1/2}$	(81%)
2_{12}^+	8110		$p_{3/2} \otimes p_{1/2}$	(75%)

[a]Unresolved.

The other new excited 2^+ states cannot be found in the literature. It is worth noting that our experimental energies are very close to the calculated ones displayed in Table I. The experimental energy of the $(i_{13/2})^2$ 2^+ state has the largest discrepancy (387 keV) with the calculations. This claims for more theoretical investigations, especially in the $(i_{13/2})^2$ two-body matrix elements. The possible two states composing the broad structure at 4.94 MeV can be assigned to the two 2^+ states of $f_{7/2} \otimes p_{3/2}$ and $f_{7/2} \otimes f_{5/2}$ two-proton configurations.

Similarly, spin and parity assignments $J^\pi = 3^-$ are proposed to the new level established at 3490-keV excitation energy (see Sec. III B), based on one hand on the J^π values of the levels fed by its deexcitation and on the other hand by the fact that only natural-parity states can be directly populated, excluding 1^+, 2^-, and 3^+ assignments. This 3^- state is very likely the one expected from the $\pi f_{7/2} \otimes i_{13/2}$ configuration. It is in very good agreement with the calculated state, the experimental energy being 87 keV lower than the calculated one at 3577 keV. It is worth noting that among the two possible two-proton 3^- states ($h_{9/2} \otimes i_{13/2}$ and $f_{7/2} \otimes i_{13/2}$), only the latter, lying at ~650 keV above the former, is evidenced in our work. This may be explained by the difference in transferred angular momentum leading to the population of the respective states. This feature is also observed in the higher population of the $(f_{7/2})^2$ 2_3^+ state than the population of the $(h_{9/2})^2$ 2_1^+ yrast state. All the levels established in this work are displayed in Fig. 7.

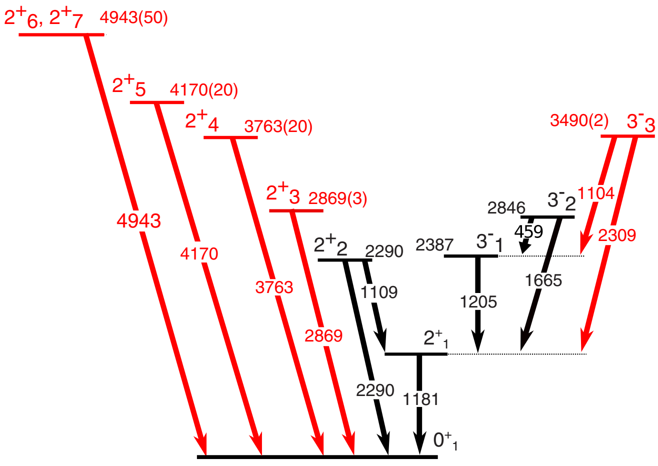

FIG. 7. Partial level scheme of ^{210}Po exhibiting all the known 2^+ and 3^- excited states. Levels and γ rays identified in this work are displayed in color. All arrow widths are identical and do not represent the relative γ intensities.

V. SUMMARY

In the analysis of the ^{208}Pb(^{12}C, ^{10}Be) two-proton stripping reaction, new information has been obtained on the structure of ^{210}Po. All possible 2^+ states issued from the valence two-proton configurations are now established through their γ deexcitation toward the 0^+ ground state up to $\sim$5 MeV excitation energy. Furthermore, the expected two-proton 3^- level originating from the $f_{7/2} \otimes i_{13/2}$ configuration has been very likely localized at 3490 keV excitation energy. It would be important to study again this reaction with much larger statistics in order to obtain precise, quantitative comparisons of the ^{210}Po populations obtained by $2p$ and $1p$ stripping reactions.

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