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The excited states of odd-odd ^{82}As are studied in the β-decay of ^{82}Ge. An isotopicially pure beam of ^{83}Ga was produced at Holifield Radioactive Ion Beam Facility using a resonance ionization laser ion source and high-resolution electromagnetic separation. The atoms of ^{82}Ge are created after β-delayed neutron emission in the decay of ^{83}Ga. The number of ^{82}Ge atoms is found by normalization to the 1348 keV γ-ray. Detailed analysis of the decay scheme is compared with shell-model calculations with several commonly used fpg shell interactions.

I. INTRODUCTION

The odd-odd isotopes have always been more challenging to study, for both experiment and theory, than their even-even or even-odd neighbors. Even in the simplest picture where we consider only a single proton and a neutron outside of an even-even core, a complex residual interaction is needed to explain the low-energy structure of an odd-odd nucleus. This interaction spreads the lowest multiplet into a group of closely placed states. Often, within this multiplet, due to small energy spacing and large spin differences, isomerism is observed which creates additional difficulty for the experimentalists. Moreover, at the current level of development of nuclear models their predictive power is limited in precision, and they cannot provide a reliable description even of the lowest levels in the medium-heavy odd-odd nuclides.

Proper description of the nuclear structure, reflected e.g. in β-decay strength function, is needed in in order to predict basic nuclide properties such as half-live or β-delayed neutron emission probability. For example, in case of the neutron-rich even-even nuclides β-decay rates are highly influenced by the position of 1^+ states in their odd-odd daughters. The only allowed Gamow-Teller β-transitions are $0^+ \to 1^+$ which are additionally characterized by enhanced $\log(ft)$ values, compared to other allowed transitions [1].

Nuclear theory predictions are commonly used in nuclear physics applications, e.g. in modeling the astrophysical process of rapid neutron capture (r-process) [2] and in nuclear reactor control or nuclear fuel post-processing [3, 4]. In modeling the r-process theoretical models, like the shell-model, provide this information for the experimentally unknown nuclides (e.g. recent work [5]). Yet, if we want to use nuclear models to predict properties of isotopes out of experimental reach we need to also understand the structure of odd-odd nuclei.

The odd-odd N = 49 isotones in the vicinity of doubly-magic ^{78}Ni show all of the aforementioned complexity. In all isotones between Z = 31 and 37 several low lying long-lived isomers decaying by β-emission have been identified. An isomeric state in ^{82}As has been already found in 1970 [6], but its mass was unknown for over 35 years until recently the masses of the ground and the isomeric state were measured with a Penning trap [7]. There are different proposals for the spins of the ground and the isomeric state, including 2^- [8, 9] or 1^+ [10, 11] for the ground state, and 5^- [8] or 1^+ [9] for the isomeric state.

The decay of ^{82}Ge to ^{82}As is rather poorly known. Only three γ-transitions of 1092, 843 and 248 keV were firmly assigned to this decay [12], and two - tentatively at 140 and 952 keV. The isomeric state was not observed in the β-decay. This situation provides an interesting opportunity for testing shell model interactions. Multiple shell model interactions in the fpg model space have been developed in this region over the years which have incorporated information on neighboring isotopes. Therefore one should expect a good description of the structure of ^{82}As by shell model calculations. The differences between the experiment and the calculations can provide comparison and an estimation of the accuracy of different shell-model interactions commonly used in this region of the chart of nuclides.

In this article we report the detailed study of the ^{82}Ge β-decay revealing 9 previously unobserved states in ^{82}As. The study of γ-rays following β-decay (19 transitions in total) determined the precise location of the isomeric state. The spin assignments are discussed and compared with shell model calculations.

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II. EXPERIMENTAL TECHNIQUE

The experiment was performed at the Holifield Radioactive Ion Beam Facility (HRIBF) at Oak Ridge National Laboratory. The HRIBF [13] is an isotope separation on-line type facility. A 50 MeV proton beam of average intensity of 15 μA was used to induce fission in a UC_x target of 4.2 g/cm^2 thickness. Ions of ^{83}Ga were extracted from the resonant ionization laser ion source (RILIS), utilizing a two-step ionization scheme [14], accelerated to 200 keV kinetic energy, and mass analyzed using two steps of mass-separation with resolving power of $m/\Delta m$ 1000 and 10000 respectively. An isotopically pure ion beam was transmitted to the Low energy Radioactive Ion Beam Spectroscopy Station (LeRIBSS). A beam with intensity of up to 1.2×10^4 (on average 4.1×10^3) ions per second of ^{83}Ga was achieved. The ^{82}Ge atoms were produced in the decay of ^{83}Ga after β-delayed neutron emission ($P_n = 62.8(25)\%$ [15]).

The LeRIBSS station was equipped with a Moving Tape Collector (MTC), two high-purity Ge clover detectors, two plastic β detectors and 48 ^{3}He ionization chambers (consisting of a total of 600 liters of ^{3}He) for neutron detection. The neutron detectors were mounted in a polyethylene support with Cadmium shielding. The detectors closely surrounded the implantation point. The beam was implanted in the middle of the setup into a magnetic tape with a Mylar backing. The measurement cycle consisted of 2 s activity build-up, 1 s decay with no beam on, followed by a 0.7 s tape transport that moved the irradiated spot into a chamber located behind 5-cm of lead shielding. The data were collected in this mode for 6.5 hours. Additionally, for 30 minutes the tape was stopped in order to measure the long-lived daughter activities (so called "saturation" mode).

The efficiency of the Ge detectors was calibrated with a set of standard calibration sources and was 22% for 88 keV and 5% for 1 MeV γ-rays . The β detectors were used to reduce the background in the γ-spectrum. The efficiency of the β-detectors depends on the average electron energy which is related to the unknown feeding pattern. However, the intensities of the γ transitions were found from the γ-singles spectrum and the efficiency of the β-counter was not needed in this part of the analysis. Neutron emission in the decay of ^{82}Ge is energetically forbidden, therefore anti-coincidence with the neutron counters was used for additional γ-ray discrimination.

The read-out of the detection system, including the MTC cycles, was based on the XIA Pixie16 Rev. F digital electronics modules [16]. The acquisition system was operated without a master trigger, and all events above noise threshold were recorded independently and time-stamped with a 250 MHz clock synchronized across all modules. This allowed for detailed off-line analysis.

III. RESULTS

A. γ-spectroscopy

The β-gated γ-spectrum, including data collected both with tape cycling and the saturation measurement, is presented in the Fig. 1a. In fig. 1b γ-singles registered with and without the tape movement are presented. All spectra were recorded up to 8.2 MeV, however only the crucial part, below 1.5 MeV, is shown for clarity.

Apart from ^{83}Ga and its daughter activities (^{82,83}Ge, ^{82,83}As), γ-rays emitted from (n, n') and (n, γ) reactions on the natural germanium isotopes in the detectors [17] were registered. The neutrons originate from β-delayed neutron emission following the decay of ^{83}Ga.

Transition identification was based on the grow-in/decay pattern, coincidences with the known γ-rays, and coincidence with the neutron counters. Some of the γ-lines (240, 357, 675, 711 and 735 keV) observed in the spectrum remained unidentified. The shape of the grow-in/decay-out pattern suggest that in all cases these lines belong to the second or third nucleus in the decay-chain. However, it was not possible to provide unambiguous identification.

Figure 2 presents grow-in and decay patterns of the selected γ-transitions observed in the decay of the ^{83}Ga, ^{83}Ge, ^{82}Ge, and ^{82}As. All the activities follow the Bateman equations solution with the primary beam consisting of ^{83}Ga ions only. The other activities appear as daughters or grand-daughters.

B. Number of ions

The decay of ^{83}Ga was previously measured with a precise ion-counting technique, and absolute intensities of the γ-transitions in this decay are known [15]. Based on the number of observed events in the 1348-keV line, and 28.4(10)% absolute intensity we find the total number of ^{83}Ga ions is $52.4(34) \times 10^6$. Consequently we find the expectation number of β-decays of ^{82}Ge and ^{82}As within the tape cycle to be $6.82(44) \times 10^6$ and $0.262(17) \times 10^6$ respectively. These calculations include known half-lives of ^{83}Ga, ^{82}Ge, and ^{82}As^{gs,m} and the integrated probability of decay within the observation window. The efficiency of the cycle for ^{83}Ga, ^{82}Ge, ^{82}As^{gs,m} is 97.7%, 13.0%, 0.5% respectively.

C. Absolute γ–rays intensities

The number of observed 1092 keV γ rays (strongest line observed in the decay of ^{82}Ge [12]), corrected for the detector efficiency, is $5.28(26) \times 10^6$. Therefore, this transition satisfies 77.4(63)% of the expectation number of decays calculated from absolute intensities. Our result is in very good agreement with the 80(20)% value reported in Ref. [8].

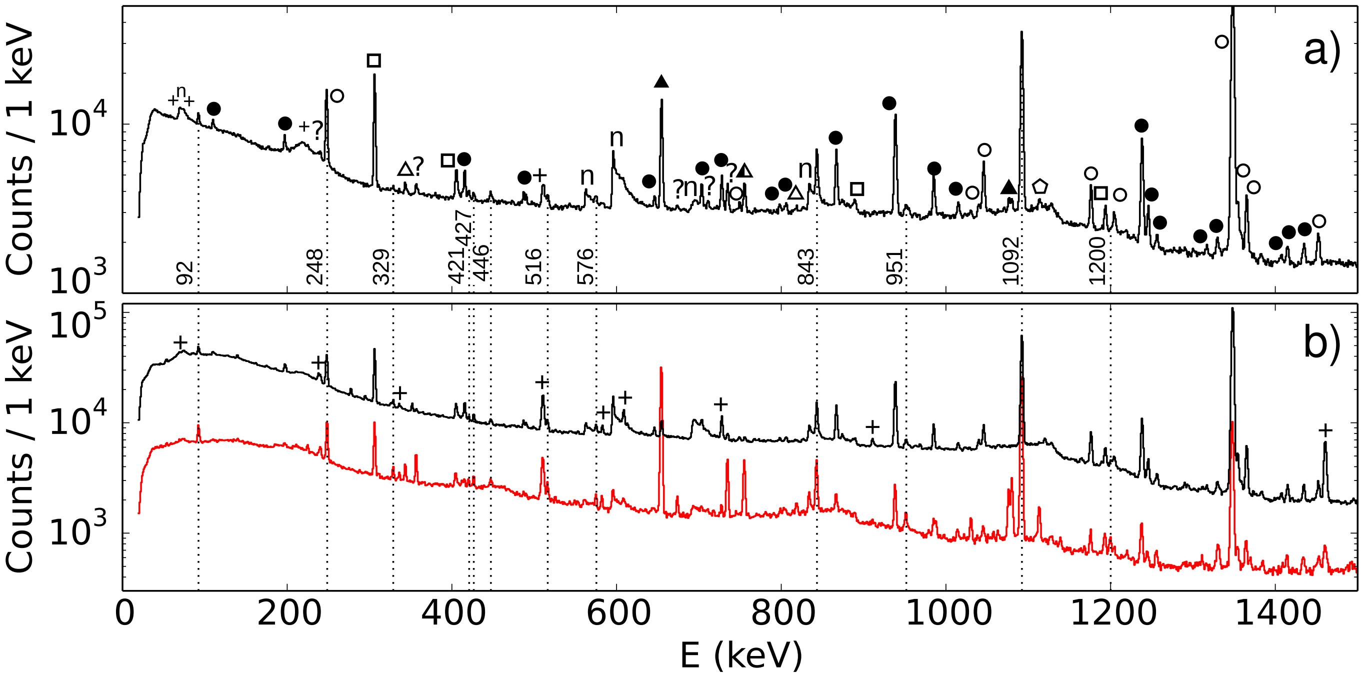

FIG. 1. (color online) a) Total β-gated γ-spectrum obtained in the experiment. Transitions identified by dotted line and energy were assigned to the decay of ^{82}Ge. Other transitions are marked by parent decay: open circles (^{83}Ga β0n), filled circles (^{83}Ga βn), squares (^{83}Ge), open triangles (^{82}As^{m}), half-filled triangles (^{82}As^{gs}), filled triangles (both ^{82}As^{gs,m}) pentagons (^{83}As) or question mark if unassigned. The letter n indicates that the γ-ray is emitted in the neutron reaction on natural Germanium isotopes (A = 70, 72-74, 76). The crosses indicate a background transition.
b) γ-singles spectra obtained in tape-cycling mode (upper curve, black), and in saturation mode (lower curve, red). Most prominent common background lines are marked with crosses.

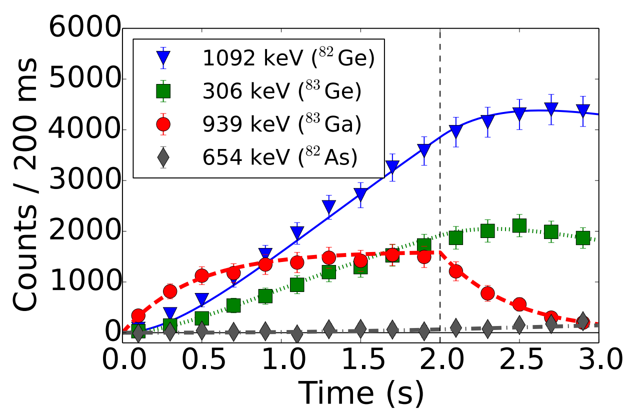

FIG. 2. (color online) The grow-in/decay-out pattern of selected γ-transitions. The lines show the solutions of the Bateman equation for the first (dashed) , second (solid and dotted) and third (dashed-dotted) isotope in the radioactive chain. The curves were calculated using known half-lives of the isotopes and absolute γ-ray normalization, the only fitted parameter was the implantation rate of ^{83}Ga ions.

In a recent β-decay measurement of ^{82}As^{gs} and ^{82}As^{m} the absolute intensities of the γ transitions were given [8]. The 745-keV γ transition was reported to occur only in the decay of the ground state, with an absolute intensity of 9.5(5)%. Using this value we calculate the number of observed ^{82}As^{gs} to be $0.313(78) \times 10^{6}$. This result is within the error bars of the expectation number of ^{82}As decays found from the number of implanted ^{83}Ga atoms, which yields 11(1)% absolute intensity for that transition.

The 343-keV γ transition is observed only in the decay of the isomeric state. Comparing the intensity of this transition with the intensity of 745-keV transition (using the new normalization), we find that in the decay of ^{82}Ge the relative feeding of the isomeric state ^{82}As^{m} is 1.2(3)% and of the ground state ^{82}As^{gs} is 98.8(3)%.

D. ^{82}Ge decay scheme

Using the γ-singles and γ-γ coincidence spectra we have built the decay scheme presented in Fig. 3. Examples of γ-γ coincidences data are presented in Fig. 4. The spin assignments will be discussed in the next section.

Of the previously reported γ rays in the decay of ^{82}Ge (248, 843, 1092, and tentatively, 952 and 140 keV), we may confirm the placement of the 248, 843 and 1092 transitions. However, the 952-keV γ ray is in clear coincidence with the 1092-keV transition (see Fig. 4c). Therefore the 952-keV transition is place above the 1092-keV level. This placement is confirmed by the 1064-keV transition de-exciting the 2044-keV level to the 980-keV level.

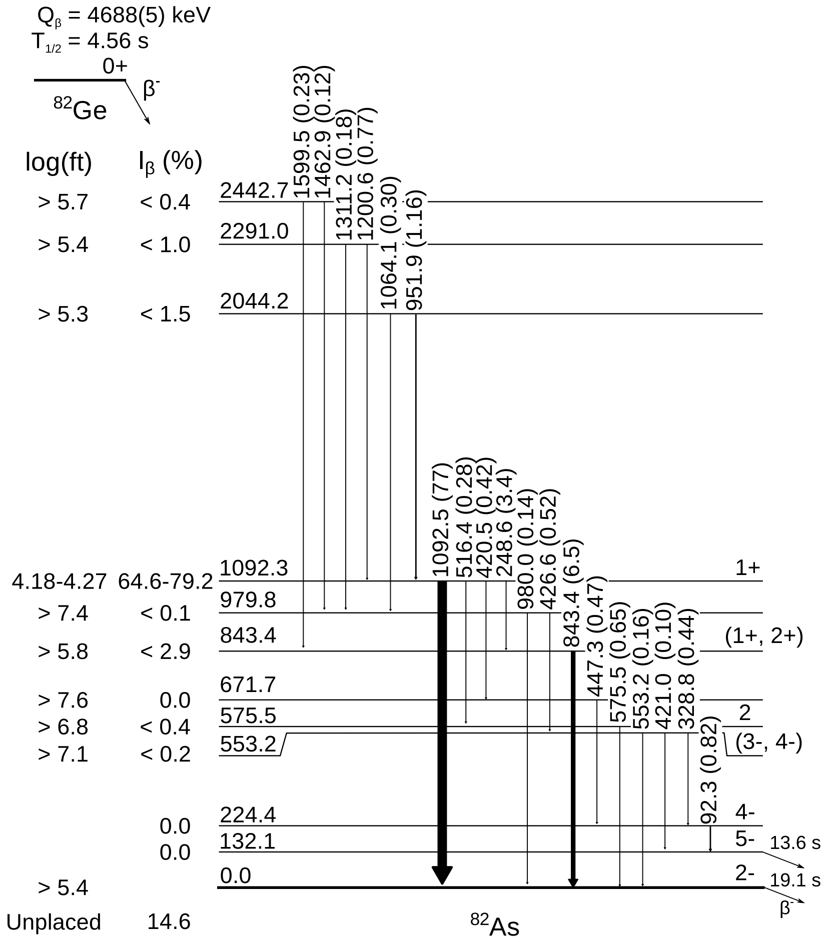

FIG. 3. Proposed β-decay scheme of ^{82}Ge. Intensities of γ transitions (in brackets) are given per 100 parent decays. Notice that 14.6% of β-feeding is unplaced in the decay scheme. This value is included in the $\log(ft)$ calculations.

We do not observe a 140-keV line in the spectrum and therefore we cannot confirm the assignment of this transition to the decay of ^{82}Ge.

The intensities of the observed γ-rays are normalized to 100 parent decays. The total observed β-feeding is 85.4(71)%, the remaining 14.6% might proceed through undetected γ transitions or directly to the ground state. A summary of γ-lines assigned to the decay of ^{82}Ge is presented in table I.

The location of the isomeric state at 132-keV is deduced from transitions feeding and de-exciting the 553-keV level. The $\gamma-\gamma$ coincidence spectra (Fig. 4a,b) confirm the placement of 92, 329, 421, 427, and 553 keV transitions and the energy of the isomeric state.

The placement of the isomeric state at 132.1(2) keV is in very good agreement with the value of 128(6) keV found in a Penning trap measurement [7]. The lower part of the level scheme obtained in this work is also in very good agreement with the one measured in ^{82}Se$(t,^{3}$He$)^{82}$As reaction [18]. The level schemes are compared in Fig. 5. The state located at 124(15) keV would correspond to the isomeric state found in this experiment. None of the states above 980 keV were observed in the reaction experiment [18]. Additionally there are two states that were not seen in the β-decay, located at 340 and 600 keV. Their possible properties will be discussed later.

E. Spin and parities discussion

a. Literature survey The spins of the ground state and the isomeric state were previously assigned on the basis of the incomplete β-decay schemes for ^{82}Ge and ^{82}As^{gs,m} and on systematics.

In the work of van Klinken et al. [6] we find an extensive discussion of the spin assignments. The authors argue that strong feeding to the ^{82}Se ground state indicates 1^{+} for the ground state of ^{82}As. The ^{82}Se ground state feeding is reported to be 80(10)%, in clear disagreement with the result found in Ref. [8] (25(25)%) and the results from this work ($<11\%$). The source of this large discrepancy is an assumption that all unobserved β transitions are feeding the ground state [6].

The article by P. Hoff and B. Fogelberg [12] suggests 2^{-} for the ^{82}As ground state and is based on the systematics

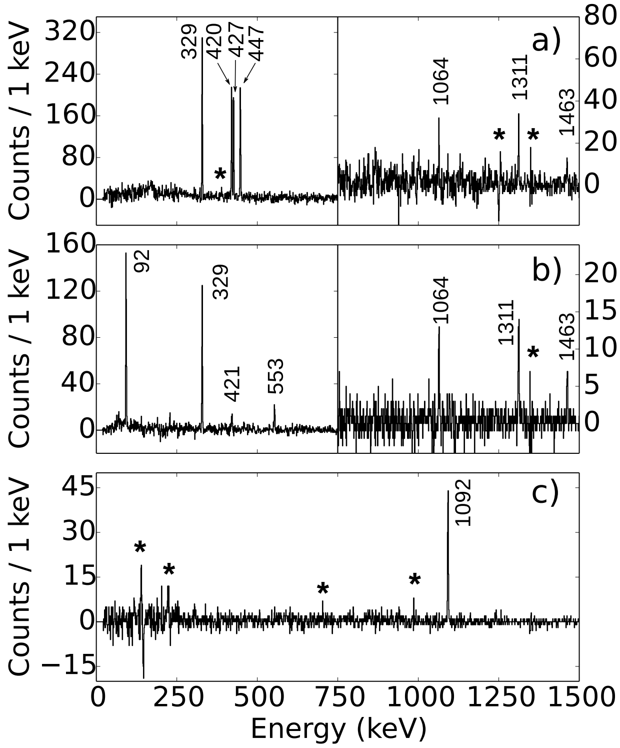

FIG. 4. Background-subtracted $\gamma - \gamma$ coincidence spectra gated on the following transitions: 92 keV (a), 427 keV (b), and 952 keV (c). The peaks marked with star ($\star$) are artifacts due to the background- subtraction procedure.

TABLE I. Summary of γ lines assigned to the decay of ^{82}Ge. Intensities are given relative to the 1092 keV transition. For absolute intensities in percent, multiply by 0.77.

Energy (keV)	I_γ	$\gamma - \gamma$
92.3(2)	1.07(5)	329, 420, 427, 447, 1064, 1311, 1463
248.6(5)[a]	4.4(3)	843, 1201
328.8(2)	0.57(6)	92, 427, 1311
420.5(5)[b]	0.54(5)	92, 447
421.0(5)[b]	0.13(5)	427
426.6(2)	0.67(10)	92, 329, 421, 553, 1064, 1311, 1463
447.4(2)	0.61(5)	92, 420
516.4(2)	0.36(3)	575
553.2(5)[c]	0.21(5)	—
575.5(2)	0.84(6)	516
843.4(2)	8.4(3)	248, 1201, 1600
951.9(2)	1.5(1)	1092
980.0(2)	0.14(7)	—
1092.3(2)	100(1)	952, 1201
1063.9(5)[c]	0.3(1)	—
1200.1(3)	1.0(3)	843, 1092
1311.2(5)[c]	0.23(5)	—
1462.9(5)[c]	0.15(5)	—
1599.5(5)[c]	0.3(1)	—

[a] Doublet with the 247.5 keV transition in ^{83}Ge. Resolved with the coincidence data.
[b] Doublet resolved with the coincidence data.
[c] Observed in the coincidence spectra only.

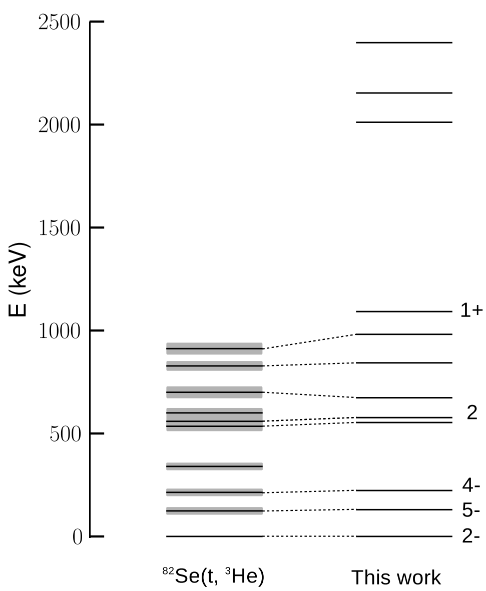

FIG. 5. Comparison of the experimental level schemes of ^{82}As obtained in the β-decay (this work) and in ^{82}Se(t,^{3}He)^{82}As [18]. In the latter case the thickness of the levels reflects the experimental uncertainties (10-20 keV).

of the N = 49 isotones (^{84}Br and ^{86}Rb). The isomeric state was not observed and was not discussed.

The $2^-, 5^-$ sequence was supported by the work of Gausemel et al. [8] studying the β-decay of ^{82}As^{gs} and ^{82}As^{m}. In this case the claim is based on differences in the feeding of states in ^{82}Se. However the large uncertainty in the ^{82}Se ground state feeding (25(25)%) limits the conclusions that can be drawn from that method.

Clearly none of the cited methods provides a reliable way to establish the spin. The assignment based on systematics could be misleading for an odd-odd nucleus where a number of closely spaced states are expected at low-energy, and their ordering is difficult to predict. The partial β-decay schemes are subject to the "pandemonium" effect [19] where the β-feeding and γ de-excitation paths are fragmented between many weak branches. They may remain undetected and significantly alter the β-feeding values obtained from the γ-ray balance. This effect is credited with many incorrect log(ft) measurements [19]. However, it must be noted that the β-decay scheme can provide the lower limit of the log(ft) values, and, if the absolute normalization is known, the higher limit of log(ft) for strong transitions.

One of the methods to overcome the limitations of the β-decay studies is the total absorption spectroscopy with a high efficiency γ-ray detector[19]. The decay of ^{82}As was measured with such a technique [20], unfortunately the decays of ^{82}As^{gs} and ^{82}As^{m} were not resolved and a sum of the two was presented in Ref. [20]. The ratio of the ^{82}As^{gs}/^{82}As^{m} was not given, but the half-life of 16.3 s suggests that the mixture could be approximately 1:1. The result shows that a significant part of the beta-strength is located at energies > 5 MeV. This supports the "pandemonium" scenario and the need to regard log(ft) values obtained from the γ balance as lower limits.

b. Discussion With the new data on ^{82}As^{gs,m} and the new decay scheme of ^{82}Ge, the assignment of the spins and parities will be revisited. We were able to find the range of log(ft) values for the 1092 keV level. The upper limit is obtained under assumption that all missing transitions are feeding this level, and yields log(ft) = 4.27. The lower limit of log(ft) = 4.12 is obtained from the apparent β-feeding. The range of log(ft) values clearly indicates an allowed Gamow-Teller transition [1]. The ground state of the even-even nucleus ^{82}Ge is 0^+, therefore, the only possible spin assignment for the 1092 keV level is 1^+.

For other states, including the ground state, we can only give the lower limit of the log(ft) value, since the missing transitions can fully explain apparent β-feeding derived from the current decay scheme.

The indirect feeding of the first excited (isomeric) state in ^{82}As from the γ intensities balance is 1.2(1)%. This value is in very good agreement with the one obtained from the comparison of the γ-transitions observed in the decay of ^{82}As^{gs,m} (1.2(3)%). Therefore, we conclude that there are no direct β-transitions to the isomeric state, and this state is populated only in the de-excitation of other levels.

All the detected γ-transitions have a half-life shorter than 20 ns, which is the sensitivity limit of our detection setup. This limits the choice of transition multipolarities to M1, E1, M2 or E2.

The low-lying levels of ^{82}As are expected to be of negative parity, built from the neutron hole $\nu g_{9/2}^{-1}$ and 5 protons in the $\pi f_{5/2}$ and $\pi p_{3/2}$ single particle levels. This assumption is well supported by the measurements of the neighboring even-odd nuclides (^{83}As, ^{81}As, ^{83}Se). The configurations one can obtain from coupling the particles $g_{9/2}^{-1} \otimes (f_{5/2}, p_{3/2})^5$ are $I^\pi = 0 - 10^-$. However, the lowest excitation states are expected to be $I^\pi = 2 - 7^-$ created from a configuration where four protons are coupled into pairs and the odd proton is coupled with the neutron hole. The lowest positive parity states can be built by creating a hole in the $\nu p_{1/2}^{-1}$ or $\nu f_{5/2}^{-1}$ particle states. These hole states coupled with $\pi f_{5/2}$ or $\pi p_{3/2}$ lead to $I^\pi = 0 - 5^+$.

Since the 1092 keV level has spin 1^+ and the 1092 keV transition has half-life less than 20 ns, the spin of the ground state is limited to $I = 0 - 3$. The fact that the transition between the isomeric state and ground state is not observed and the β half-life is 13.6 s, require that the difference in the spin between the two states is $3\hbar$ or higher. There is no observed direct feeding of the isomeric state; the ^{82}Se ground (0^+) and first excited (2^+) state are not fed in the decay of the isomer; and the 4^+ and 5^- states are strongly fed. Therefore we deduce that the isomeric state has higher spin than the ground state, and the 1092 keV γ-transition feeds the ground state.

The multiplet of $I^\pi = 2 - 7^-$ provides five possible choices that can result in the observed isomeric state properties. These are: 2^- and (5^- or 6^- or 7^-), and 3^- and (6^- or 7^-), for the ground and isomeric state, respectively. At the same time, the spin of the second excited state at 224.4 keV must be $\pm 1\hbar$ different than the isomeric state (or the 92 keV transition should have detectable half-life), and $\pm 2\hbar$ or more different than the g.s (or the 224 keV transition should be observed).

The spin assignments proposed in this work are based on observed transitions, cross-transitions (or lack of such) and intensity balance. Of the possible combinations we find the most plausible to be 2^- g.s. and 5^- i.s, thus confirming the conclusions from ref. [8]. Consequently, the state at 224 keV is assigned 4^- spin and parity. This conclusion is based on the pattern of γ-transitions deexciting the 224, 553, 672, 843, 980 and 1092 keV levels. The remaining combinations of the ground state and isomer spin would result in a need to assign M3 or higher multipolarity to one of the transitions. An M3 transition of 500 keV will have an approximate half-life of 10 ms and most likely the de-excitation would proceed by a different path, or its half-life would be detected, even in the case of a strongly enhanced transition (i.e. up to 5×10^5 W.u.).

The tentative spin of the 553-keV level is proposed based on three γ-transitions originating from this level. Taking into account typical [21] strengths for E1, M1, and E2 transitions in this region ($10^{-4}, 10^{-2}, 10$ W.u., respectively) one can find that both $3^-, 4^-$ result in intensities close to the experimentally observed ones.

The spin of the 575-keV level was assigned based on the following observations. The 1092-keV level (1^+) decays by a cascade of two γ-transitions via 575-keV level to the ground state (2^-); the 516-keV transition from 1092-keV level must be able to compete with a strong 1092-keV transition; the 575-keV level is not, or only weakly, fed in the β-decay. In order to meet these requirement we propose a spin of 2. The parity of the state cannot be assigned firmly.

It is worth noticing that direct β-decay to the 2^- ground state is a second forbidden transition, and, even in the case of the lowest observed $log(ft)$ values (7.5 [1]), the feeding is expected to be no larger than 0.1%. Therefore we expect that remaining unobserved feeding deexcites through a weak, undetected transitions, and, to finalize the decay scheme, a total absorption spectroscopy experiment should be performed.

IV. SHELL-MODEL CALCULATIONS

The shell-model calculations for ^{82}As were carried out in the *fpg* subspace, consisting of $p_{1/2}, p_{3/2}, f_{5/2}$, and $g_{9/2}$ orbitals for both neutrons and protons. This sub-space covers isotopes from ^{56}Ni to ^{100}Sn. This region of the chart of nuclides constantly meets with interest of both experiment and theory, and a number of shell-model interactions were created. We have used interactions of two major categories, the realistic interactions (N3LO [22] and V18 [22]), and effective interactions (JUN45 [23] and JJ44 [24]). The calculations were cross-checked by using three different shell-models codes: ANTOINE [25], NuShellX [26] and a shell-model code by M. Hjorth-Jensen et al. [22].

Additionally a very simplistic model of residual interaction, the Surface Delta Interaction (SDI) [27], was also used to provide a level scheme that is easy to interpret. In the latter case the parameters of the model, $V_{T=0}$ and $V_{T=1}$, were tuned to the experimentally known levels of ^{58}Cu, and the same single particle energies as in the JUN45 interaction were used.

The comparison of the calculated level scheme and the levels obtained in the experiment is shown in Fig. 6. For clarity only the lowest-lying levels with a given spin are labeled. The levels provided by N3LO, V18 and SDI are quite similar. In all cases the lowest multiplet consists of $5^-, 4^-, 6^-, 3^-$. Both N3LO and V18 fail to predict the position of the suggested ground state 2^- level even in approximate way: in these cases the 2^- is located at the energy of 2.3 and 2.1 MeV, in N3LO and V18 calculations respectively. The N3LO interaction also fails in predicting the position of the first 1^+ state, placing it at 3 MeV. It must be noted that the position of this state is crucial for estimating the half-life, since it bears most of the feeding in the beta-decay ($\log(ft) \approx 4.2$). Surprisingly, the simplistic SDI interaction is a little better at placing both 2^- and 1^+ states, but obviously it is also far from the experimental picture.

One could expect that the effective interactions JJ44 and JUN45, being tuned to the region of interest should give better results. While the JUN45 is by far the best choice of interaction for ^{82}As giving results closest to the experimental values, the JJ44 is on par with the SDI.

A closer inspection of the two-body matrix elements reveals that the elements responsible for the poor behavior of the realistic interactions are probably related to the $g_{9/2}$ orbital, $T = 1$ part of the interaction. The differences are strongly enhanced in the case of ^{82}As since the $\nu g_{9/2}^{-1}$ hole interaction with protons in a negative parity orbitals is the primary contribution to the lowest states, including the 5^- and 2^-. The 1^+ state, built mainly on $\pi p_{3/2}$ coupled with $\nu p_{1/2}^{-1}$ and $\nu f_{5/2}^{-1}$, changes position probably due to the differences in the two-body matrix elements containing the $f_{5/2}$ single particle orbital. However, one must also notice that this region of the chart of nuclides is known from presence of low-energy intruder states [12, 28] that are beyond shell-model approximation and may contribute to position of the positive parity states.

It is also worth noticing the differences in the single particle energies between models, particularly in the position of the $p_{1/2}$ and $f_{5/2}$ orbitals [23, 24]. In the JUN45 interaction the single particle energies were treated as fit parameters [23], while in other interactions they were derived from the position of the excited states of isotopes in the neighborhood of ^{56}Ni. This core is noticeably softer ($E_{2+} = 2.7$ MeV) than other doubly-magic nuclei, hence the experimentally observed states may not be sufficiently well described as single-particle states.

A comparison with levels populated in the (t, ^{3}He) reactions suggest that the two levels missing in the beta-decay scheme are good candidates for the 6^- state predicted by all the models. Such states would not be observed in the β-decay due to the large spin differences. However, due to lack of experimental evidence we cannot propose this spin assignment firmly.

V. SUMMARY

We have presented results of a study of excited states in ^{82}As populated in the β-decay of ^{82}Ge. The measurements were performed using mass-separated, fission-fragment beams of excellent isobaric purity and a state-of-the-art detector setup with digital electronics. The decay scheme was largely extended, to 9 states and 19 γ-ray transitions. Thanks to the purity of the beam, the absolute intensities of the transitions have been found. This allowed for more reliable spin assignments and comparison of the results with the shell-models calculations. Out of tested interaction models only the level scheme predicted by the effective interaction JUN45 was close to the experimental results. The realistic interactions were shown to be very inaccurate, most probably due to bad description of two-body matrix elements involving the $g_{9/2}$ orbital. This orbital influences also decays of isotopes in the r-process region N > 50, Z > 28, where a favored Gamow-Teller transition to highly excited states is observed [29, 30]. This shows that the use of realistic interactions in attempts to describe nuclei out of experimental reach, e.g. those needed in r-process modeling, should be included with great care.

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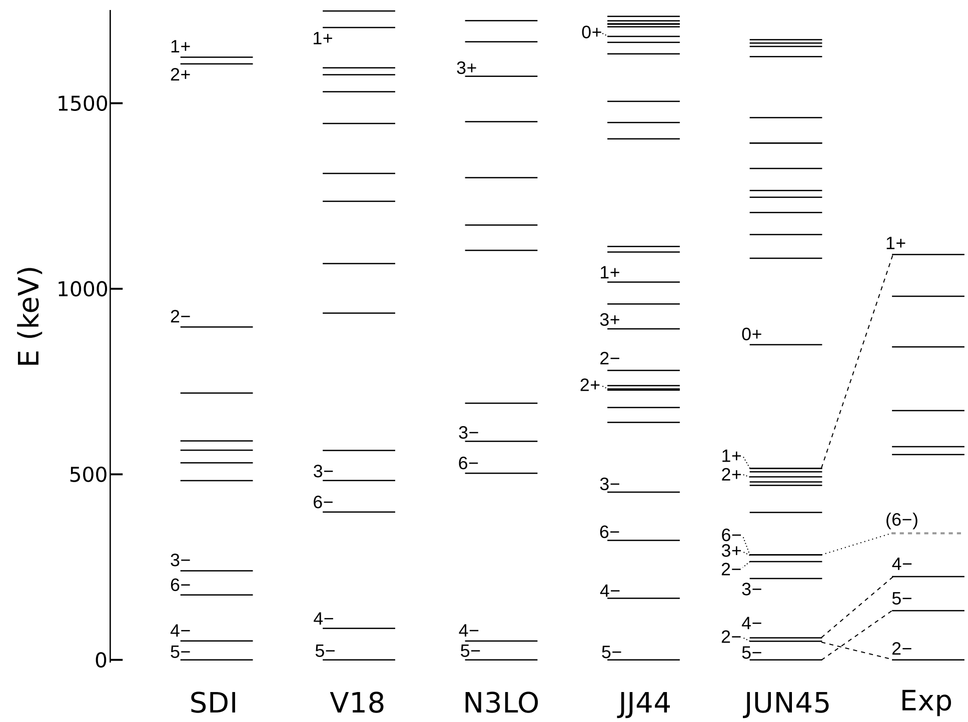

FIG. 6. Comparinson of the ^{82}As level scheme from the present work and results of the shell-model calculations with different interactions (see text for more details). The tentative 6^{-} state at 340 keV is from [18].

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