ADVANCED NUCLEAR SPECTROSCOPY NEAR ^{132}Sn*

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(Received January 31, 2001)

A summary of recent experimental efforts on nuclei in very close vicinity to the doubly magic ^{132}Sn and perspectives for further progress in the very near future, are presented. A special attention is given to the selected key developments in this mass region via three avenues of production and investigation of exotic nuclei: β decay at the ISOL facilities, prompt γ-rays in spontaneous fission probed using large Ge arrays, and μ-second isomers produced in the fragmentation and in-flight separation of energetic uranium beams or in fission using recoil separators.

PACS numbers: 27.60.+j, 21.10.Pc, 21.60.Cs

1. Introduction

The nuclei at double shell closures command a considerable interest as they represent a micro-laboratory where a complex multi-nucleon assembly can be simplified into a system where up to a few valence nucleons interact among themselves and with a largely inert core. While studies of the doubly magic nucleus itself reveal the mechanism of core excitations, nuclei with a single valence particle or hole provide the single particle energies, which are critical parameters for model calculations on a wide range of nuclei extending well beyond the shell crossing. Moreover, systems with a few valence nucleons reveal the residual interactions among two kinds of nucleons and in various orbits. These nuclei provide stringent tests of the nuclear models. A strong theoretical interest in the nuclei at the doubly magic regions, has been discussed in depth by Prof. Aldo Covello in the preceding presentation, thus we focus here on the experimental results.

* Presented at the XXXV Zakopane School of Physics "Trends in Nuclear Physics", Zakopane, Poland, September 5–13, 2000.

The studies of exotic nuclei at the double shell closure represent a formidable experimental challange. Recently, thanks to novel techniques of production, separation and identification, new experimental information is emerging on the doubly magic regions far-off stability line. These data provide an opportunity to predict properties of even more exotic regions where new phenomena are expected. Of particular interest are the loosely bound systems with a large neutron excess. Here some of the key information is provided by the nuclei at ^{132}Sn, which is the only neutron-rich doubly magic region for the medium to heavy mass range, currently accessible for detailed spectroscopical studies. This presentation provides an update of an earlier review on the nuclei at ^{132}Sn given in Gatlinburg in 1998 at the International Conference *Nuclear Structure '98* [1].

2. Advanced means of production, separation and identification

The experimental studies on the neutron-rich ^{132}Sn region explore in various ways fission of heavy targets as the means of production. In recent years, the range of available production and separation techniques for accessing this region has greatly increased as well as the quality of data coming from established methods has strongly improved. The latter is thanks to a new generation of detectors with vastly increased efficiency. One can identify three areas of research at ^{132}Sn that have a strong impact and can be classified via a distinctive method of production and separation and/or identification of exotic nuclei. The first one includes studies of ground state properties (masses, magnetic moments, *etc.*) and β decays via the traditional route of fission product isotope separation as utilized at ISOLDE at CERN or OSIRIS at Studsvik using "standard" ion sources. At both facilities a new generation of ion sources has been introduced, which dramatically improved the exploration of exotic nuclei in selected regions. For example a new isotope of ^{135}Sn has been identified and studied at the OSIRIS separator by Korgul *et al.* [2] by introducing a special ion source which included ^{238}U as target material with fission induced by fast neutrons. The same isotope of ^{135}Sn has been subsequently reached also at ISOLDE by Shergur *et al.* [3] using the Resonance Ionization Laser Ion Source (RILIS) and a host of associated techniques. The latter study reports also on the first identifcation of the decay of ^{136}Sn. The use of the RILIS ion source coupled with the High Resolution Separator (HRS), which resolution is gradually improved, opens up a host of new measurements at ISOLDE characterized by high resolution and sensitivity, for example: the mass measurements via the ISOLTRAP and MISTRAL RF-spectrometer and laser spectroscopic studies. The measurements at ^{132}Sn will also gain sensitivity by use of a compact Ge array, which will be applied at ISOLDE in the nearest future. Similarly at OSIRIS, further development of the ^{238}U target ion source, and utilization of a small Compton-suppressed Ge array comprised of Nordball detectors, will improve the sensitivity of studies. At both facilities new possibilities for studies of magnetic moments via the Low Temperature Nuclear Orientation (LTNO) technique and dynamical moments via Advanced Time-Delayed Multi-Coincidence Methods are further explored. Finally, one should note, that the application of Penning traps for the full isobaric separation, would result in an extraordinary possibilities at ISOLDE for studies of the exotic nuclei near ^{132}Sn.

The second key approach to the ^{132}Sn nuclei is offered by probing prompt γ-rays in spontaneous fission. These studies use a new generation of multi-detector arrays, EUROGAM or GAMMASPHERE, which provide the necessary level of sensitivity to allow a detailed investigation of medium-spin yrast and some rare sequences for nuclei at ^{132}Sn. It is interesting to note, that in many cases the level schemes deduced from prompt fission and β decay studies have no common excited states, which makes it difficult to fix the excitation energies of the former group of states on an absolute scale. For example, such is the present case for ^{132}Sb and ^{134}Sb. Further studies of prompt γ-rays in fission, will certainly proceed via different fissioning sources, either in the case of spontaneous fission or fission induced by neutrons, protons or heavier projectiles, providing a higher yield for population of selected groups of nuclei at ^{132}Sn. This will allow for high quality angular corrrelations, linear polarization, conversion electron, and level lifetime measurements via the Doppler shift "plunger" and fast time-delayed methods, for many nuclei in this region.

The third technique utilizes the fact that some nuclei have excited isomeric states with level lifetimes in the micro- to milli-second range, in order to separate them from other fission products. This old technique, which many years ago was so successfully applied to the ^{132}Sn region, *e.g.* by Prof. Kornel Sistemich group at the JOSEF separator at Jülich [4], has been recently strongly invigorated at the LOHENGRIN facility at ILL Grenoble [5]. However, a new approach is offered at the in-flight fragment separator FRS at GSI in Darmstadt, where by the fragmentation of energetic uranium beams one can reach further away from the line of stability. This approach was already shown at GSI by Bernas *et al.* [6,7] to provide means of production of a host of new nuclei somewhat near ^{132}Sn, yet the production intensities are low. The strength of the method is a nonselective extraction of the fission fragments and full A and Z separation. The first test run, conducted in 1999 by Hellström *et al.* [8], in search for the μs isomers near ^{132}Sn, has affirmed a strong potential of this technique. Although the data analysis is still in progress, this test run has easily revealed [8] several known isomers in this region, and it has also produced a new one, at ^{136}Sb.

However, the full potential of this technique is yet to be unleashed, while the proposed upgrade of the GSI facility and new detector systems considered in the RISING project can dramatically improve the research possibilities at FRS. GSI, however, offers further experimental possibilities that go beyound the μs isomer approach, *e.g.*: direct mass measurements in the storage ring, β decay studies at FRS, or Coulomb excitation in the inversed kinematics, which will certainly be explored at GSI in the nearest future.

The aim of this presentation is to review the current status of the experimental data at ^{132}Sn with projects concluded or started since 1998. The next sections describe the new data on the excited states in these nuclei, followed by a summary on the ground state properties. No discussion is provided on the new RNB facilities under development, which will strongly impact the future knowledge of nuclear structure at ^{132}Sn.

3. The doubly magic core nucleus ^{132}Sn

The current knowledge on the excited states in ^{132}Sn is largely summarized in the study by Fogelberg *et al.* [9]. No new experimental information has been offered recently, although preliminary results from the on-going studies via the β delayed neutron emission of ^{133}In [10] (see the discussion on ^{133}Sn) and prompt γ-rays in fission [11] offer hope for the identification of several new states in the low-spin and high-spin regimes, respectively. At OSIRIS, a higher sensitivity offered by a small array of Compton-suppressed Ge (Nordball) detectors may prompt a high sensitivity reinvestigation of ^{132}Sn from the β decay of ^{132}In. Most likely in the next few years, there will be a measurement on ^{132}Sn using Coulomb excitation in inversed kinematics, as the intensities of energetic secondary beams of ^{132}Sn are reported at a few facilities to reach significant levels. Perhaps the first such study will be performed at GSI in Darmstadt as suggested by Dr. Jürgen Gerl [12] in his talk at this School. It is understandable, that such experiments should be given top priority treatment at these facilities.

4. Single-valence particle/hole nuclei

Almost complete sets of single particle states have been determined in the single-valence proton ^{133}Sb and single-valence neutron-hole ^{131}Sn. The recently proposed [13] location of the single neutron states in ^{133}Sn requires further verification, but little is known on the single proton-hole states in ^{131}In.

Single-neutron states in ^{133}Sn: The location of the single-neutron $p_{3/2}$, $h_{9/2}$ and $f_{5/2}$ states was found by Hoff *et al.* [13] at 853.7, 1560.9 and 2004.6 keV, respectively, from the measurements involving β delayed neutron emission of ^{134}In. This first (test) measurement performed at ISOLDE did not identify, however, the $p_{1/2}$ state expected to be lying at the excitation energy of about 2 MeV. At the same time, two γ transitions of energy 354.0 and 802.0 keV (potential candidates for the de-excitation of this state) were identified as lines in ^{133}Sn, but have not been firmly placed in the level scheme. A more recent attempt to repeat this measurement [10] has failed, however, due to a very strong presence of Cs impurities. The next attempt will require the high resolution HRS separator and/or the RILIS ion source. It should be noted, however, that a very low level of Cs impurities enjoyed in the first measurement was extraordinary. Extraordinary, was also lack of any ^{229}Fr activity in the experiment IS322 that immediately followed the ^{133}Sn run and used the same ion source. The apparent suppression by 1–2 orders of magnitude the production of Cs and ^{229}Fr remains to be explained. (A steady clean beam of ^{229}Ra, with a marginal presence of the ^{229}Fr activity, has been provided for a few days — a condition never repeated in subsequent runs.) This could possibly imply that there is a way to suppress Cs in a "standard" ion source, which if true, would be very interesting. A strong level of Cs impurities remains a problem at the ISOLDE facility for almost all measurements on exotic nuclei at ^{132}Sn and is related to the inherent mechanism of 1 GeV proton induced spallation/fission of heavy targets coupled to very high surface ionization efficiency for Rb, Cs or Fr. In contrast, Cs impurities are virtually non-existent in this mass region at OSIRIS as the production proceeds via neutron-induced fission of U targets.

In ^{133}Sn, the 1561 keV transition was identified by Urban *et al.* [14] in the spontaneous fission of ^{248}Cm in coincidence with lines in ^{112}Pd, which was the strongest fission partner to ^{133}Sn. The observation of the 1561 keV line provides [14] a strong support for the interpretation of the 1561 keV level in ^{133}Sn as the $h_{9/2}$ single-neutron state. The argument here relies on the fission process to populate preferentially the yrast states.

Single neutron-hole states in ^{131}Sn: Initially it was believed that a complete set of single neutron-hole states has been identified in ^{131}Sn [15,16]. However, the proposed location of the $h_{11/2}$ state at 241.8 keV, has been suspected for some time to be too high [17]. This purely empirical conclusion is based on the analysis of the two quasiparticle states in the neighboring nuclei, which suggests the location of this state to be considerably lower at about 100 keV. Firm determination of the excitation energy of the $h_{11/2}$ state in ^{131}Sn is a goal of a few independent investigations. At OSIRIS an initial reinvestigation of the γ decay scheme for the decay of ^{131}In did not produce a firm result yet [18]. Another avenue represent precise mass measurements using ISOLTRAP, which are capable of precision of about 10–15 keV and separation of isomeric states as close as $\sim$100 keV (this was demonstrated in the case of ^{185}Hg, where an isomeric state was located 118(5) keV above the ground state; its known energy is 99.3(5) keV). A preliminary analysis of the test mass measurements on the Sn nuclei near $A = 132$ using ISOLTRAP, performed at ISOLDE in July 2000 by Bollen *et al.* [19], did not reveal presence of an isomeric state in ^{131}Sn. However, these measurements will be repeated with much higher statistics in the summer of 2001, with a strong focus on the $h_{11/2}$ case in ^{131}Sn.

Single-proton and core-coupled states in ^{133}Sb: There has been a significant progress in the knowledge of the excited states in ^{133}Sb. A high-sensitivity investigation of the β decay of ^{133}Sn to ^{133}Sb, performed at OSIRIS by Sanchez-Vega *et al.* [20], has clarified the position of the proton single particle $d_{3/2}$ state at 2439.5 keV, and provided a number of key γ branchings and absolute transition rates among the proton single particle states. Despite, high sensitivity of this study, the proton $s_{1/2}$ single particle state has not been located. Various theoretical models predict this state to be located from about 2 to 5 MeV in the excitation energy, see for example Table 2 in [21]. The same investigation [21] has provided a detailed experimental β strength for the decay of ^{133}Sn, including precise values of $\log f_0 t = 5.44$ and 6.05 and $\log f_1 t = 9.3$ for the $\nu f_{7/2} \to \pi g_{7/2}$, $\nu f_{7/2} \to \pi d_{5/2}$, and $\nu f_{7/2} \to \pi d_{3/2}$ transitions, respectively. Moreover, the β decay of ^{133}Sb to ^{133}Te has been also re-investigated [22] leading to a large number of new levels and transitions in ^{133}Te. A detailed experimental β strength, which was obtained for the decay of ^{133}Sb, has provided an important test case for the advanced microscopic model calculations [23].

There have been three independent studies of the 16 μs isomeric state [4] at ~4.5 MeV in ^{133}Sb. They all concluded that the isomer is due to the $21/2^+$ member of the three quasiparticle configuration $\pi g_{7/2}\nu\,(f_{7/2}h^{-1}_{11/2})$ formed by coupling of the valence proton to the excitation of the core. The first investigation by Isakov *et al.* [24] was based on model calculations and the experimental systematics of the absolute transition strength for the E1, M1, E2, M2, E3, M3 and E4 transitions recently deduced at ^{132}Sn. It concluded that the 16 μs state was in fact unobserved in the earlier study [4] and it lies about 40 keV or less above the known state at 4526 keV. Two parallel experimental studies, subsequently reported findings in agreement with the conclusion of [24]. The investigation at LOHENGRIN via thermal neutron induced fission of ^{241}Pu, by Genevey *et al.* [5], found only the main isomer reported in [4], with the $T_{1/2}$=16.8(5) μs in good agreement with the previous value of 16.0(1.5) μs. This study [5] allowed to firmly deduce M1 multipolarity for the 61.5 and 162.5 keV transitions, and to lower the energy gap between the unobserved isomer and the 4526 keV state to less than 20 keV. Finally, Urban and collaborators [25] who investigated the isomer populated in the spontaneous fission of ^{248}Cm at the EUROGAM2 array, provided the spin/parity determination for the lower-lying levels by measurements of angular correlations and linear polarization of γ rays. Although a considerably more complex decay scheme was observed, nevertheless this study also concluded that the $16\,\mu$s isomer remains unobserved and must be located just above the 4526 keV level. The interpretation of the isomer as a core-coupled state with spin $21/2^+$, have been provided in all three studies via shell model calculations.

Single proton-hole states in ^{131}In: Until recently, only two single proton-hole states were known in ^{131}In, the $g_{9/2}$ ground state and the $p_{1/2}$ state at 365 keV, both from the β decay studies to ^{131}Sn. However, a steady and impressive progress in the exploration of the exotic nuclei below ^{132}Sn, shown by the Mainz group of Prof. Karl-Ludwig Kratz, has recently resulted in the first information on the β decay of ^{131}Cd to ^{131}In. In a work performed at ISOLDE using the RILIS ion source, Hannawald *et al.* [26] have measured a surprisingly short half-life of 68(3) ms and a weak β delayed neutron branch of 3.5(10) % for the decay of ^{131}Cd. Moreover, from the γ-rays identified in the experiment as belonging to ^{131}Cd, possible positions of the $p_{3/2}$ and $f_{7/2}$ single particle states were very tentatively suggested at 1.65 and 2.75 MeV, respectively. The results were interpreted as supporting the mass values derived from models that include shell quenching. The new data certainly show that more detailed γ spectroscopy of the excited states in ^{131}In has become feasible.

5. Two-valence particle/hole systems

Two-valence neutron ^{134}Sn: Recently, a new excited state at 2508.9 keV was reported by Korgul *et al.* [27], which de-excites to the 6^+ state of the known $\nu(f^2_{7/2})$ multiplet [28]. The proposed interpretation of the new state as $\nu(f_{7/2}h_{9/2})_{8^+}$ has been based on the shell model calculations with the OXBASH code. The new level was found in the investigation of spontaneous fission of ^{248}Cm using the EUROGAM2 array.

Two-valence neutron-hole ^{130}Sn: The decay scheme of ^{130}In to ^{130}Sn is currently under detailed investigation at OSIRIS. Preliminary level lifetimes for the 4^+_1, 6^+_1, 8^+_1, 10^+_1, 4^-_1 and 5^-_1 states are reported by Mach *et al.* in [29]. These values are discussed in the study of the effective charges in ^{130,132,134}Sn by Isakov and collaborators [32].

Two-valence proton ^{134}Te: A detailed investigation of the β decay of the high-spin isomer of ^{134}Sb to ^{134}Te has been performed at OSIRIS by Omtvedt *et al.* Their early report [30], which was focused on the issue of effective charges and octupole collectivity in the ^{132}Sn region, is followed now by detailed presentation of the level scheme and the β strength from the decay of Sb [31]. There is a need to re-investigate in great detail the β decay of the low-spin isomer of ^{134}Sb, which would populate the missing low-spin members of the low-lying multiplets in ^{134}Te.

Two-valence proton-hole ^{130}Cd: The identification of excited states of the proton $g_{9/2}$ multiplet in ^{130}Cd — a system with two-valence proton-holes coupled to the doubly magic core, constitutes a real challenge to the experimentalists. Of particular interest is the issue of quenching of the $N = 82$ shell below ^{132}Sn, which has been raised and systematically investigated by the Mainz group. Recently a potential breakthrough has been reported by Kautzsch *et al.* [33]. They have investigated at ISOLDE the decay of ^{130}Ag to ^{130}Cd using the RILIS ion source. For $A = 130$, they have identified a γ-line at the energy of 957 keV associated with a short decay with an estimated half-life of about 50 ms. This line, which was tentatively attributed to the decay of ^{130}Ag, may represent the $2_1^+ \to 0_1^+$ transition in ^{130}Cd. If true, this 2_1^+ energy is considerably lower than expected for a strong shell closure at $N = 82$ for Cd.

A strong shell closure would also imply an isomerism for the 8_1^+ member of the multiplet. A search for this isomer is conducted both at FRS separator at GSI and at ISOLDE. In the latter case, the use of HRS in its capacity and a compact efficient Ge miniball, that should be operational in 2001/2002, will strongly enhance the research possibilities.

6. Odd–odd systems

^{134}Sb: The yrast states in the valence proton-neutron ^{134}Sb nucleus have been recently investigated by Urban *et al.* [14] who confirmed and extended the decay scheme established by Bhattacharyya and collaborators [34]. They reported a new excited state at 2434 keV, which feeds via the 307.5 and 1361.5 keV γ-rays the lower-lying states at 2126.5 and 1072.5 keV. From the interpretation of this state as the 10^+ member of the $(\pi g_{7/2} \nu i_{13/2})$ configuration, the authors estimate the excitation energy of the presently unknown, $i_{13/2}$ single particle state in ^{133}Sn at 2694 keV. A very recent study by Fornal and collaborators [35] using the Gammasphere array and the source of ^{248}Cm, has established several new levels at ~ 4.5 MeV which feed the states at 2126 and 2434 keV. One of these states is interpreted as $(\pi h_{11/2} \nu i_{13/2})_{12^-}$ and the rest as the $(\pi g_{7/2} \nu f^2_{7/2} h_{11/2})$ excitation of the core.

In the work of Urban *et al.* a cascade of transitions at 52 and 171 keV was also established as belonging to ^{134}Sb. Since the energy of the first transition is very close to the 52.8 keV line reported by Fogelberg *et al.* [36] in the study of the β decays of ^{134}Sn and of the low-spin isomer of ^{134}Sb, yet unassigned to any of those decays, it was suggested to clarify its nature by reinvestigation of the β decay of ^{134}Sn. The experiment has been performed at OSIRIS in early 1999 using a specially prepared ion source containing ^{238}U target. The fission was induced by fast neutrons from the Studsvik R2-0 reactor. Special arrangements were made to minimize the presence of absorbers between the reactor core and the target material. As a result, the relative yield of the isobaric impurities has been significantly lowered, giving much higher sensitivity for investigation of the decay of ^{134}Sn. (Note, that with the same arrangements it was possible to identify [2] for the first time the decay of ^{135}Sn, as discussed above.) A preliminary report from this study [37] includes a strongly modified level scheme. The 171.3–52.8–317.7–13.0 cascade of γ rays defines the 4_1^-, 3_1^-, 2_1^-, 1_1^- and 0_1^- members of the $(\pi g_{7/2}\nu f_{7/2})$ multiplet. The presence of the level at 13 keV, which was necessitated by the decay pattern from other states, has been confirmed by coincidences between the 317.7 and 13 keV γ-rays.

^{132}Sb: A detailed investigation of the β decay of ^{132}Sn to ^{132}Sb is conducted at OSIRIS [38]. Its aim is to establish the higher spin members of the low-lying multiplets in ^{132}Sb.

^{132}In: First information on the decay of ^{132}Cd to ^{132}In has been reported by Hannawald *et al.* [26] from a study performed at ISOLDE. Using the RILIS ion source, the half-life of 97(10) ms and a β delayed neutron branch of 60(15) % has been measured for the decay of ^{132}Cd. Again, this new data certify that a more detailed γ spectroscopy of the excited states in ^{132}In is feasible and will be likely performed in the near future.

7. Ground state properties

Mass measurements: The masses of exotic nuclei are the key structure indicators and relate strongly to the excitation energies of specific quasiparticle configurations. Based on the shell model interpretation of the latter states, observed in ^{134}Te and ^{135}I via studies of the ^{248}Cm fission source at EUROGAM2, Zhang *et al.* [39] has recently challenged the accepted masses of some of the $N = 82$ isotones near ^{132}Sn. A similar discrepancy was later reported also by Nowak *et al.* [40] using the high spin data on ^{136}Te. As a consequence Fogelberg *et al.* have reinvestigated the total β decay energies of 14 nuclei in the vicinity of ^{132}Sn. The measurements were performed at OSIRIS used the high resolution β–γ coincidence technique. The study reported in [41], corrected the previous value for the decay of ^{134}I, and provided results with much improved precision for most of the decays under study. The new results remove the discrepancy raised by Zhang and collaborators.

Direct mass measurements on the nuclei at ^{132}Sn, using the ISOLTRAP and MISTRAL RF-spectrometer are being prepared at ISOLDE. The first (test) mass measurements using ISOLTRAP have been performed in the summer of 2000 [19]. These experiments will be repeated with higher statistics in 2001. The expected precision in the mass meaurements is of the order of 10–15 keV. The recent improvements in the technique allow for the measurements on the exotic nuclei with lifetimes as short as 170 ms.

Laser spectroscopy: So far laser spectroscopy has not been performed on the nuclei at ^{132}Sn. However, measurements of the magnetic moment μ and the variation of the mean square charge radius ($\delta\langle r_c^2\rangle$) have been recently proposed for the ground and long-lived isomeric states of Sn isotopes from $A = 125$ to 132 and heavier systems, by Le Blanc and co-workers [42]. The measurements are proposed for the COLLAPS and COMPLIS setup at ISOLDE, and will possibly start in 2000.

Magnetic moments: A systematic program of measurements of magnetic moments for nuclei near ^{132}Sn are conducted at the OSIRIS LTNO apparatus by the Oxford group of Prof. Nick Stone. These measurements included the case of ^{133}Sb, with one proton beyond ^{132}Sn, which provided a stringent test of the meson exchange theory of nuclear moments [43]. The measurement on ^{135}I [44] completed the series of odd-A $g_{7/2}$ proton moments from occupancy 1 to 7. In the series of I and Sb isotopes leading up to the proton shell closure, the measurements of the magnetic moments gave compelling evidence that "collective" wavefunction admixtures to the mainly $g_{7/2}$ proton configuration depart from the normal "collective" g-factor of Z/A but agree well with discrete admixture shell model calculations. The measurements included also the magnetic dipole moments on the isomeric $11/2^-$ states in ^{131,133}Te [45]. A summary of the results is presented in [46, 47]. Presently, the group is investigating the magnetic moments for ^{130}Sb and ^{132}Sb.

The nuclear orientation was used by White *et al.* [48] to deduce the mixing ratios for a number of transitions in ^{133}Te, which were then compared to the model calculations. In late 2000, tests will be performed at OSIRIS to utilize for spectroscopy the anisotropies of β delayed neutrons [49]. The first test case will involve orientation of the precursor ^{137}I and measurements of both neutrons and γ-rays emitted from the daughter ^{137}Xe. ^{137}Xe will also provide an opportunity to investigate possible parity mixing in the high density of states above 4 MeV in excitation. The evidence for the effect would come from the γ-ray emission, namely the forward–backward, parity breaking asymmetry in the emission.

8. Spectroscopy of nuclei in further vicinity of ^{132}Sn

Here, much of the current research on exotic nuclei is concentrated to the "north-east" from ^{132}Sn. Of special importance is the first identification of the decay of ^{135}Sn at OSIRIS by Korgul *et al.* [27], and of ^{136}Sn at ISOLDE by Shergur *et al.* [3] using advanced ion sources. The latter group confirmed the OSIRIS data and obtained more detailed information on the decay of

^{135}Sn. First observation of the excited states in ^{137,138,139}Te isotopes has been reported from the studies of prompt γ-rays in the spontaneous fission of ^{248}Cm at EUROGAM2 by Urban *et al.* [50, 51] and Hoellinger *et al.* [52]. The first search for the μs isomers at FRS/GSI by Hellström and collaborators [8] has already revealed a new $\sim 1\,\mu$s isomer in ^{136}I with a potential for more exciting results in this region. Also at FRS/GSI, Schatz *et al.* [53] have studied the exotic neutron-rich nuclei by implantation into Si detector followed by correlated β–neutron coincidence measurements.

It is a great pleasure to thank M. Bernas, J. Blomqvist, G. Bollen, R. Broda, B.A. Brown, A. Covello, P. Daly, B. Fogelberg, J. Gerl, H. Grawe, J. Hamilton, M. Hellström, P. Hoff, V.I. Isakov, A. Korgul, U. Köster, K.-L. Kratz, J.P. Omtvedt, M. Mineva, T. Nilsson, J. Pinston, H. Ravn, J. Rikovska-Stone, M. Sanchez-Vega, H. Schatz, N.J. Stone, W. Urban, W.B. Walters and A. Wöhr, who contributed their materials or information. This work was supported by the Swedish Natural Science Research Council.

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