C. SPECTROSCOPY OF VERY HEAVY ELEMENTS

There has been significant progress in the spectroscopy of heavy nuclei. We have successfully continued our program of decay studies of the very heaviest elements that can be produced in reactors. We have continued to inelastically excite actinide targets with very heavy beams above the Coulomb barrier. Finally, we have continued to use fusion reactions to study entry regions, odd-A nuclei, groundstate α-decays, and isomers. This forefront research on very heavy nuclei continues to be a domain where the ATLAS beams and the Fragment Mass Analyzer (FMA) allow us to make unique contributions. Investment in rotating targets and new focal-plane detectors has been important in keeping this research competitive.

c.1. Strength of Octupole Correlations in the Actinides: Contrasting Behavior in the Isotones ^{239}Pu and ^{237}U (S. Zhu, R. V. F. Janssens, M. P. Carpenter, I. Ahmad, N. Hammond, T. L. Khoo, F. G. Kondev, T. Lauritsen, C. J. Lister, E. F. Moore, D. Seweryniak, G. J. Lane,*† I. Wiedenhöver,‡ A. P. Byrne,* P. Chowdhury,§ D. Cline,¶ A. Deacon,|| G. D. Dracoulis,* S. J. Freeman,|| G. D. Jones,** A. O. Macchiavelli,† J. F. Smith,|| and C. Y. Wu¶)

Octupole correlations play an important role in determining the low level structure of nuclei throughout the periodic table. This is the case in the actinide region, where two distinct collective modes have been identified associated with an octupole vibration and the rotation of an octupole deformed nucleus. A study of high spin states in the odd-neutron isotones ^{239}Pu and ^{237}U was performed at ANL with Gammasphere. Striking differences were found in the properties of rotational bands in these two nuclei. The level schemes for these two isotones deduced from present work are displayed in Figs. I-15 and I-16.

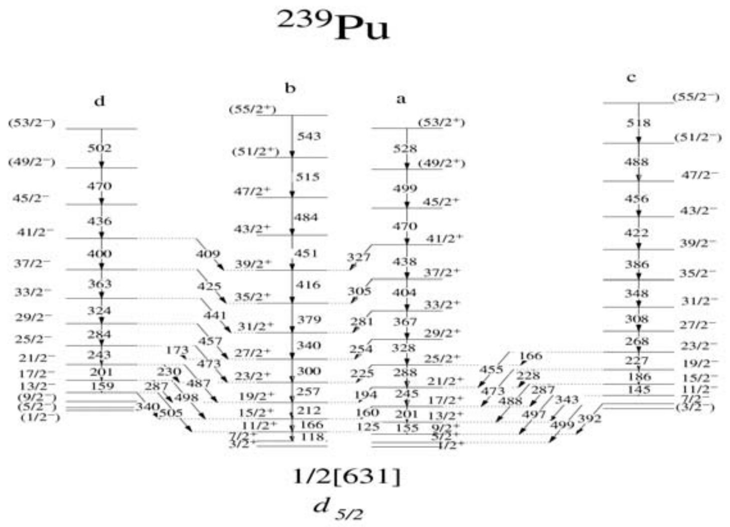

Fig. I-15. Proposed ^{239}Pu level scheme with the transition energies given in keV. Bands c and d are the octupole bands under discussion in this report.

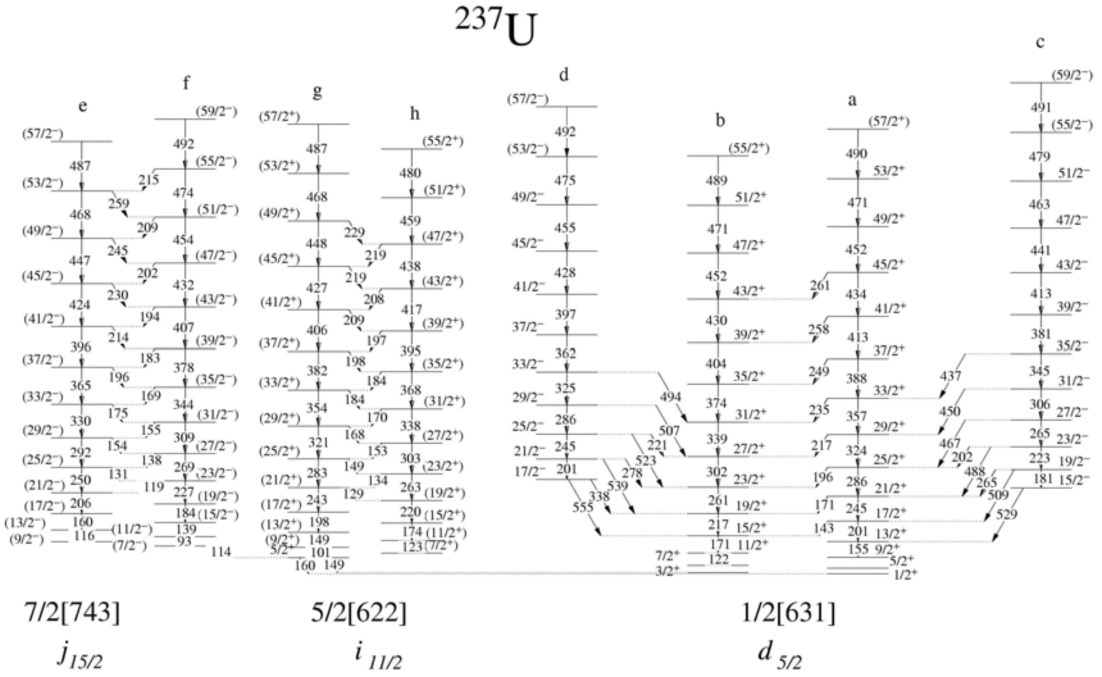

Fig. I-16. Proposed ^{237}U level scheme with the transition energies given in keV. Bands c and d are the octupole bands under discussion in the present report.

A key indicator of strong octupole correlations in odd-mass nuclei is the presence of parity doublets: the stronger the correlations, the smaller the energy difference between quantum states with the same spin and opposite parity. In the ^{237}U and ^{239}Pu isotones, the negative parity bands appear to be associated with an octupole vibration at low spin as the experimental energy difference is ~0.5 MeV. However, with increasing angular momentum, the ^{239}Pu levels of same spin and opposite parity come closer and closer in excitation energy: the $45/2^+$ and the $45/2^-$ states are 47 keV apart, the two 49/2 levels are separated by only 17 keV and the 53/2 states lie within 8 keV of each other. In contrast, the energy differences at high spin in ^{237}U remain of the order of 200 keV. Furthermore, the staggering factor (which is a measure of the extent to which the sequences of opposite parity are interleaved in spin and can be regarded as a single rotational band of octupole character) in the ^{239,240}Pu isotopes are large at low spin, but become small and comparable to those seen in nuclei with octupole deformation for spins at $I \geq 24$ ħ. In contrast, in ^{237}U the values of the staggering factor decrease with spin, but start leveling off at spin 20 ħ. Finally, the decoupling parameters are of the same (small) magnitude, but opposite sign in ^{239}Pu, in line with expectations when strong octupole correlations are present. In ^{237}U, the Coriolis effects appear to be negligible in the negative-parity band, illustrating further the contrasting situation between the two isotones. In addition, from the extracted experimental E1/E2 branchings, the D_0 moment of ^{239}Pu is 40% larger than the corresponding quantity in ^{237}U.

All of these differences mirror those observed in the even-even Pu and U immediate neighbors and appear to be related to the assumption that the strength of octupole correlations is larger in ^{239}Pu than in its isotone ^{237}U. It was proposed[1] that the strength of the correlations in the two even ^{238,240}Pu isotopes may be such that a transition from an octupole vibration to a stable octupole deformation occurs at the highest spins, in agreement with the theoretical description by Jolos and von Brentano.[2,3] The same appears to occur in ^{239}Pu. It is worth noting that, in both odd nuclei under consideration, the octupole excitations are based on the same neutron orbital and the marked difference in behavior then must reflect changes in the respective cores. This in turn points to a significant role for the additional two protons in Pu in polarizing the nuclear shape. However, these protons cannot be solely responsible for the increase in strength: the neutron number has a significant impact as octupole correlations have been shown to be weaker in both the heavier ^{242,244}Pu[1] and the lighter ^{236}Pu.[4] It is believed that strong octupole correlations or stable octupole deformation impact the magnitude of the alignment gain i_x and its evolution with rotational frequency. The Pu yrast bands show a small and gradual alignment of ~2 ħ over the entire frequency range. The negative parity excitations experience the initial (2 - 3) ħ alignment characteristic of the octupole phonon and no further increase at higher frequency. In contrast, a strong alignment occurs in every sequence in the two U isotopes, i.e. they all experience a noticeable rise at ħω ~ 0.25 MeV. It has been shown that this rise is due to the alignment of a pair of $i_{13/2}$ protons, in agreement with expectations based on cranked shell model calculations.

To summarize, the present work indicates that the striking difference in behavior between the A = 238, 240 even Pu isotopes and other actinide nuclei extends to the odd ^{239}Pu nucleus. Further analysis of this data set continues and is focused on ^{238}U in which new bands have been identified.

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*Australian National University, Canberra, Australia, †Lawrence Berkeley National Laboratory, ‡Florida State University, §University of Massachusetts, ¶University of Rochester, ||University of Manchester, United Kingdom, **University of Liverpool, United Kingdom.

[1] I. Wiedenhöever *et al*., Phys. Rev. Lett. **83**, 2143 (1999).

[2] R. V. Jolos and P. von Brentano, Phys. Rev. C **49**, R2301 (1994).

[3] R. V. Jolos and P. von Brentano, Nucl. Phys. **A587**, 377 (1995).

[4] K. Abu Saleem *et al*., Phys. Rev. C **70**, 024310 (2004).

c.2. Behavior of ^{240}Pu at the Highest Spins (R. V. F. Janssens, S. Zhu, M. P. Carpenter, I. Ahmad, J. P. Greene, T. L. Khoo, T. Lauritsen, C. J. Lister, D. Seweryniak, X. Wang,§ S. Freeman,¶ F. G. Kondev,* I. Wiedenhöver,† A. Bernstein,† P. Wilson,† E. Diffenderfer,† C. Teal,† A. Larabee,‡ B. Meredith,‡ and U. Garg§)

A few years ago,[1] a study of the level structure of ^{240}Pu suggested that this nucleus possibly evolves from an octupole vibrator at low spin to an octupole rotor at high spin, in agreement with theoretical suggestions by Jolos and von Brentano.[2,3] The evidence was based mostly (a) on the fact that, at the highest spins, the yrast states of spin-parity I^+ become interleaved with the $(I-1)^-$ and $(I+1)^-$ levels of the octupole band and (b) on the strength of the $(I+1)^- \rightarrow I^+$ E1 linking transitions. The purpose of the present experiment was to explore the structure of this nucleus further by (1) identifying the linking E1 transitions between the states of opposite parity at the highest spins and by (2) searching for additional band structures in this nucleus.

The experiment was carried out with Gammasphere at ATLAS. A ^{208}Pb beam of 1300 MeV bombarded a 350μg/cm^2 ^{240}Pu target evaporated on a thick Au backing. More than 3 billion events with fold 3 or higher were collected.

The analysis is on-going. A number of coincidence cubes and hyper-cubes have been created after the data were transposed into a so-called BLUE data base. It is clear that the available knowledge on ^{240}Pu will be expanded considerably.

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[1] I. Wiedenhöver *et al.,* Phys. Rev. Lett. **83**, 2143(1999).

[2] R. V. Jolos and P. von Brentano, Phys. Rev. C **49**, R2301 (1994).

[3] R. V. Jolos and P. von Brentano, Nucl. Phys. **A587**, 377(1995).

c.3. Proton Single-Particle States in ^{249}Bk (Z = 97) (I. Ahmad, E. F. Moore, M. P. Carpenter, R. R. Chasman, J. P. Greene, R. V. F. Janssens, T. Lauritsen, C. J. Lister, D. Seweryniak, F. G. Kondev,* R. W. Hoff,† J. E. Evans,† R. W.Lougheed,† C. E. Porter,‡ and L. K. Felker‡)

The heaviest odd-proton nuclide available in a large quantity for spectroscopic measurements is the α decaying ^{253}Es ($T_{1/2}$ = 20.47 d). We have studied the level structure of its daughter ^{249}Bk by measuring the γ-ray spectra of an isotopically enriched, chemically pure ^{253}Es sample. Using gamma singles spectra, measured with high-resolution Ge detectors, we were able to identify many weakly populated states that decay by γ rays with intensities as low as 1.0×10^{-6}% per ^{253}Es α decay. A gamma-gamma coincidence experiment was performed with the Gammasphere spectrometer at Argonne in order to determine the decay pattern of high-lying states. The high efficiency and resolving power of Gammasphere allowed us to identify many weak gamma rays that were not observed in the singles spectrum. Information on low spin states of ^{249}Bk was obtained from γ-ray spectroscopic study following β^- decay of ^{249}Cm at Livermore.

Using the results of the present study and the data available from the previous ^{248}Cm(α,t) investigation, the following single-particle states have been identified in ^{249}Bk: $7/2^+[633]$, 0.0 keV; $3/2^-[521]$, 8.78 keV; $1/2^+[400]$, 377.55 keV; $5/2^+[642]$, 389.17 keV; $1/2^-[530]$, 569.20 keV; $1/2^-[521]$, 643.0 keV; $5/2^-[523]$, 672.9 keV; $9/2^+[624]$, 1075.1 keV. In addition, four vibrational bands were identified at 767.9, 932.2, 1150.7, and 1223.0 keV with tentative assignments of $\{7/2^+[633]\times1^-\}9/2^-$, $\{7/2^+[633]\times0^-\}7/2^-$, $\{7/2^+[633]\ 1^-\}5/2^-$ and $\{7/2^+[633]\times0^+\}7/2^+$. The experimental level spacings are in good agreement with the theoretical values, as shown in Fig. I-17. The results of this study were published.[1]

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*Nuclear Engineering Division, Argonne National Laboratory, †Lawrence Livermore National Laboratory, ‡Oak Ridge National Laboratory.

[1] I. Ahmad *et al.*, Phys. Rev. C **71**, 054305 (2005).

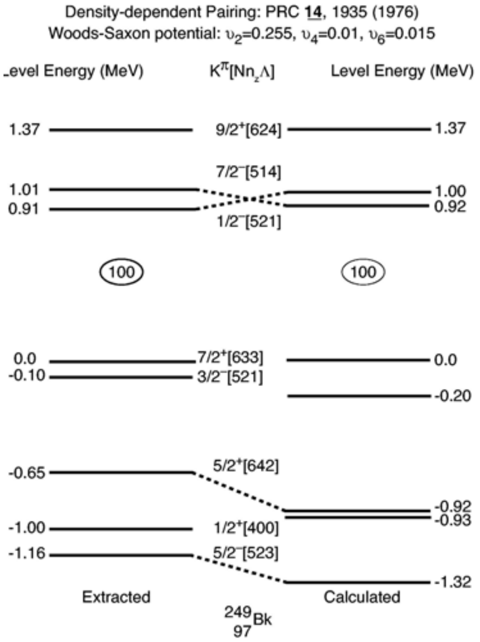

Fig. I-17. A comparison of the measured and calculated level energies in ^{249}Bk. Extracted energies represent the measured energies from which contributions of pairing correlations have been removed. Level energies on the right side represent energies calculated with a Woods-Saxon potential with deformation parameters $\nu_2 = 0.255$, $\nu_4 = 0.01$ and $\nu_6 = 0.015$.

c.4. Properties of the Lightest Nobelium Isotopes (D. Peterson, B. B. Back, M. P. Carpenter, C. Davids, A. Hecht, R. V. F. Janssens, C. L. Jiang, T. L. Khoo, T. Lauritsen, C. J. Lister, D. Seweryniak, X. Wang, S. Zhu, P. Chowdhury,* S. Tandel,* U. Tandel,* and A. Heinz†)

Recent experiments in the synthesis of superheavy elements utilizing beams of ^{48}Ca are both exciting and puzzling. To study systematic trends in the Z > 100 region, two separate studies[1,2] of neutron-deficient nobelium isotopes via the ^{204}Pb(^{48}Ca,xn) reaction were undertaken by groups working in Dubna. Both experiments only observed spontaneous fission (SF) decay, but measured three different lifetimes (60[1], 36[2], and 6[2] μs). Belozerov *et al.*,[2] attributed the 36 μs lifetime to ^{249}No, but the possibility of an isomeric decay could not be excluded. Those experiments also suffered from limited statistics, and the 3n channel necessary to produce ^{249}No was expected to be very small at the energies used.[2]

We have conducted a new experiment to clarify these decays. Our goal in the present experiment was to use the Fragment Mass Analyzer (FMA) at Argonne National Laboratory to collect enough statistics to unambiguously determine the masses corresponding to each decay and to unfold the multiple decay components if present. Furthermore, with increased statistics, we hoped to find the previously unobserved α decay to obtain a branching ratio for SF/α. Finally, the focal plane of the FMA was equipped with three Ge clover detectors to detect γ's emitted from the decay of an isomer if that was a source of one of the decays.

An isotopically pure ^{204}Pb (99.708%) target consisting of four wedges of average thickness 0.540 mg/cm^2 was mounted onto a Gammasphere-style rotating target wheel, which was in turn mounted to a support arm specifically designed to allow the use of this smaller target wheel in the heavy-element scattering chamber.[3] The wheel was rotated at speeds of 1100 - 1700 rpm to prevent the target material from melting under intense beam currents. The maximum current delivered to the target was 85 pnA ($q = 10^+$), with an average intensity of 55 pnA. The beam current was limited by the ion source operation. Future experiments with this setup can certainly take advantage of larger currents. Besides the modified target wheel assembly, another new technique for this experiment was the use of three separate amplifier channels for each strip of the focal plane silicon strip detector (DSSD). In addition to the standard delay-line amplifiers and shaping amplifiers with gains for energy signals in the range of 0-20 MeV (α-equivalent), we also incorporated a low-gain branch range of 0 - 800 MeV to register the expected fission decays without signal saturation.

Analysis is ongoing. We have identified nearly 160 implant-fission coincidences. Proper normalization to obtain absolute cross sections, as well as uncertainties in the χ^2-space for fitting the decays must be understood. The search for indications of γ-rays from an isomeric level and possible α-decays are also in progress.

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*University of Massachusetts-Lowell, †Yale University.

[1] Oganessian *et al.*, Phys. Rev C **64**, 054606 (2001).

[2] Belozerov *et al.*, Eur. Phys. J. A **16**, 447-456 (2003).

[3] D. Peterson *et al.*, section h.9. of this report.

c.5. Structure of ^{253}No (T. L. Khoo, I. Ahmad, A. Heinz, T. Lauritsen, C. J. Lister, D. Seweryniak, M. P. Carpenter, C. N. Davids, J. P. Greene, F. Kondev, R. V. F. Janssens, A. A. Sonzogni, I. Wiedenhöver, P. Reiter,* A. Afanasjev,† P. A. Butler,‡ A. J. Chewter,‡ J. A. Cizewski,§ P. T. Greenlees,¶ K. Helariuta,¶ R.-D. Herzberg,‡ G. Jones,‡ R. Julin,¶ H. Kankaanpää,¶ H. Kettunen,¶ W. Korten,§ P. Kuusiniemi,¶ M. Leino,¶ S. Siem,|| and J. Uusitalo¶)

The heaviest nuclei are stabilized by a shell-correction energy, which lowers the ground-state, thereby creating a barrier against fission. The shell-correction energy originates from the clustering of single-particle orbitals. Hence, the single-particle eigenstates form the basis of the shell stabilization. The most direct data on the orbital energies come from odd-A nuclei, providing our motivation to investigate the odd-N nucleus ^{253}No. The single-particle energies also provide a direct test of nuclear models that predict the properties of superheavy nuclei. Thus, by testing model predictions[1] against data on the heaviest nuclei that are accessible for spectroscopy, one may judge their reliability for predicting the properties of superheavy elements, e.g. the next spherical shell closures beyond ^{208}Pb.

The production cross section of ^{207}Pb(^{48}Ca,2n)^{253}No reaction was measured as ~0.5 μb at Jyväskylä. In a subsequent experiment at Argonne, the γ rays were detected with Gammasphere, in coincidence with ^{253}No residues detected in the FMA. The γ-ray spectrum for ^{253}No has many weak lines, but is dominated by the K X-rays. Heavy odd-A nuclei, such as ^{253}No, represent the limits of in-beam γ spectroscopy due to overwhelming conversion electron competition in M1 transitions. Of the expected low-lying configurations in ^{253}No, only the $7/2^+$[624] orbital is expected to have sufficiently small M1 branching ratios to permit detection of intraband E2 γ rays. However, due to the low γ-ray cross sections of 25-50 nb, it was necessary to develop new methods based on (a) quantitative comparisons of results from experiment and from model predictions; (b) enhancement of transitions with high γ multiplicity; and (c) finding evidence for a rotational band in a sparse γγ matrix. Similar methods will be required for in-beam γ spectroscopy of nuclei far from stability, which have diminutive cross sections.

The kinematic and dynamic moments of inertia, $J^{(1)}$ *and* $J^{(2)}$, of the $7/2^+$[624] band are shown in Fig. I-18, where they are compared with values from those of the neighboring nuclei ^{252,254}No. The $J^{(1)}$ *and* $J^{(2)}$ moments of inertia of ^{253}No are rather well reproduced by the self-consistent cranked relativistic Hartree Bogoliubov (CRHB) theory. In contrast, the theoretical description[2] of the $J^{(2)}$ moments of inertia of the even-even nuclei ^{252,254}No is not as good. That is probably due to a less-than-perfect description of the quasiparticle energies. On the other hand, the moments of inertia in an odd-even nucleus is sensitively dependent on (and hence characteristic on) the occupied orbital; hence the $J^{(1)}$ *and* $J^{(2)}$ moments of the $7/2^+$[624] band could be well described.

A bandhead energy of 355 keV was deduced from the data for the $7/2^+$[624] configuration. This energy compares with theoretical predictions of 240, 400 and 1200 keV, which are given by, respectively, a Nilsson model based on the Wood-Saxon potential and by self-consistent mean-field theories using the Skyrme Hartree-Fock or CRHB methods.[1-2] Of course, a systematic test of theory should encompass a set of quasiparticle states, and has recently been performed for self-consistent mean-field theories.[1-2] For example, Ref. 1 points out that the relativistic mean-field method is able to describe many single-particle energies, but that several (including the 7/2+[624] orbital) that originate from specific spherical orbitals deviate by more than 1 MeV from experimental energies.

A paper on the results has been accepted for publication in Phys. Rev. Lett.

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*University of Cologne, Germany †University of Notre Dame, ‡University of Liverpool, United Kingdom, §Rutgers University, ¶University of Jyväskylä, Finland, ||University of Oslo, Norway.

[1] A. Afanasjev *et al.*, Phys. Rev. C **67**, 024309 (2003).

[2] M. Bender *et al.*, Nucl. Phys. **A723**, 354 (2003).

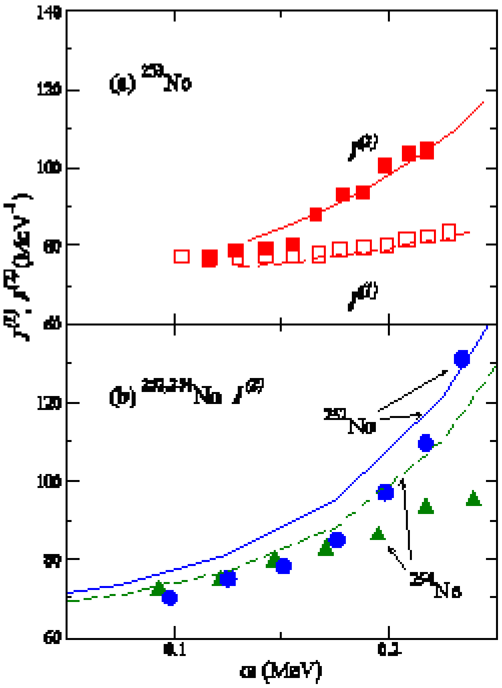

Fig. I-18. (a) The moments of inertia $J^{(1)}$, $J^{(2)}$ *for the 7/2*$^{+}$*[624] band in* ^{253}*No. (b)* $J^{(2)}$ *for* ^{252,254}*No. (a) Experimental data. Results from CRHB theory are shown as solid or dashed lines.*

c.6. Electrons from a 0.3s Isomer in ^{254}No* (T. L. Khoo, R. Blinstrup, D. Seweryniak, I. Ahmad, M. P. Carpenter, C. N. Davids, S. Freeman, J. P. Greene, N. Hammond, R. V. F. Janssens, F. G. Kondev, T. Lauritsen, C. J. Lister, G. Mukherjee,* P. A. Butler,† P. Chowdhury,* J. A. Cizewski,‡ R. Gramer,* R. D. Herzberg,† A. Heinz,§ P. Ikin,† M. Johnson,‡ G. D. Jones,† E. Ngijoi-Yogo,* and P. Reiter¶)

Data on pairing and single-particle energies are essential for reliable predictions of the stability of the superheavy elements. The single-particle energies constitute the basis of the shell-correction energy, which provides the essential bulk of the binding energy, and pairing further lowers the ground-state. The energies and configurations of 2-quasiparticle high-K isomers in heavy shell-stabilized nuclei can provide information on both single-particle energies and the pair gap.

High-K isomers are expected in shell-stabilized nuclei around ^{254}No because there are many high-Ω single-particle orbitals near the Fermi level. An isomer has been identified[1] in ^{254}No ($T_{1/2}$ = 0.28 s), but no information on its decays exists. We have observed the electrons accompanying the decay of this isomer in an experiment where nobelium nuclides are produced with the ^{208}Pb(^{48}Ca,2*n*) reaction at ATLAS. The evaporation residues were transported and identified with the Fragment Mass Analyzer (FMA) and implanted in 1 × 1 mm^{2} pixels of a Si double-sided strip detector. In the *same pixel* where a residue was implanted, electrons from the decay of an isomer were observed in a 1.4 s time interval, followed by α decays from the ground state of ^{254}No within a 120 s interval. (Similar results have recently been obtained[2] at Jyväskylä.) The source of the electrons was unambiguously characterized by: (i) identification of ^{254}No; (ii) time and spatial correlations of residue, electron and α; and (iii) the electron and α decay half-lives. The electron spectrum represents the sum energy from transitions within a rotational band following the isomer decay, either from the ground band or an excited band. In a search for the γ rays depopulating the isomer, two transitions were found at 944 and 842 keV, which were previously identified as prompt (< few ns) emissions in experiments at Argonne and Jyväskylä. This finding implies that the 0.26 s decays to an excited rotational band, which is the source of the isomeric electrons.

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*Argonne National Laboratory and University of Massachusetts-Lowell, †University of Liverpool, United Kingdom, ‡Rutgers University, §Yale University, ¶University of Cologne, Germany.

[1] A. Ghiorso *et al*., Phys. Rev. C **7**, 2032 (1973).

[2] R. Herzberg *et al*., University of Liverpool, private communication (2004).

c.7. Gamma Decay from a 0.3s Isomer in ^{254}No* (T. L. Khoo, D. Seweryniak, I. Ahmad, M. P. Carpenter, J. Chapman, C. N. Davids, J. P. Greene, R. V. F. Janssens, F. G. Kondev, T. Lauritsen, C. J. Lister, S. Tandel,* P. A. Butler,† P. Chowdhury,* P. Greenlees, R. D. Herzberg,† A. Heinz,§ P. Ikin,† G. D. Jones,† G. Mukherjee,* P. Reiter,¶ and U. Tandel*)

Reliable calculations of the stability of the superheavy elements require accurate single-particle energies. Gaps in the single-particle energies give rise to the quantum-mechanical shell-correction energy. Data on the single-particle energies come not only from odd-A nuclei, but also from the energies of 2-quasiparticle states in even-even nuclei. In addition, the latter provide valuable constraints on the pair gap.

Evidence of a high-K isomer in ^{254}No ($T_{1/2}$ = 0.28 s) has been found from the electron sum-energy spectrum (see section c.6.). In order to establish the energy and quantum numbers of the isomer, we have recently succeeded in detecting the γ rays which accompany the decay of the isomer. Residues of ^{254}No were produced with the ^{208}Pb(^{48}Ca,2*n*) reaction at ATLAS, using beams of up to 100 pnA intensity. The residues were transported and mass-identified with the Fragment Mass Analyzer (FMA). Gamma rays coincident with isomeric electrons were detected in an interval of ~1 s following implantation of a ^{254}No nucleus. High-energy transitions at 842 and 944 keV were observed. These two γ rays have previously been observed as prompt emissions with Gammasphere at ATLAS, as well as in experiments at Jyväskylä. Hence, these transitions cannot directly deexcite the 0.28 s isomer, but instead decay from a short-lived (~ns) two-quasiparticle state. We deduce that the isomer decays, probably via a 53-keV transition, to a rotational band built on a K = 3^+ two-quasiparticle state at 988 keV. Decays within the bands proceed predominantly through emission of electrons. The electron sum energy spectrum was previously detected (see section c.6.). A preliminary level scheme for the isomer is shown in Fig. I-19. In addition, a new shorter-lived isomer (~200 µs) has been found, which is established to decay into the 0.28 s isomer.

The K = 3^+ two-quasiparticle state has a proposed proton *1/2$^-$[521] x 7/2$^-$[514]* configuration. Its low energy (988 keV) puts tight constraints on the individual quasiparticle excitation energies and also sets a lower bound of 0.5 MeV on the proton pair gap.

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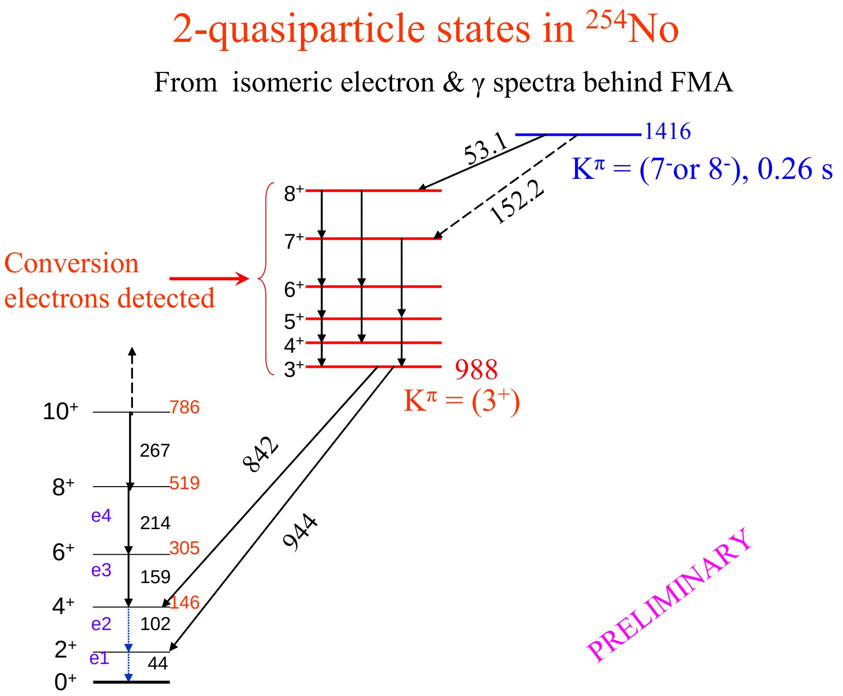

Fig. I-19. Tentative decay scheme for the 0.26 s isomer in ^{254}No.

c.8. Limiting Angular Momentum in ^{254}No (T. L. Khoo, D. Seweryniak, I. Ahmad, M. P. Carpenter, C. N. Davids, S. Freeman, J. Greene, N. Hammond, R. V. F. Janssens, F. G. Kondev, T. Lauritsen, C. J. Lister, P. A. Butler,‡ P. Chowdhury,† J. A. Cizewski,§ R. Gramer,† R. D. Herzberg,‡ A. Heinz,¶ P. Ikin,‡ M. Johnson,§ G. D. Jones,‡ G. Mukherjee,*,† E. Ngijoi-Yogo,† and P. Reiter||)

Our investigations of the shell-stabilized nobelium nuclei have shown that they, perhaps surprisingly, survive up to high angular momentum and that the fission barrier is >5 MeV for spins larger than 10 ħ. In other words, shell-stabilized nuclei are quite robust at high spin. Stimulated by these experiments, several self-consistent mean-field theory calculations have found that the fission barrier that the barrier remains sizeable at high spin. The HFB predictions of Egido and Robledo[1] suggest that ^{254}No should survive up to spin 30 - 35 ħ. Self-consistent mean-field theories, with interactions determined from properties of lighter nuclei, provide a promising method for predicting the properties of superheavy nuclei, particularly since they do not employ parameters tailored to different mass regions. However, the reliability of these predictions needs to be tested by comparison to data of shell-stabilized nuclei and also by expanding the small database for this comparison.

To determine how much angular momentum a ^{254}No nucleus can sustain before it is torn apart by fission, we have conducted an experiment with Gammasphere operated in coincidence with the FMA. This combination provides a capability, which is unique in the world for reactions with sub-μb cross sections, namely the ability to detect γ rays with both high resolution and with 4-Π calorimetric capability. We attempted to measure the two-dimensional entry distribution, i.e. the initial spin-energy distribution of the nucleus. However, a technical problem with Gammasphere precluded measurements of the BGO energy and, hence, of the sum energy in the reaction. The multiplicity information remained intact. The maximum input angular momentum was increased from ~20 to ~33 ħ by using a higher beam energy than in our previous experiment[2] -- from 219 to 223 MeV. The measured fold distribution clearly demonstrated an increase of the maximum spin from 22 to 28 ħ. Although ^{254}No is loosely bound, it is quite stable against rotation;[3]

its fission barrier remains large enough at high angular momentum for it to survive to a spin of almost 30 ħ.

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*Argonne National Laboratory and University of Massachusetts-Lowell, †University of Massachusetts-Lowell, ‡University of Liverpool, United Kingdom, §Rutgers University, ¶Yale University, ||University of Cologne, Germany.

[1] L. Egido and L. Robledo, Phys. Rev. Lett. **85**, 1198 (2000).

[2] P. Reiter *et al*., Phys. Rev. Lett. **84**, 3542 (2000).

[3] A. Afanasjev *et al*., Phys. Rev. C **67**, 024309 (2003).