D. OTHER TESTS OF NUCLEAR STRUCTURE UNDER EXTREME CONDITIONS

Investigation of hot nuclei was made using the FMA and a large array of barium fluoride detectors. The analysis of these data is nearing completion, as is analysis of the "ridge" structure in the gamma-continuum of superdeformed nuclei. In discrete line spectroscopy, a collective octupole vibrational band has been found in the classic superdeformed rotor ^{152}Dy, and other studies on nuclear structure of "superdeformed" structures continue.

d.1. Hot Giant Dipole Resonance γ Rays in Sn Nuclei (B. B. Back, M. P. Carpenter, T. L. Khoo, T. Pennington, P. Heckman,* J. P. Seitz,* E. Tryggestad,* T. Baumann,* M. Thoennessen,* R. L. Varner,† D. J. Hofman,‡ and V. Nanal§)

The GDR in Sn was studied by employing two fusion-evaporation reactions, namely ^{18}O + ^{100}Mo and ^{17}O + ^{100}Mo. The beams of ^{18}O and ^{17}O were accelerated to energies of 95 and 78.8 MeV, respectively.[1]

The final γ-ray spectra extracted in this experiment are shown in Fig. I-41a,b. The parameters of the GDR are the sum rule strength (S), energy (E_D), and Width (Γ). The γ-ray spectra were fit with CASCADE[2,3] by varying the GDR parameters to minimize χ^2. It was also necessary to include a non-statistical bremsstrahlung component in the fits. The curved-bremsstrahlung parameterization was used to account for this non-statistical component, just as in Ref. 4. Since the same reaction was used in Ref. 4, this form should be valid here. The CASCADE and bremsstrahlung calculations were folded to account for the detector response, as simulated with GEANT,[5] before comparisons were made with data.

The result of the fits are shown as the solid curves in Fig. I-41a,b. The quality of the fits to the data is very good. The reduced χ^2 for the reactions ^{17}O + ^{100}Mo (^{117}Sn) and ^{18}O + ^{100}Mo (^{118}Sn) was found to be 1.5 and 1.1, respectively. To further demonstrate this point, divided plots of $F(E_\gamma)$ were created by dividing both the experimental and calculated spectra by a statistical spectrum assuming a constant E1 strength of 0.2 W.u. The divided plots are shown in Fig. I-41c,d. In the case of ^{117}Sn, the GDR parameters were found to be S = 0.87, E_D = 15.08 MeV, and Γ = 6.9 MeV at a temperature (T) of 1.74 MeV. For ^{118}Sn, S = 0.63, E_D = 15.16 MeV, and Γ = 8.17 MeV at T = 1.84 MeV.

The extracted GDR widths allow for comparisons to be made between this data and previous measurements. The results of this analysis are shown in Fig. I-42, along with previous experimental results. The widths found in this work are very similar to other measurements performed.

The γ-ray spectra measured in this work can be further used to test the validity of thermal shape fluctuation model calculations. In a recent work,[6] it was shown that the thermal shape fluctuation model fails to predict the behavior of the GDR width at low T. Using this data, it may be able to verify this finding. Also, since the reactions used in this work populate high spin states, it may also be possible to test if the spin dependence of the GDR width is well understood.

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[1] Argonne Annual Report, "Hot GDR in ^{118}Sn", (2001).

[2] F. Pühlhofer, Nucl. Phys. **A280**, 267 (1977).

[3] R. Butsch *et al.*, Phys. Rev. C **41**, 1530 (1990).

[4] M. P. Kelly *et al.*, Phys. Rev. Lett. **82**, 3404 (1999).

[5] Detector Description and Simulation Tool GEANT, Version 3.21, CERN Program Library, Geneva.

[6] P. Heckman *et al.*, Phys. Lett. **B555**, 43 (2003).

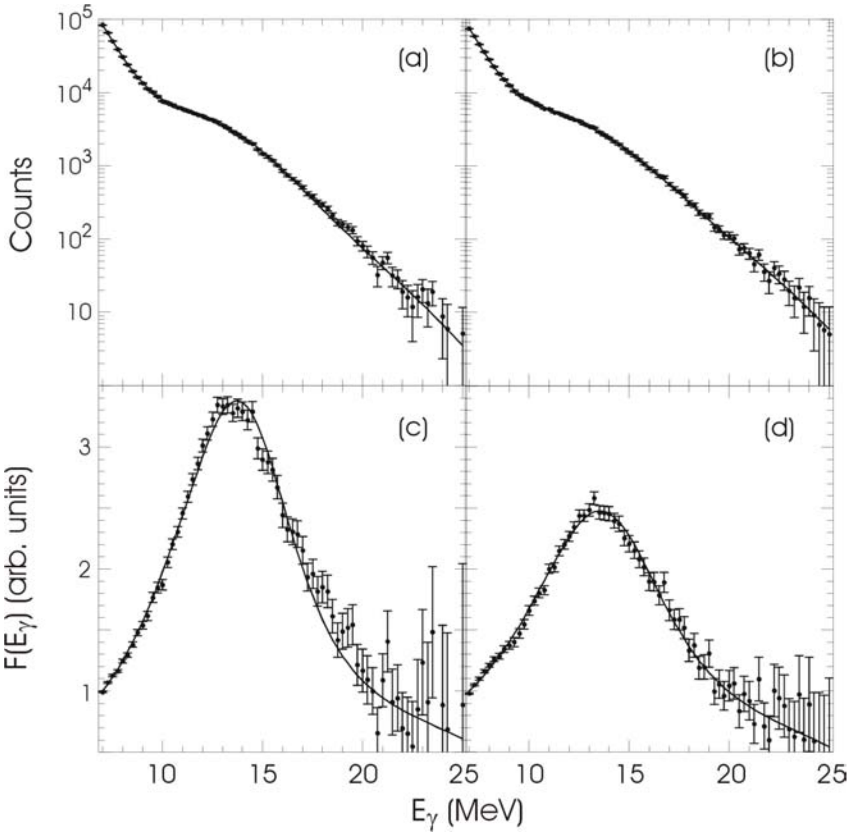

Fig. I-41. Panels (a) and (b) show the γ-ray spectra, while panels (c) and (d) show divided plots of the γ-ray spectra from experiment 889. The plots in panels (a) and (c) show the result from ^{117}Sn formed in the reaction ^{17}O + ^{100}Mo. The plots in panels (b) and (d) show the result from ^{118}Sn formed in the reaction ^{18}O + ^{100}Mo. In all panels, the data is shown as the solid points, and the calculations are shown by solid curves.

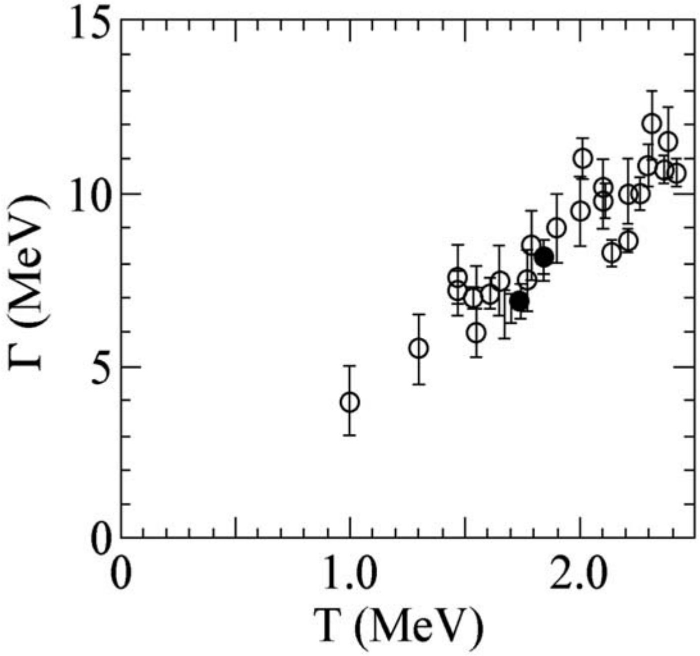

Fig. I-42. The experimental data for the GDR width as a function of temperature is shown. The solid circles are from this work and the open circles are from previous experiments.

d.2. Highly Selective Studies of GDR in ^{164}Er (V. Nanal,* T. L. Khoo, B. B. Back, M. P. Carpenter, A. M. Heinz, D. Henderson, D. Jenkins, M. P. Kelly, F. G. Kondev, T. Lauritsen, C. J. Lister, B. McClintock, S. Mitsuoka, T. Pennington, R. H. Siemssen, R. J. van Swol, P. Wilt, D. J. Hofman,† I. Dioszegi,‡ K. Eisenman,§ M. L. Halbert,¶ P. Heckman,§ J. Seitz,§ M. Thoennessen,§ R. L. Varner,¶ and Y. Alhassid||)

We initiated a program to study the properties of the giant dipole resonance (GDR) in hot nuclei with at a well-defined spin and excitation energy. These properties are revealed through the GDR spectra emitted by hot compound nuclei, which eventually decay into uniquely identified evaporation residue channels. For this purpose, the ORNL/MSU/TAMU BaF_2 array of 148 detectors was integrated with the 50 element BGO spin/sum-energy spectrometer and the fragment mass analyzer (FMA) at the ATLAS facility (ANL). We also introduced a new but simple method for specifying the spin and internal excitation energy above the yrast line, from which GDR gamma emission occurs. For a given decay channel at different bombarding energies, it is possible to map out a wide range of angular momentum region while keeping the excitation energy above yrast line similar. These efforts constitute the most comprehensive systematic investigation of the GDR spectra from hot nuclei in exclusive measurements (see Fig. I-43). The high-energy gamma rays from ^{164}Er are measured in coincidence with the 4n evaporation channel. The ^{164}Er is a well-deformed nucleus. With increasing temperature, shape fluctuations will appear but the spread will be less than that for transitional nucleus. There are theoretical predictions indicating a rapid increase in width at high spin.[1]

The experiment was carried out at ATLAS (at ANL) using 163 and 187 MeV ^{40}Ar beams on a ^{124}Sn target. The average angular momenta for the 4n decay channel are 26 $\hbar$ and 45 $\hbar$, respectively. The high-energy gamma ray spectra for BGO fold $K \geq 2$, gated by mass A = 160 residues, are shown in the figure after dividing by the constant exponential (with arbitrary normalization). There is an implication that the increase in width at higher incident energy is related to the angular momentum effect as predicted in Ref. 1.

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[1] Y. Alhassid, Nucl. Phys. **A649**, 107c (1999).

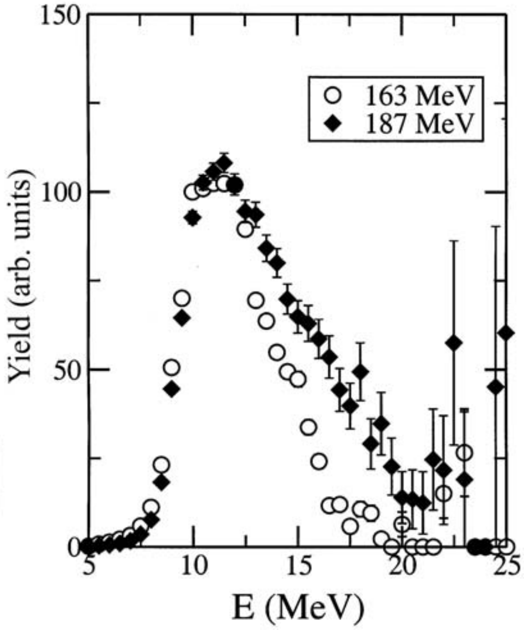

Fig. I-43. The GDR in ^{164}Er extracted following an analysis similar to that described in section d.1. The high energy gamma-rays were detected in coincidence with A = 164 residues.

d.3. **Observation of the GDR in Highly Excited ^{224}Th** (B. B. Back, M. P. Carpenter, M. P. Kelly, T. L. Khoo, B. McClintock, T. Pennington, R. van Swol, R. H. Siemssen, S. Mitsuoka,* V. Nanal,† J. Seitz,‡ T. Baumann,‡ K. Eisenman,‡ P. Heckman,‡ M. Thoennessen,‡ R. L. Varner,§ D. J. Hofman,¶ and I. DiÓszegi||)

The observation of the GDR in heavy fissile nuclei has so far been measured in coincidence with fission fragments. The pre-fission GDR has to be extracted from a large background of γ rays from the highly excited fission fragments. We performed a first measurement to observe the GDR γ rays in coincidence with evaporation residues in a system which is dominated by fission and where only a small fraction of the cross section leads to evaporation residues. The reaction ^{48}Ca + ^{176}Yb at 256 MeV formed the compound nucleus ^{224}Th at an excitation energy of 83 MeV. The evaporation residues were measured with the FMA at ANL, and the high-energy γ rays were detected with the ORNL-MSU-TAMU BaF$_2$ array. The γ-ray spectrum shows evidence for the GDR at a resonance energy of ~12 MeV, consistent with the predicted value for the GDR of the ground state for this mass region.

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d.4. **Octupole Vibration in Superdeformed ^{152}Dy** (T. Lauritsen, R. V. F. Janssens, M. P. Carpenter, D. G. Jenkins, T. L. Khoo, F. G. Kondev, K. Abu Saleem, I. Ahmad, A. M. Heinz, C. J. Lister, D. Seweryniak, P. Fallon,* B. Herskind,† A. Lopez-Martens,‡ A. O. Macchiavelli,* D. Ward,* R. M. Clark,* M. Cromaz,* T. Dossing,† A. Korichi,‡ and G. Lane*)

Nine transitions of dipole character were identified linking an excited superdeformed (SD) band in ^{152}Dy to the yrast SD band. As a result, the excitation energy of the lowest level in the excited SD band was measured to be 14238 keV. This corresponds to a 1.3 MeV excitation above the SD ground state. The levels in this band were tentatively determined to be of negative parity and odd spin. The measured properties are consistent with an interpretation in terms of a rotational band built on a collective octupole vibration.

The large data set used to link the ^{152}Dy yrast SD band to the normal deformed levels[1] was also exploited to obtain the best possible spectrum of the very weakly populated SD band 6 (~5% of the yrast SD band[2]). ^{152}Dy was produced with the ^{108}Pd(^{48}Ca,4n) reaction using a 191 MeV (at mid-target) ^{48}Ca beam delivered by the 88-inch cyclotron facility at the Lawrence Berkeley National Laboratory. The target consisted of a stack of two 0.4-mg/cm self-supporting ^{108}Pd foils. The Gammasphere array, with 100 Compton suppressed germanium detectors, measured the gamma rays of interest. As described in Ref. 1, events associated with ^{152}Dy were selected by detecting with high efficiency the decay of a 86 ns, 17+ yrast isomer (isomer tag). The result of summing triple coincidence spectra gated on clean SD lines in band 6 is shown in Fig. I-44: the members of the yrast SD band (from 601 keV to ~1113 keV) are clearly in coincidence with SD band 6, as was suggested in Ref. 2. As a matter of fact, 53(8)% of the decay of band 6 proceeds through band 1.

Due to small differences in the moments of inertia of SD bands 1 and 6, any set of linking transitions between them will be characterized by specific energy spacings that depend on which levels are actually linked. Fig. I-45A presents the high energy part of the coincidence spectrum of Fig. I-45A. Nine weak transitions can be seen from 1645 to 1795 keV separated by one of the possible energy spacings (~20 keV). Coincidence gates were placed on the 1696 keV transition together with relevant lines in SD band 6, while also requiring the isomer tag: the resulting spectrum is given in Fig. I-45. It clearly shows only transitions in SD band 6 with energies $E\gamma$ ± 850 keV, i.e. the 805 keV and 762 keV gamma rays of the sequence are clearly missing. Under the same coincidence conditions, only transitions of the yrast SD band with $E\gamma$ ± 784 keV are observed. This unambiguously establishes the ordering proposed in the level scheme of Fig. I-47. Additional supporting evidence is given in Fig. I-45. In panel B, the gamma cascades are required to pass through SD band 6 and include the 830 keV band 1 transition: the decay-out transitions below 1715 keV are clearly absent. Conversely, in panel C, the gamma cascades are required to pass through the lower part

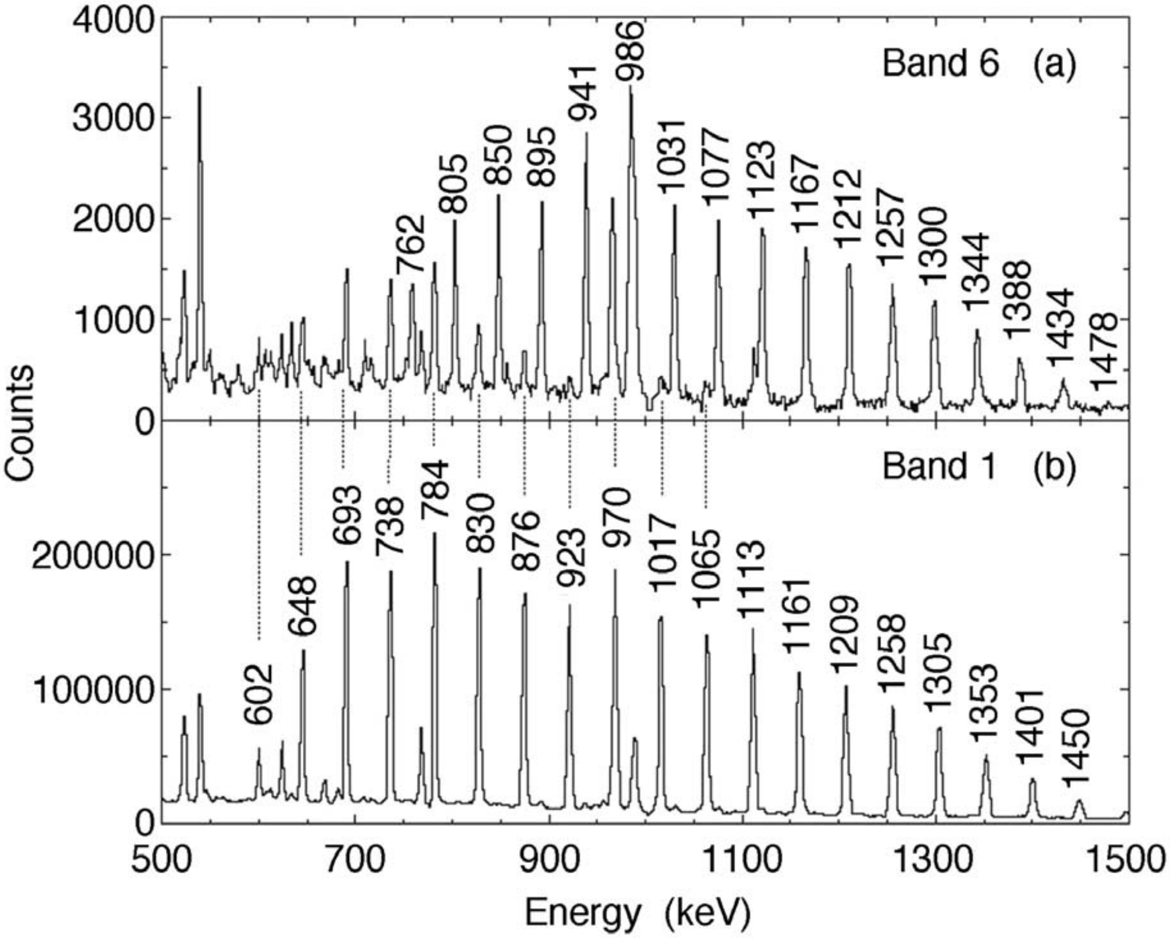

Fig. I-44. [A] Spectrum from triple coincidence gates on lines in SD band 6 of ^{152}Dy. Clean combinations of the following SD transitions were used in the analysis: 762, 805, 850, 895, 941, 1031, 1077, 1123, 1167, 1212, 1257, 1300, 1344 and 1388 keV. [B] Spectrum obtained from setting pairwise gates on clean SD lines in band 1 of ^{152}Dy.

of band 1 and include the 895 keV band 6 transition. Now the lower decay-out transitions are present, but the upper ones, from 1734 keV on, are missing. Thus, an excited SD band in the mass 150 region has for the first time been linked to an yrast SD band, which in turn is firmly connected to the normal states it decays into.[1]

An angular distribution analysis of the three linking transitions at 1676, 1696 and 1715 keV finds negative A2 coefficients in every case (-0.9(4), -0.3(3) and -0.3(3), respectively). If the yields of these three lines are added up and analyzed together, the combined A2 coefficient is determined to be -0.5(2), see Fig. I-45D. This value is consistent with those expected for stretched or anti-stretched E1 or M1 transitions (-0.24 – -0.21), but inconsistent with transitions of E2

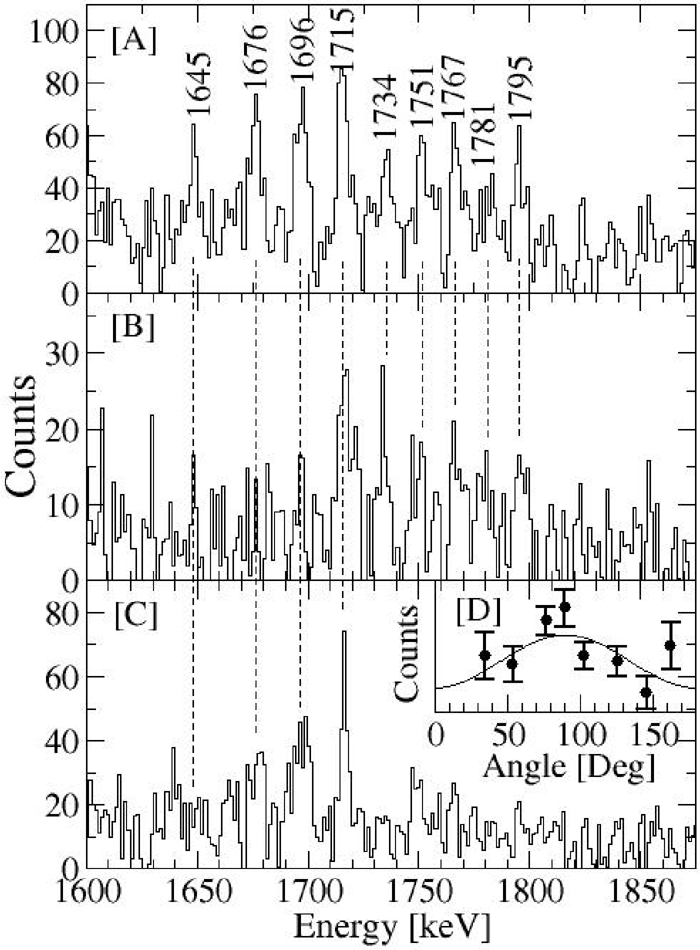

Fig. I-45. [A] Summed coincidence spectrum obtained by placing gates on clean SD band 6 high energy transitions and SD band 1 low energy transitions. The nine transitions linking SD band 6 to band 1 are marked with their energies. [B] As A, but requiring the 830 keV transition in band 1. [C] As A, but requiring the 895 keV transition in band 6 and any SD band 1 transitions below 876 keV. [D] Angular distribution of the sum of the intensities in the 1676, 1696 and 1715 keV linking transitions vs. the polar angle of the Gammasphere detectors.

character or with E1 transitions without spin change (where large positive A2 values of +0.34 and +0.45 are expected).

Assuming that SD band 6 has the same transition quadrupole moment of 17.5 eb as the yrast SD band,[3] it is possible to extract the partial half-lives of the interband transitions. Some of these are given in Table I-3, along with the transition strengths in Weisskopf units (W.u.) under the assumptions of E1 and M1 multipolarity. It is unlikely that M1 transitions between different quasiparticle configurations would occur with such short partial half-lives; the B(M1) values in Table I-3 are roughly one order of magnitude larger than those typically observed in deformed nuclei for interband gamma rays.[4] On the other hand, while the B(E1) values of Table I-3 are stronger than typical E1 transitions in heavy nuclei,[4] they are similar to those observed among actinide nuclei exhibiting strong octupole collectivity in the normally deformed well.[5] These B(E1) values are also comparable to those reported recently for transitions in the SD wells of the A ~ 190 nuclei[6,7,8,9] that have been interpreted in terms of an octupole vibration. These considerations lead us to propose a negative parity for the levels of SD band 6. Based on the measured angular distribution, two possible spin values could be assigned to these levels, making the nine interband gamma rays either J + 1 → J or J - 1 → J transitions. While the former transitions could a priori be expected to dominate (because the larger energy is favored), it is sometimes the case for octupole vibrations that J - 1 → J deexcitations gather more of the strength.[10,11]

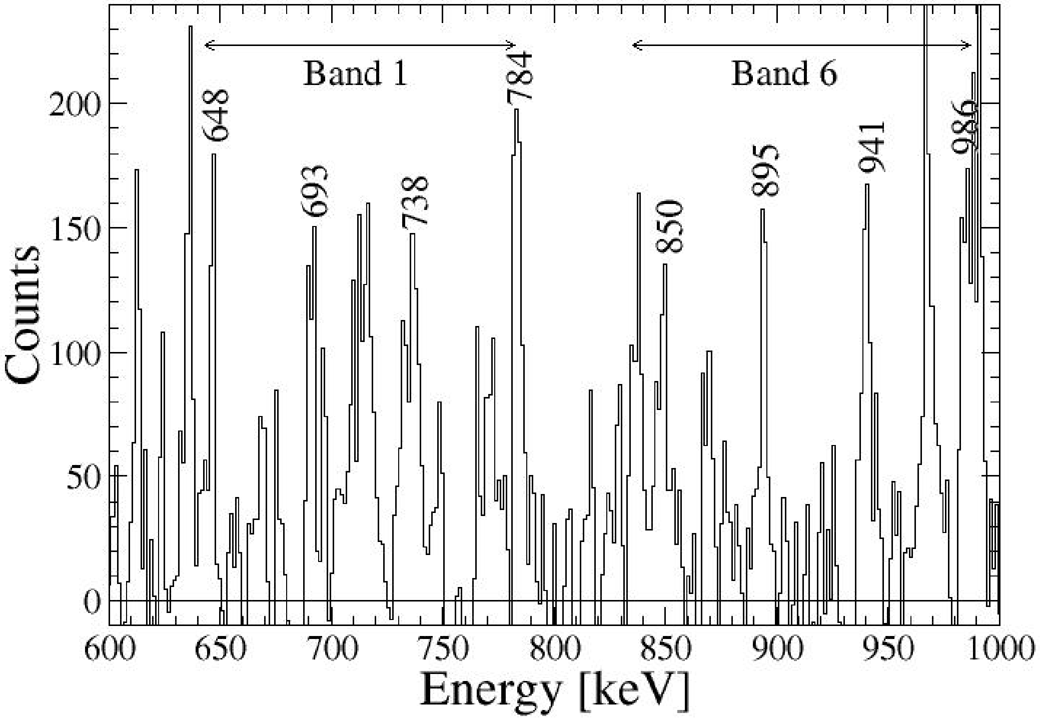

Fig. I-46. Summed coincidence spectrum obtained by placing gates on the 1696 keV linking transition and clean lines in SD band 6.

An RPA calculations by Nakatsukasa *et al.*[12] interpret SD band 6 as an octupole excitation with signature α = 1. At zero frequency, the band is characterized by K = 0, but K-mixing is significant at the frequencies of interest because of the Coriolis force. Experiment and calculations are compared in Fig. I-48, where the Routhian of band 6 with respect to the yrast SD band is given as a function of the rotational frequency. The figure presents the lowest octupole excitation (dashed

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[1] T. Lauritsen *et al.*, Phys. Rev. Lett. **88**, 042501 (2002).
[2] P. J. Dagnall *et al.*, Phys. Lett. **B335**, 313 (1994).
[3] D. Nisius *et al.*, Phys. Lett. **B392**, 18 (1997).
[4] K. E. G. Loebner. Phys. Lett. **B26**, 369 (1968).
[5] I. Ahmad and P. A. Butler. Annu. Rev. Nucl. Part. Sci. **43**, 71 (1993).
[6] H. Amro *et al.*, Phys. Lett. **B413**, 15 (1997).
[7] A. Korichi *et al.*, Phys. Rev. Lett. **86**, 2746 (2001).
[8] G. Hackman *et al.*, Phys. Rev. Lett. **79**, 4100 (1997).
[9] D. Rosbach *et al.*, Phys. Lett. **B513**, 9 (2001).
[10] G. D. Dracoulis, C. Fahlander, and M. P. Fewell, Nucl. Phys. **A383**, 119 (1982).
[11] F. G. Kondev *et al.*, Phys. Rev. C **61**, 044323 (2000).
[12] T. Nakatsukasa, K. Matsuyanagi, S. Mizutori, and W. Nazarewicz, Phys. Lett. **B343**, 19 (1995).

line), and the first 1p-1h configuration (solid line). From Fig. I-48, it is clear that the excitation energy and the evolution of the Routhian with frequency are well reproduced when the interband transitions are considered to be of the J + 1 → J type. This agreement argues for the spin assignment given in Fig. I-47. These results were published in Phys. Rev. Lett. **89**, 282501 (2002).

Table I-3. Branching ratios, partial half-lives and Weisskopf estimates for some of the strongest linking transitions.

Eγ (keV)	Branching Ratio	Part Half-Life (fs)	B(E1) W.u. 10^{-4}	B(E2) W.u. 10^{-2}
1751	0.08(3)	130	4.9	4.6
1734	0.08(3)	169	3.9	3.7
1715	0.11(3)	152	4.5	4.2
1696	0.12(4)	185	3.8	3.6
1676	0.22(10)	331	2.2	2.1

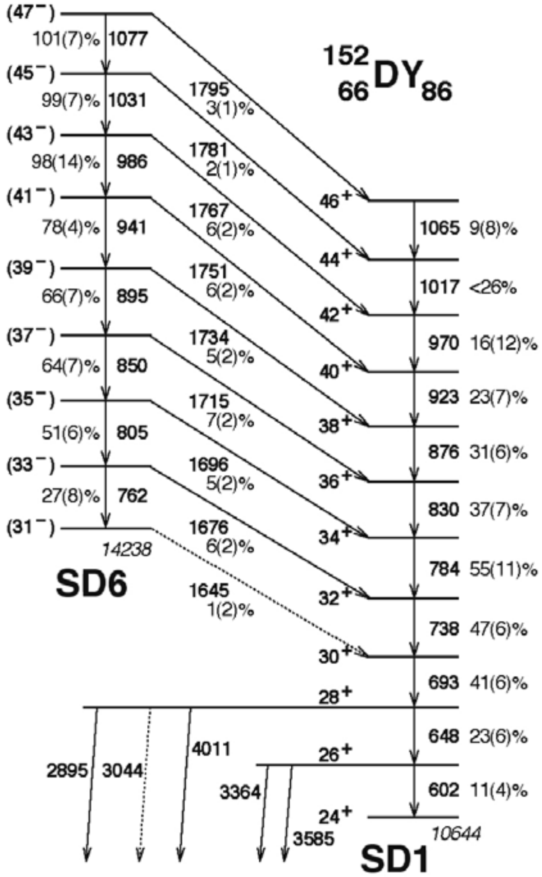

Fig. I-47. Partial level scheme of ^{152}Dy showing the lowest part of SD band 6, the lowest part of the yrast SD band 1 and the transitions that link the yrast SD band 1 to the normal states.[1] The transition intensities, given in %, reflect the requirement of the isomer tag and are with respect to the strongest lines in SD band 6 (the 1031 and 1077 keV lines). The intensities shown for band 1 are from the feeding by band 6 only.

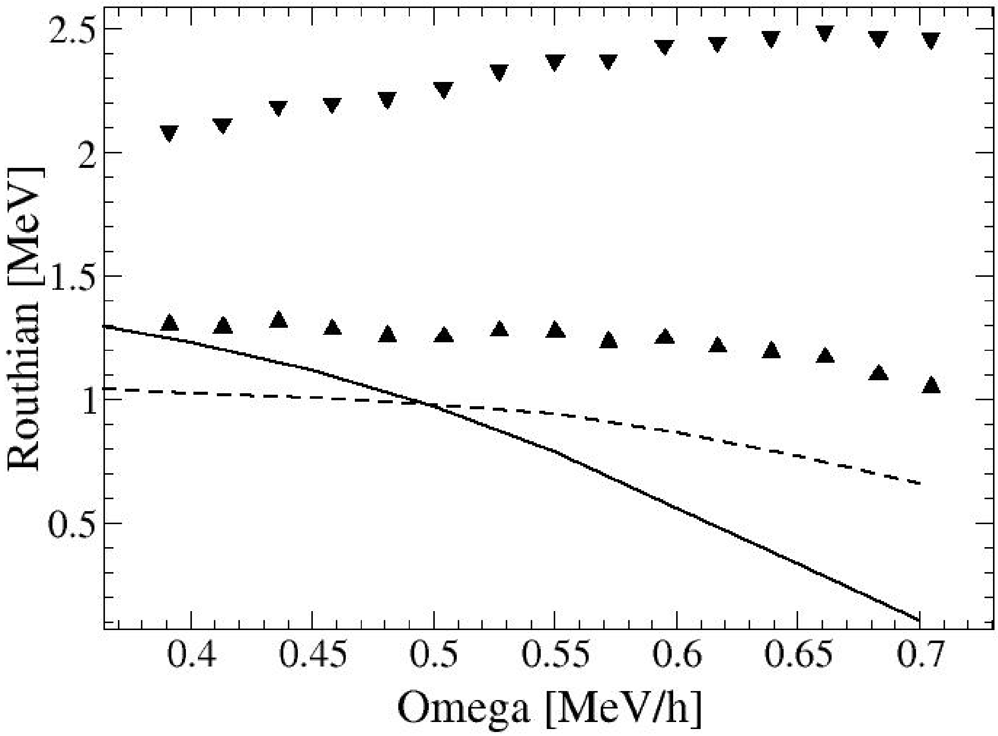

Fig. I-48. Routhians of band 6 with respect to band 1 as a function of rotational frequency. The up (down)-triangles are the data with the high (low) spin assignments to band 6. The lines are the result of the RPA calculations protect[12] for negative-parity states with signature $\alpha = 1$. The dashed line characterizes the lowest SD excitation associated with an octupole vibration. The solid line likewise shows the lowest 1p-1h excitation which, according to,[12] corresponds to SD band 2.

d.5. **Narrow Spreading Widths of Excited Bands in a Superdeformed Well** (T. L. Khoo, T. Lauritsen, D. Ackermann, I. Ahmad, H. Amro, D. J. Blumenthal, I. Calderin, S. M. Fischer, G. Hackman, R. V. F. Janssens, D. Nisius, M. P. Carpenter, A. Lopez-Martens,* T. Døssing,† B. Herskind,† M. Matsuo,‡ K. Yoshida,§ S. Asztalos,¶ R. M. Clark,¶ M. A. Deleplanque,¶ R. M. Diamond,¶ P. Fallon,¶ F. Hannachi,* A. Korichi,* R. Krücken,¶ I. Y. Lee,¶ A. O. Macchiavelli,¶ R. W. MacLeod,¶ G. J. Schmid,¶ F. S. Stephens,¶ and K. Vetter¶)

Excited states within a superdeformed (SD) well provide opportunities to investigate: (i) the excited states of a false vacuum; (ii) a transition from ordered motion along the yrast line to chaotic motion above, where quantum numbers and symmetries break down, perhaps through an ergodic regime; (iii) the robustness of collectivity with increasing excitation energy; (iv) the evolution with energy and spin of moments of inertia, collective spreading widths, in-band probabilities, quadrupole moments; and (v) the largely-unexplored feeding mechanism of SD bands.

Data for the present work came from a Gammasphere experiment conducted at LBNL with the ^{150}Nd(^{48}Ca,4n)^{194}Hg reaction. E_γ - E_γ matrices were constructed from pair wise gates on (a) SD and (b) normal-deformed (ND) transitions in ^{194}Hg; (a) selects only transitions feeding SD band 1, while (b) includes other SD transitions, which do not necessarily feed into the SD yrast line, but continue to lower spin. In the SD-gated matrix, 3 ridges (parallel to the diagonal) with E_γ > 450 keV can be seen (see Fig. I-49) and, in the ND-gated matrix, 5 - 6 ridges, which persist

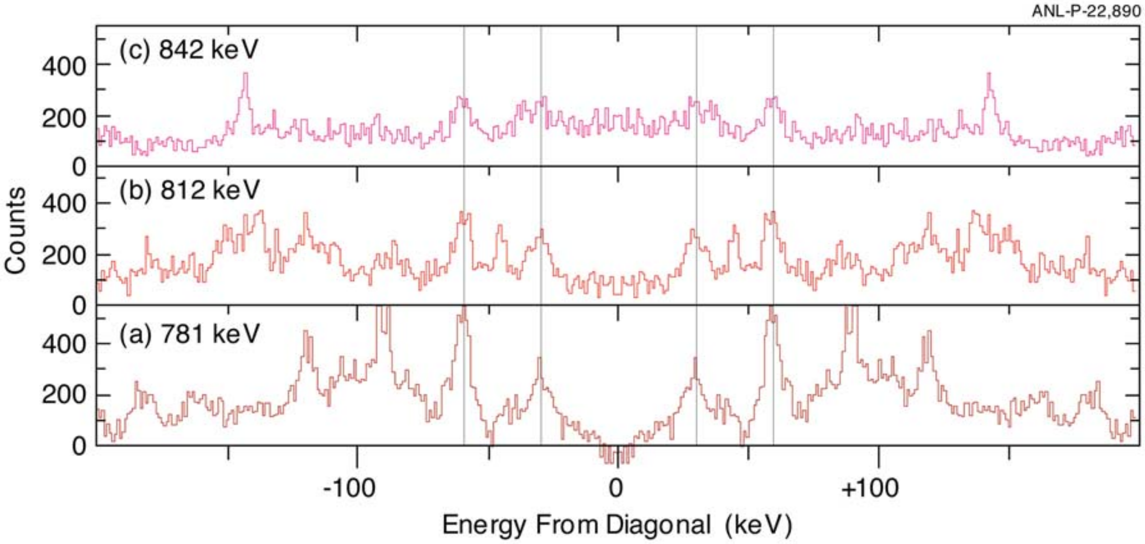

Fig. I-49. Projections perpendicular to the diagonal of an E_γ - $E_\gamma$matrix, obtained with pair wise gates on lines of the yrast superdeformed (SD) band I in ^{194}Hg. The diagonal is at channel 0. The projections, which are centered at 781, 812 and 842 keV, cover 24 keV of the ~30 keV interval between the SD lines and show peaks (marked by vertical lines) separated by about 30 keV from the diagonal. The innermost peak from the diagonal contains counts from only the quasicontinuum ridge, while the next one contains an additional contribution from a SD peak.

down to ~340 keV. The former matrix represents the first instance where ridges are detected with gates on SD transitions. The persistence of ridges to lower energy in the ND-gated matrix occurs because the γ cascades are not forced into the SD yrast line and implies small tunneling to ND states – even ~2 MeV above the SD minimum. The ridges reveal the following properties: (1) narrow spreading widths (~ 5 - 10 keV), which increase with spin; (2) ridge spacings and, hence, $\mathcal{J}^{(2)}$ identical to that of SD band 1; (3) N_{path} ~ 100 - 150, from fluctuation properties; (4) in-band probability ~1, for $E_\gamma > 790$ keV; and (5) ratio of ridge intensity/total E2 strength ~1 for $E_\gamma < 770$ keV. The large number of unresolved bands suggests that they are excited, probably from an interval 1.5 - 2 MeV above the SD yrast line. Yet, unexpectedly, the moments of inertia are nearly identical to that of the yrast SD band.

The two most prominent features of the ridges are the narrow spreading widths and the $\mathcal{J}^{(2)}$ moments of inertia, which are identical to the those of the yrast SD band. The narrow ridges imply that that E2 flow connects bands that must be parallel. For this to occur, the multitude of excited bands (100 - 150) must have the same $\mathcal{J}^{(2)}$ moments of inertia. Furthermore, the different components in the wavefunctions cannot change much with spin increments of 2 ħ. The similarity of the $\mathcal{J}^{(2)}$ values is intimately connected with the observation that the $\mathcal{J}^{(2)}$ values of many SD in the A = 190 nuclei are almost identical at high frequency. Hence, the SD bands in this mass region have the remarkable property of being nearly perfect rotors, with the appearance of moments of inertia governed ostensibly by only the SD shape. A second interesting observation is that the collective flow is constrained within bands, even though the wavefunction for each band is complicated, with many components; i.e. they are almost chaotic. In other words, they probably have level spacings given by the Wigner distribution and interband decay strengths that are governed by Porter-Thomas fluctuations (although these properties have not yet been established by experiment). Yet the collective E2 flow is very ordered. Bands with these unusual properties have been predicted[1] and have been labelled ergodic bands.

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[1] B. R. Mottelson, Nucl. Phys. **A557**, 717c (1993).

[2] K. Yoshida and M. Matsuo, Nucl. Phys. **A636**, 169 (1998).

Detailed analyses of the band properties were conducted within the cranked shell model,[2] which predicts the narrow ridges. They indicate that there are 2 - 8 components in the wave functions of the excited SD states. They further suggest that the excited SD bands are precursors to ergodic bands, which meet a condition T < D_2, but not the condition T < D required for ergodic bands. T is defined as the width of the ridges, D the average separation between SD states (of the same spin) and D_2 the separation between SD states that are connected by the two-body residual interaction.

d.6. Excitation Energies, Spins and Pairing in the Yrast Superdeformed Band in ^{191}Hg

(S. Siem,* P. Reiter, T. L. Khoo, T. Lauritsen, M. P. Carpenter, I. Ahmad, I. Calderin,
S. M. Fischer, D. Gassmann, G. Hackman, R. V. F. Janssens, D. Nisius, P.-H. Heenen,†
H. Amro,‡ T. Døssing,¶ U. Garg,|| F. Hannachi,** B. Kharraja,|| A. Korichi,**
I-Y. Lee,†† A. Lopez-Martens,** A. O. Macchiavelli,†† E. F. Moore,§ and C. Schück**)

Although about 250 superdeformed (SD) bands were found in the A = 150 and 190 regions, the energies and quantum numbers weren determined for only a handful of SD bands. The excitation energies and spins of the yrast superdeformed band in ^{191}Hg were found from two single-step γ transitions and the quasi-continuum spectrum connecting the superdeformed and normal-deformed states. This is this the first case where the energies and spins of a SD band were determined in an odd-A nucleus. The results are compared with those from theoretical mean field-calculations with different interactions.

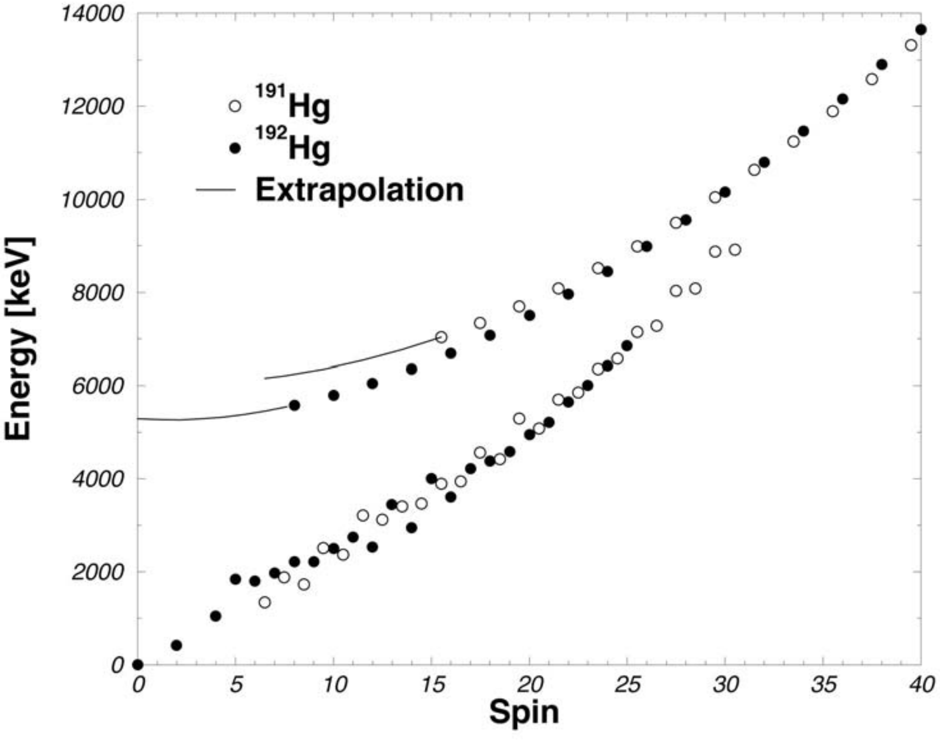

Fig. I-50. The spins and excitation energies of the SD and ND yrast bands for ^{192}Hg (filled circles) and ^{191}Hg (open circles), plotted after correcting for the difference in mass excess, i.e. E(^{191}Hg) = E_x(^{191}Hg) - mass excess(^{192}Hg) + mass excess(^{191}Hg). The ground state of ^{192}Hg is set at zero. The solid lines are extrapolations of the ^{191,192}Hg SD bands to the respective "ground-state" spins.

By comparing the energies of SD bands in adjacent even-even and odd-A nuclei, we can extract information of the pair correlations in the SD well. Figure I-50 shows both normal- and super-deformed bands in ^{191,192}Hg, plotted on an absolute mass scale, i.e. after correcting for the mass excess. The energy of the ground state of ^{192}Hg is lower than that of ^{191}Hg by 1.4 MeV, reflecting the extra binding from the pair correlation energy. For the SD states at the "ground-state" spins, the mass difference is 0.9 Mev. This provides a quantitative measure that the pair correlation energy is smaller in the SD well. However, it is interesting to note that the energy difference in the two nuclei persists to higher spin in the SD well, suggesting that pairing for SD states is less affected by angular momentum than for normal states.

A paper is being prepared for publication.

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d.7. Composite Chiral Pair of Rotational Bands in the Odd-A Nucleus ^{135}Nd

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The rotational motion of triaxial nuclei attains a chiral character if the angular momentum has substantial projections on all three principal axes of the triaxial density distribution. Up to now, the phenomenon was observed only in odd-odd nuclei.

High-spin states in ^{135}Nd were populated with the ^{110}Pd(^{30}Si,5n)^{135}Nd reaction at a bombarding energy of 133 MeV. Two $\Delta I = 1$ bands with close excitation energies and the same parity were observed. These bands are directly linked by $\Delta I = 1$ and $\Delta I = 2$ gamma-ray transitions. The chiral nature of these two bands was confirmed by comparison with three-dimensional tilted axis cranking calculations. These results represent an important confirmation of the geometrical interpretation in terms of broken chiral symmetry, which claims that pairs of nearly degenerate $\Delta I = 1$ bands with the same parity appear whenever there is a chiral geometry of the angular momentum components, irrespective of how they are composed. ^{135}Nd represents the first case where three quasiparticle excitations (rather than two quasiparticle) are involved in chirality. A paper describing the results was submitted for publication.[1]

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[1] S. Zhu *et al.*, to be published.