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AROUND A = 160

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HIGH-SPIN PROPERTIES OF SOME NUCLEI AROUND A = 160*

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Two new types of behavior have been observed in ^{156}Er. The first is a terminating band ending on a 42+ fully aligned state. The second is a strong cross feeding among four negative parity bands, due most likely to a severe reduction or collapse of the neutron pairing. In ^{158}Er we have found two sequences feeding the 38+ level; one slow and one fast. This suggests that some feeding goes through regions of oblate (or nearly so) shapes, and some does not. Lifetimes have been determined for levels around 30+ in ^{166}Yb, which seem to be longer than is easily explained.

1. INTRODUCTION

The present report contains the first results from the High Energy-Resolution Array, HERA, recently built at Berkeley. The experiments began with the 4 Compton-suppressed germanium (CSG) detectors available about one and one-half years ago, and conclude with the full array of 21, used for the first time just a little over a month ago. Yet to build in the full system, HERB, are back-scatter suppressors and a central ~ 4π BGO ball. The HERA now performs as expected with Compton-suppressed doubles rates of 10-12 thousand per second, and triples plus higher-order rates of 3-4 thousand per second. We are at present learning how to use the higher-order high-resolution events in studies of both resolved and unresolved spectra. However, rather than tell you about the exciting prospects there (which we, among other people, have been doing for some time) I decided to tell you about our first finished, or nearly finished, results. These are for nuclei in the mass region around 160, and include the level structure of ^{156}Er, which indicates some new types of behavior, and some results from a new generation of lifetime studies.

2. HIGH-SPIN STRUCTURE OF ^{156}ER.

Transitional nuclei, between the double-closed shell N = 82, Z = 64 and the deformed nuclei, N ≈ 90, 64 < Z ≲ 70, have received considerable attention recently. There are several interesting properties expected in these nuclei.

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At very high spins ($\gtrsim 50\hbar$) superdeformations are predicted and evidence for them has been seen[1] in correlation plots of the unresolved spectra of ^{152}Dy. At spins below $40\hbar$ there is known to be a competition among several shapes: approximately spherical, weakly deformed oblate, and moderately deformed prolate. Above ~$40\hbar$ there are no resolved spectra available. The unresolved spectra contain mostly stretched quadrupole transitions, suggesting appreciable collectivity. Correlation plots, however, seem to show an absence of strongly populated rotational sequences. Whether this indicates band irregularities associated with weak collectivity or high collectivity, with a low probability to stay within a single band, is not yet very clear. We[2] chose to study ^{156}Er since it is a representative nucleus in this mass range about which rather little was known at high spins.

The present data on ^{156}Er represent the first results from HERA.[3] Nine CSG detectors were available at the time of these experiments, giving maximum rates of 600-800 Compton-suppressed Ge-Ge coincidences per second. The present data set consists of about 1.2×10^8 such events accumulated over a period of two days.

The ^{156}Er was produced as the 4n product resulting from bombardment of ^{120}Sn with 170 MeV ^{40}Ar projectiles produced by the 88-Inch Cyclotron at the Lawrence Berkeley Laboratory. The ^{120}Sn targets were about 1 mg/cm^2 thick on lead backing. This backing stopped the recoiling Er nuclei in ~1 ps. It was found that all the resolved γ-ray lines were emitted after stopping, resulting in no Doppler shift or broadening. This is due to the (previously known[4]) long feeding times in transitional nuclei, and improved the resolution from 3-4 keV (when thin targets were used) down to ~2 keV. However, no delayed transitions were observed in this nucleus with lifetimes longer than ~20 nsec, the electronic resolving time used in this experiment.

The level scheme for ^{156}Er was constructed from the coincidence data and is shown in Fig. 1. Because of the large number of connections among the various bands we consider the scheme reasonably certain. There are several cases, especially high in the scheme, where the ordering of transitions is not well defined, and a few uncertain assignments are included with dashed lines.

The spin assignments are based on angular correlation data. Six of the detectors were effectively at ~30° (two at ~30° and four at ~150°) and the other three at ~95°. Thus, about half of all events have one detector at ~30° and the other at ~95°. These were sorted into a 2D-spectrum (x,y) with the former along the x-axis, and the latter along the y-axis. A projection selecting a given γ ray on the y-axis (95°) and projecting the coincident spectrum along the x-axis (30°) can be compared with

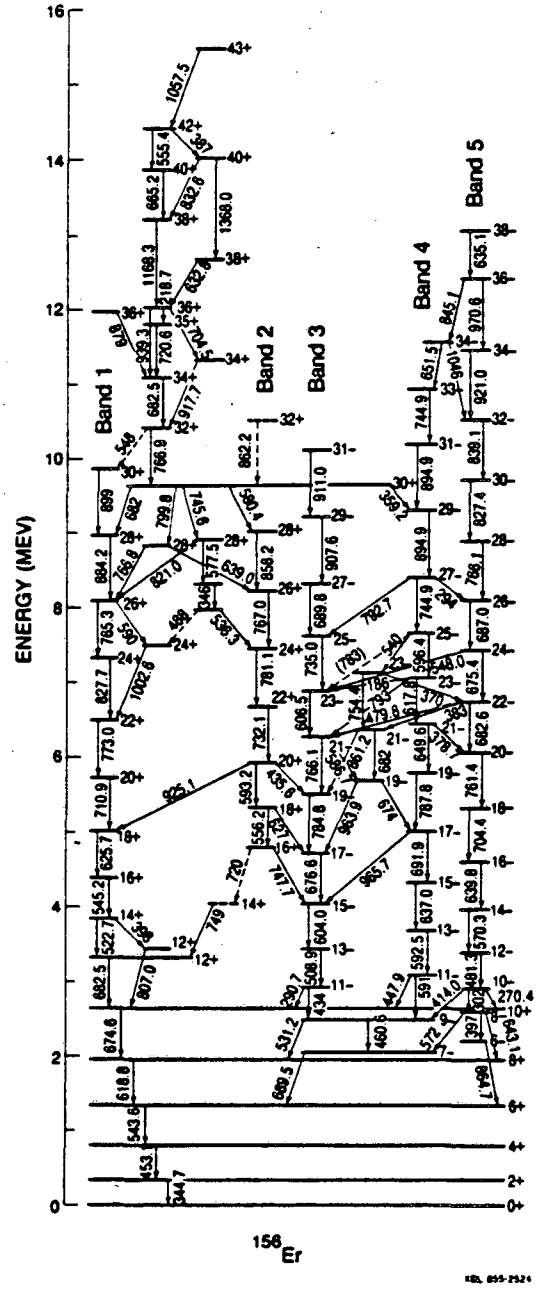

Fig. 1 Level scheme of ^{156}Er

the inverse projection--the given γ ray on the x-axis (30°) and the projected spectrum on the y-axis (95°). Gamma rays in the projected spectra that have the same character as the given γ ray (multipolarity and spin change) appear equally in the two spectra; whereas those with different character are generally not the same. For the common situation of a stretched dipole (ΔI = 1) and a stretched quadrupole (ΔI = 2) transition, the resulting peak is about twice as large when the dipole is at 95° and the quadrupole at 30° as for the inverted situation. An example of two such projections is shown in Fig. 2. The selected gating transitions are three successive stretched quadrupole

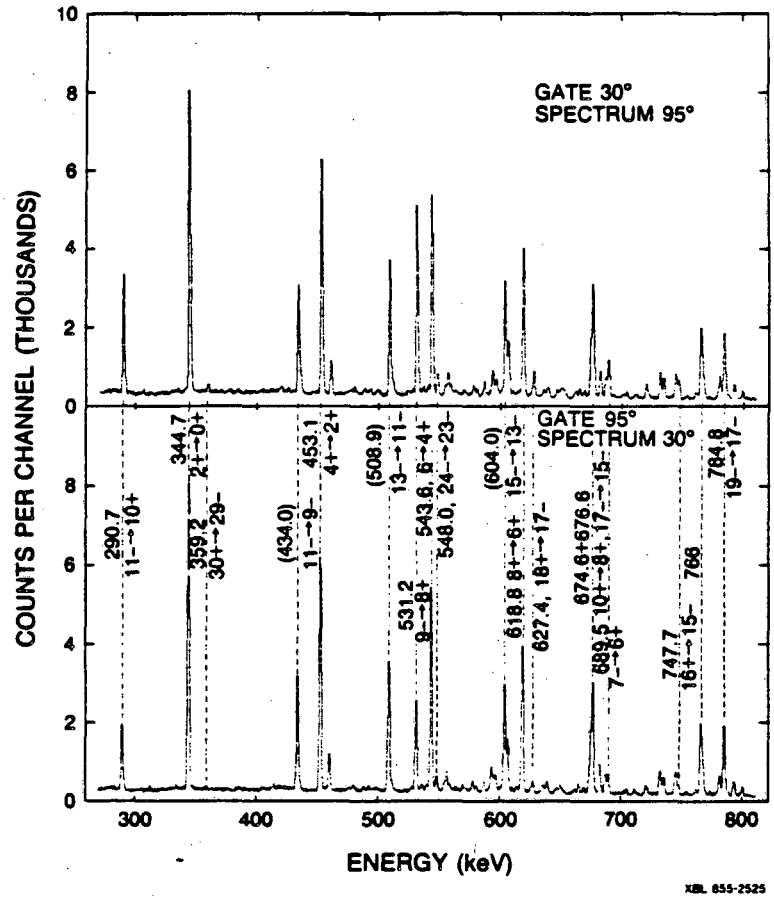

Fig. 2 Projections on the x(30°) and y(95°) axis of the summed coincidences with three γ-rays: 434, 509, and 604 keV.

transitions (604, 509, and 434 keV) in band 3. They are added together to improve the statistics in order to characterize weak transitions. Most of the transitions in the two parts of Fig. 2 are comparable, indicating a consistency with stretched quadrupole character. Notable exceptions are the 291, 531, and 690 keV transitions, consistent with stretched dipole character, as was known.[5] An important result is that the 627 and 748 keV transitions are also consistent with stretched dipole character, confirming spins and parity for band 2. The apparent stretched dipole character of the 548 keV transition also ties together the spins in bands 3 and 5. Such assignments are, of course, not certain since non-stretched and mixed transitions can be indistinguishable from stretched ones. Nevertheless, stretched transitions are predominant in high-spin studies, and furthermore there are many interconnections among the observed bands that strengthen the assignments.

Two points in the level scheme warrant additional comment. The spin and parity assignments of band 5 differ from those of Ref. 5 as do some details at the bottom of the band. Our coincidence data show that the 414 keV transition connects band 5 to the 2.5 MeV, 9- level and also indicate a weak 572 keV

transition connecting the 2.6 MeV 8- and 2.0 MeV 7- levels. Thus the previous spin assignments for band 5 are not possible. The angular correlation data for the 270 and 643 keV transitions are consistent with non-stretched dipole character and, as mentioned, the 548 keV transition (24- → 23-) looks like stretched dipole. All these properties, together with the decay pattern to the ground-state band, suggest the spins indicated for this band. The other point has to do with the 767 and 683 keV transitions above the 30+ level at 9.6 MeV. They were difficult to assign due to the existence of 5 other transitions unresolved in energy from the 767 keV one, and 4 other unresolved 683 keV transitions. The assignments were based on clean coincidence spectra from the 555, 1168, and 219 keV transitions, each of which showed the existence of approximately one extra 767 and 683 keV transition over and above what could be accounted for due to the decay of the 9.6 MeV 30+ state. These intensities were internally calibrated using the clean 453 and 619 keV transitions (taken as 1.0 and 0.9, respectively) appearing in the same spectra. The weak 705-918 cascade gives the order of these transitions, as does the tentative 548 keV line.

The lower part ($I \lesssim 30\hbar$) of the ^{156}Er level scheme is clearly rotational, resembling the heavier rare-earth nuclei. The lowest levels are probably weakly deformed prolate but soft toward deformation. Under rotation they appear (from the level spacings) to stretch out to typical deformations ($\varepsilon \sim 0.25$) by spin 8 or 10, as is seen for other nuclei in this part of the transition region.[6] The band-head assignments seem reasonably clear; band 1, vacuum; band 2, EF; band 3, AE; band 5, AF; and band 4, mainly octupole. The letters refer to particular cranked-shell-model orbitals, as given for example in Ref. 7. (For orientation, A, B, C and D are the lowest four, in increasing order, positive-parity neutron orbitals, derived from $i_{13/2}$, and E and F are the lowest two negative-parity orbitals derived from, mainly, $h_{9/2}$ and $f_{7/2}$.) These bands seem to behave reasonably up to spin ~30ħ. Band 1 has an AB crossing at ~12ħ, and a second backbend at ~24ħ, where it receives feeding from the 9.6 MeV 30+ level, via three different paths. If we assume a "band" is indicated by an essentially unbranched E2 decay pathway this band most likely proceeds up via the 884 and 899 keV transitions. Previous studies[8] tended to follow the more heavily populated links to the 9.6 MeV, 30+ level, and to identify them with the band continuation. Bands 3 and 5 have no AB backbend, but do have a backbend at spin 22 or 23 (very probably BC), and are not very regular above that. Nevertheless band 5 clearly continues up to 36ħ, far above the 9.6 MeV, 30+ state.

Band 4 is not so easy to understand. A number of interband transitions make any parity signature (π,σ), assignments other than (-,1) rather unlikely. It branches nearly 50% to band 3 at spin 27, and is strongly depopulated by spin 21. It seems to us too low in energy to be BF, which is the next lowest particle configuration expected with that parity and signature. However, a collective octupole band having these properties is expected, and band 4 seems likely to have mainly this octupole character. The band fragment between bands 3 and 4 also has (π,σ) = (-,1), but its interpretation is less clear.

A new feature observed in bands 3, 4, 5, and the above band fragment is the abundance of interband transitions at the backbends, presumably BC, around spin 22. All four of the bands participate in this cross feeding, and it is the only reason that the band fragment is seen. This cross feeding suggests that the integrity of the bands, as indicated by a single predominant B(E2) value for the decay of each state, is broken. This is known to happen sometimes at band crossings due to mixing of the two bands, but in the present case bands having different signatures are involved, requiring a more general explanation. This suggests to us that the structure changes across this region, and during the reorganization band integrity is weakened. A structural change is supported by the fact that the bands are less regular above this region than below it. The nature of the change seems very likely to be related to the BC alignment, since the cross feeding occurs exactly at the associated backbend. It is reasonable that the third and fourth quasineutrons in ^{156}Er cause a large reduction or collapse of the neutron pairing which in turn might cause some change in shape. This seems to us a consistent explanation for the observed behavior. A corresponding cross feeding seems to occur at spins 26 or 28 in the even-parity bands. To our knowledge this behavior has not previously been observed in any rotational nucleus.

Perhaps the most interesting feature of the ^{156}Er level scheme is the structure between the 9.6 MeV, 30+, and the 14.4 MeV 42+ levels. A first thought is that this is an oblate region corresponding to that seen between ~14 and 40ħ in ^{154}Er and ^{152}Dy. Indeed, the 42+ level is almost undoubtedly the fully aligned configuration $\pi(h_{11/2})^4_{16}$; $\nu(h_{9/2})^2_8(f_{7/2})^2_6(i_{13/2})^2_{12}$ (relative to a ^{146}Gd core), consistent with an approximately oblate shape. However, the backbone of this structure (the 387-1368 and 704-918 branches are weak) is a sequence of six successive stretched E2 transitions, and, furthermore, of 15 reasonably certain assignments between these spins, only the 219 and 721 keV cascade transitions are mainly dipole. We take this as evidence for some collectivity in the region. An interpretation consistent with all

this evidence, as well as current theoretical calculations, is that this is a triaxial band terminating in the (nearly) oblate fully aligned 42+ state. This is supported by the energy of these levels relative to that of a rigid rotor, shown in Fig. 3. The gain in energy compared to the rigid rotor, especially for the 40 and 42+ states, is characteristic of that calculated for such terminating bands based on fully aligned (energetically favorable) states. This low energy results in a large sudden population (nearly 10%), whereas the only continuation seen is a weak, high-energy (1058 keV) dipole transition. It is also interesting that the lowest member of this band, the 9.6 MeV, 30+ state, is distinctly different in character from the reasonably well developed rotational bands lying below it. This seems consistent with a shift (toward more triaxial shapes) to a level that is eventually related to the (essentially) oblate 42+ state. The general agreement between experiment and calculation[9] in Fig. 3 is impressive. Very recently[10] a terminating band has been proposed in ^{158}Yb, an isotone of ^{156}Er. However, the above terminating band features are much less clear there. In fact, the yrast sequence in ^{158}Yb looks quite similar to one sequence in ^{156}Er up to I = 38, but this is prior to the (main) band termination in ^{156}Er.

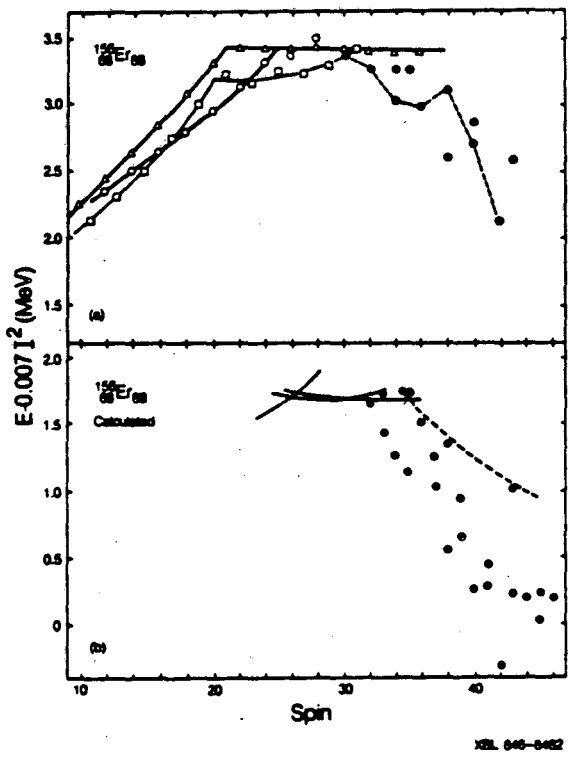

Fig. 3 Comparison of experimental (top) and calculated (bottom) energy levels in ^{156}Er, with an average rigid-rotor energy subtracted. Lines connect levels that seem to be related as bands, with the dashed line following the proposed terminating band.

It is interesting that the irregularity of such bands could explain the lack of rotational correlations in the higher-spin continuum region. But whether the continuum is composed of many such triaxial bands, or of more regular prolate bands that branch frequently, is not clear. One could probably distinguish these two possibilities by measuring B(E2) values. We suppose that there is a reasonably continuous loss of both B(E2) strength and band regularity as the shape changes from prolate through triaxial toward oblate. The continuum B(E2) measurements so far made seem to support a nearly prolate shape, but the uncertainties are large.

3. LIFETIMES IN ^{158}ER.

In the nucleus ^{158}Er calculations[11-13] predict that oblate shapes will compete with prolate and triaxial ones along the yrast line near 50ħ. Experimental evidence has recently been reported[14] for a change to oblate shape, however at somewhat lower spin, ~ 40ħ. We find[15] two branches feeding the 38^+ level, one of which is slow (> 1 ps), suggesting some population of the non-collective, oblate structures predicted; and the other of which is fast(<< 1 ps), suggesting population also of the more collective prolate or triaxial structures.

The reaction used was 175 MeV ^{40}Ar + ^{122}Sn. Two experiments were performed: one with a 1 mg/cm^2 lead-backed target and the other with a target consisting of three self-supporting ^{122}Sn foils, each ~ 0.5 mg/cm^2 thick. The gamma rays were detected in the (incomplete) array consisting of 14 (for the lead-backed target) and 15 (for the unbacked target) CSG detectors. For each target about 2 x 10^8 double events were recorded.

Figure 4 shows the spectrum obtained (unbacked target) when gates on the 1058, 1017, and 959 keV yrast transitions[14,16] are summed. The five transitions observed in Ref 14 of 827, 1031, 1203, 1210, and 1280 keV can be seen. A repeat of the upper part of this spectrum, but gated only by the 1058 and 1017 keV transitions, is shown at the top of Fig. 5. The lower part of that figure shows the same region gated by the same two transitions but for the lead-backed target, where the 1203-1210 keV lines are missing. We believe these are not observed because they are smeared out by Doppler shifts arising from: 1) a spread in velocity of the emitting nucleus as it slows down; and 2) a variety of detector angles relative to the beam direction. From range-energy data,[17] the time to stop the recoiling ^{158}Er nucleus in lead can be estimated to be around one picosecond. For the 827, 1031, and 1280 keV transitions to be sharp in the bottom part of Fig. 5 means that they must have been emitted after this time. Thus their lifetime (plus feeding time) must be

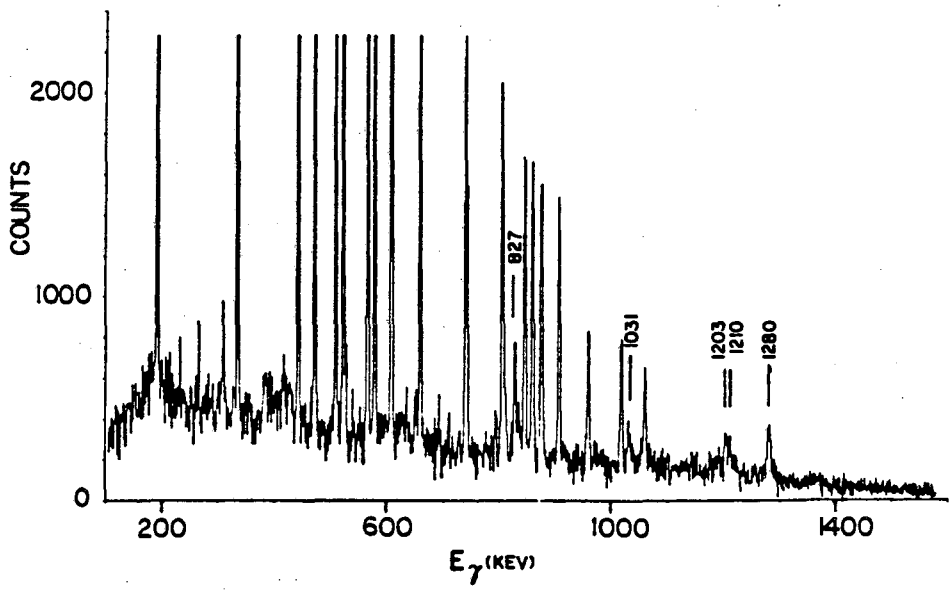

Fig. 4 Gamma-ray spectrum gated on the 959 (34^+), 1017 (36^+), and 1058 (38^+) transitions, self-supporting target.

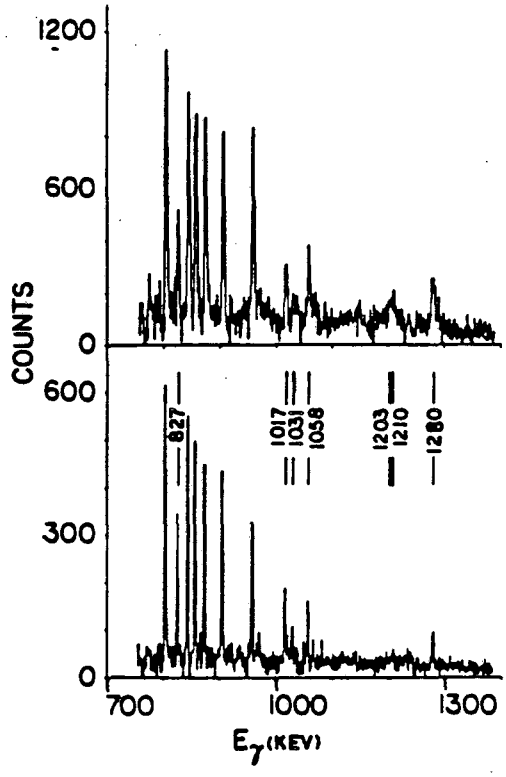

Fig. 5 Coincident gamma-ray spectra for: (top) gates on the γ-rays depopulating the spin 36^+ and 38^+ levels, self-supporting target; and (bottom) the same gates, but lead-backed target.

longer than this. On the other hand, the fact that 1200 keV lines disappear means that they have lifetimes (plus feeding times) considerably shorter than 1 ps. If the lifetime (plus feeding time) of the 1200 keV lines were shorter than ~ 0.1 ps, then they would be emitted before much slowing down occurred (i.e., at nearly full recoil velocity). In this case, if we gain shift each of our detectors to take account of its angle relative to the beam direction, a reasonably sharp line should appear in the added spectrum. We did not see 1200 keV lines in such spectra, suggesting a lifetime (plus feeding time) between 1 and 0.1 ps. However, at present we consider the lower limit to be tentative.

The coincidence data make it clear that the five γ rays of interest are in coincidence with the main sequence of the yrast band starting with the $38^+ \rightarrow 36^+$, 1058 keV transition. Figure 6 (top) is a spectrum obtained with a gate on the 1280 keV transition (unbacked target) which shows that it is not in coincidence with the 1203 and 1210 keV transitions, but is in coincidence with the 827 and 1031 keV gamma rays. Similarly, Fig. 6 (bottom), obtained from the sum of the gates on the 1203 and 1210 keV transitions, shows that the 1203 and 1210 gamma rays are <u>not</u> in coincidence with the 827, 1031, and

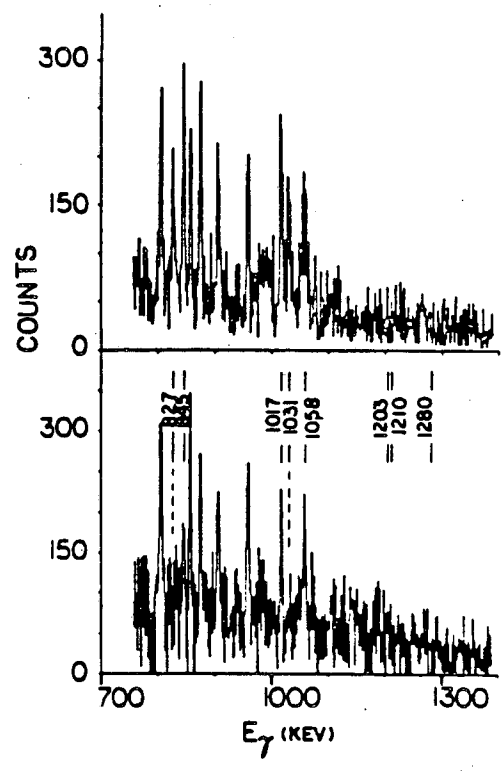

Fig. 6 Gamma-ray spectra obtained with the self-supporting target: (top) in coincidence with the 1280 keV gamma-ray; (bottom) with gates on the 1203 and 1210 keV gamma-rays.

1280 keV transitions but do feed in at the 38^+ level. The poor statistics do not permit ruling out that they separately feed the 38^+ level, but we think it more likely that they are in cascade. If so, their relative intensities suggest that the 1203 keV line is the lower. The 1031-1280-827 keV cascade is ordered on the basis of relative intensities, so the nearly equally intense 827 and 1280 KeV transitions might be reversed. The gamma-gamma angular correlation data suggest that the 1280 keV transition is a stretched E2 decay. The other new transitions were too weak to determine reliably. The top part of the level scheme determined here is shown in Fig. 7. It differs from that of Ref 14 in that the 1200 keV γ rays feed the 38^+ rather than the 40+ level. This arrangement also removes an intensity imbalance noted in Ref 14.

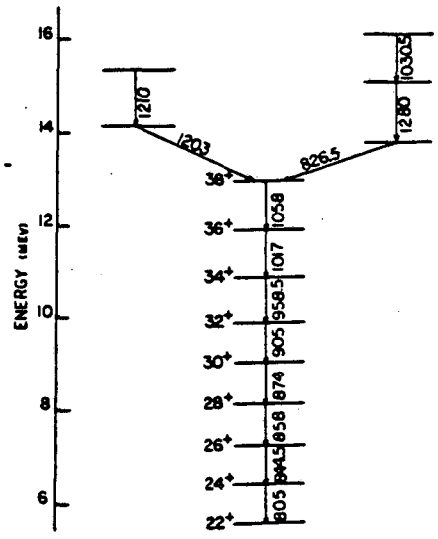

Fig. 7 Top of the level scheme for the yrast band in ^{158}Er.

The most interesting result of these experiments is the identification of fast and slow feeding components into the 38^+ state of ^{158}Er. Individually such components are well known and have generally accepted interpretations. The Gd, Dy, Er, and Yb ($64 \leq Z \leq 70$) nuclei, having neutron numbers between 82 and 88, generally have slow feeding times (> 1 ps). The reason is thought to be that they have regions of non-collective behavior (oblate or spherical shapes) along the decay pathways. Such regions have relatively slow transitions (of order single particle strength or less) and no smooth decay

pathways. In contrast, the well deformed rare-earth nuclei ($60 < Z < 74$; $90 < N < 110$) have fast feeding times (<< 1 ps), thought to be due to the presence of rotational bands. These bands provide smooth pathways of strongly enhanced E2 transitions (~ 200 times the single-particle strength), and thus provide for rapid deexciation. It is therefore not so surprising that ^{158}Er, which lies on the boundary between these regions, would have both fast and slow feeding components. In fact, such a combination of feeding times has recently been inferred[18] from the decay curves of lower-lying states in recoil distance studies of the nearby nucleus, ^{154}Dy. The difference in the present case is that we have identified resolved lines in each of these two branches, and determined how they feed into the known yrast sequence.

There is not much more we can say about the slow branch. It is perhaps worth noting that the delay is not likely to be due to the 827 keV transition alone, as it very likely lies below the 1031 keV transition, and probably the 1280 keV one, as well. Since all three lines are sharp in Fig. 6 (top), they are either all slow or the delay precedes them all. We can, however, try to infer a bit more about the 1200 keV lines. If they are sequential as shown in Fig. 7 (and this seems likely), the 1 and 0.1 ps limits refer to their combined lifetime; the individual level lifetimes would have to be about a factor of two (on average) shorter. In a typical rotational band this feeding correction (due to higher states) amounts to a factor of around 4 for such transition energies. If we take, rather arbitrarily, a factor of 3 for the feeding correction, the above limits correspond to $B(E2)/B(E2)_{sp}$ values between about 10 and 100 for the 1200 keV transitions. This is only an estimate, but indicates appreciable collectivity in this branch, as was thought. On the other hand, it is probably less than the 200 single-particle units characteristic of the low-spin regions of the well deformed nuclei and of the continuum γ-rays in ^{158}Er and other nearby Er nuclei.[19] One should remember that these 1200 keV γ-rays are very weak (~ 1%) and could represent somewhat slower links between faster decays at both higher and lower spins. Thus, they need not be similar to the average continuum γ-ray. On the other hand, the 1200 keV lifetimes are based on an assumed feeding correction and could be arbitrarily fast if all the delay is in the feeding. This could solve the 1200 keV problem, but would probably create a similar one higher up.

It will be interesting to measure both the 1200 keV γ rays and the average continuum γ rays more accurately to see if a discrepancy really exists.

We feel that the observation of fast and slow feeding pathways in ^{158}Er is an exciting result. It provides the best evidence to date that there is a

change to oblate (or at least strongly triaxial) shapes at high spin in ^{158}Er. And, at the same time, it strongly suggests that there are also decay pathways that do not go through such shapes. Perhaps most importantly, it gives us experimental access to study sparately resolved lines associated with the two types of feeding.

4. LIFETIMES OF ROTATIONAL STATES

The strength of collective E2 transitions, B(E2), is an interesting quantity because it is related to the shape (γ) and deformation (β) of the nucleus. For a rigid triaxial nucleus:

$$B(E2) \propto \beta^2 \cos^2 (\gamma + 30^\circ). \qquad (1)$$

Although one obviously cannot determine both β and γ from a knowledge of B(E2) values alone (even under the assumption of rigid shapes), nevertheless they provide strong clues as to how the nucleus is changing. Also one can often use them together with other information, whether experimental or theoretical, to determine the probable nuclear shape parameters.

There are two well known methods to measure the lifetimes of nuclear rotational states from which the B(E2) values may be determined. These are the recoil-distance method (RDM) and the doppler shift attenuation method (DSAM). Both make use of the Doppler shifted γ rays emitted by a nucleus recoiling after a nuclear reaction of some type. In the former method a foil is placed at a controllable distance from the target in order to stop (or slow down) the recoiling nucleus. The fraction of γ rays emitted from stopped (slowed) nuclei vs. those emitted in flight (unslowed), as a function of the foil to target distance, gives the lifetime of the emitting state. The range of lifetimes that can be studied by the RDM method for usual recoil velocities extends from ~ 1 ns (flight distance ~ 1 cm) to ~ 1 ps (flight distance ~ 10 μm), though values three or four times shorter have recently been measured by the GSI group.[20] In the DSAM method one places the stopping foil directly against the target, as a backing, and determines the lifetime from the detailed γ-ray line shape. This method is suitable for measuring faster lifetimes than the RDM method, the range being from ~ 1 ps (the stopping time) to ~ 10 fs (the time for a measurable velocity change). The two methods together cover about the full range of rotational lifetimes in rare earth nuclei with the ~ 1 ps boundary between them corresponding to $I \sim 20\hbar$.

We have used the DSAM method,[21] but with spectra gated by one or a few carefully selected γ rays. The advantage of using coincidences is that the

spectra are very much cleaner, so that the line shapes can be better determined. The different bands in a nucleus can be studied separately by using different gates. Until now the DSAM method has essentially not been used for measuring lifetimes of high-spin because the spectra were not sufficiently clean. We believe the coincidence method will make it possible to study lifetimes of all the high-spin states giving rise to resolved γ rays. The present report is on preliminary results from yrast bands in ^{166}Yb.

In the present work we bombarded both gold-backed and unbacked targets of ^{130}Te with ^{40}Ar ions of 175 MeV. We selected clean gating transitions for each band that were at low enough energy (slow enough) to be stopped in the gold backing, giving sharp lines from both types of target. The data from the backed target were sorted into eight groups, within which the detectors were at (Doppler) equivalent angles to the beam direction. The most forward (~ 40°) and most backward (~ 140°) spectra for the yrast sequence are shown in Fig. 8. A detailed line-fitting technique is being developed to fit the line shapes (including feeding times), but no results are available yet. However, one can simply take the centroid of the forward and backward component of the same peak and calculate the average Doppler shift. The difference in average Doppler shifts between adjacent lines is just the mean time between emission of the two rays, or the intermediate state lifetime. Analyzing the 32 → 30, 30 → 28, and 28 → 26 γ rays in Fig. 8 gives

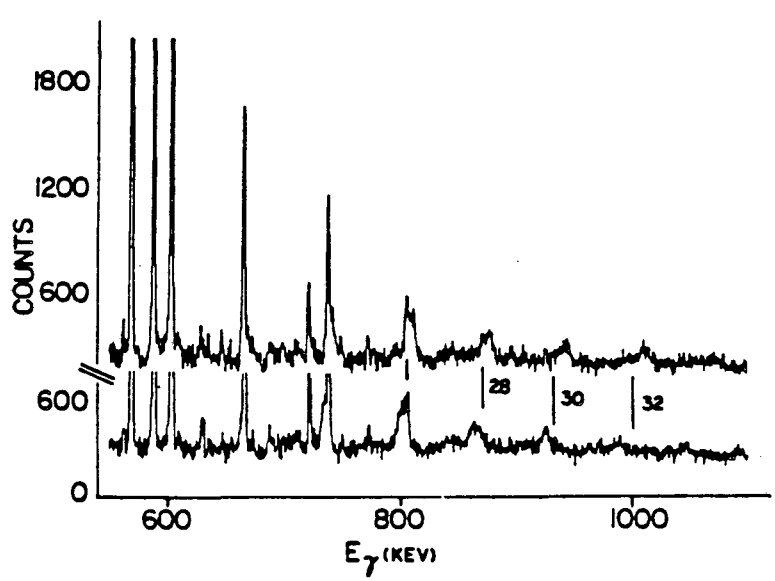

Fig. 8 Spectra gated on the yrast cascade of ^{166}Yb. The upper spectrum was taken in forward detectors and the lower in backward ones. Unshifted positions are shown for several γ rays, and the upper spins are given for three of them.

$B(E2)/B(E2)_{sp}$ = 82 and 89 for the 30^+ and 28^+ states, respectively. We have used a slowing-down behavior over the range of interest having the form $v = v_o e^{-t/t_o}$, where t_o is taken to be 0.5 ps for Yb in gold.[17]

The principal uncertainty is due to the side feeding, which is ~ 25% for these states, and whose average time distribution is assumed to be the same as that for the main sequence. Note, however, that the main sequence feeding time plays no role. Better results with realistic uncertainties must await the fitting procedures underway.

The B(E2) values measured are quite low. For well deformed nuclei at low spins $B(E2)/B(E2)_{sp} \approx 200$, so that for ^{166}Yb at spins around 30ħ the values are much reduced. These indicate large deformation or shape changes (a factor of ~ 2 in β if γ remains near 0°, or a γ value of 30–40° if β remains fixed). The true situation is probably some combination of these. Indications of low collectivity have been seen in some other nearby nuclei. Lifetimes up to the 26^+ state in ^{158}Dy have been measured,[20] and the last two of these are about the same and correspond to $B(E2)/B(E2)_{sp}$ = 110. Lifetimes up to the 30^+ level were measured[20] in ^{156}Dy, with the 30^+ and 28^+ states giving an average of $B(E2)/B(E2)_{sp}$ = 85. Another low value[22] in this mass range is for the 22^+ states in ^{160}Yb, where $B(E2)/B(E2)_{sp}$ is around 55.

In general for the lighter nuclei in this region one can understand low B(E2) values at high spins. The aligned quasi particles lie mainly in the equatorial plane (oblate relative to the rotation axis) and tend to polarize the nucleus, giving a triaxial shape (γ positive) that should reduce the B(E2) values. The limit for such polarization would be an oblate shape rotating about its symmetry axis, which has no collective B(E2) values at all. Cranked shell model (CSM) calculations[11-13,23] can reproduce this behavior for some nuclei. However, for ^{166}Yb, the aligning quasi particles have a significant hole character (as well as particle) and the polarizing effect is expected to be less. At the same time, the nuclei becomes stiffer. Aberg's CSM calculation[23] for ^{166}Yb do not show much reduction in the B(E2) values at I ~ 30ħ for the cases studied here.

In conclusion, we believe the DSAM method for lifetimes on coincidence spectra will open up the measurement of states having I > 30ħ. This is a very interesting region where large changes are sometimes predicted and also sometimes observed. It is not yet clear, however, that these "times"

coincide. Our first tentative steps into these measurements seem to produce some puzzling results.

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