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Table of Superdeformed Nuclear Bands and Fission Isomers

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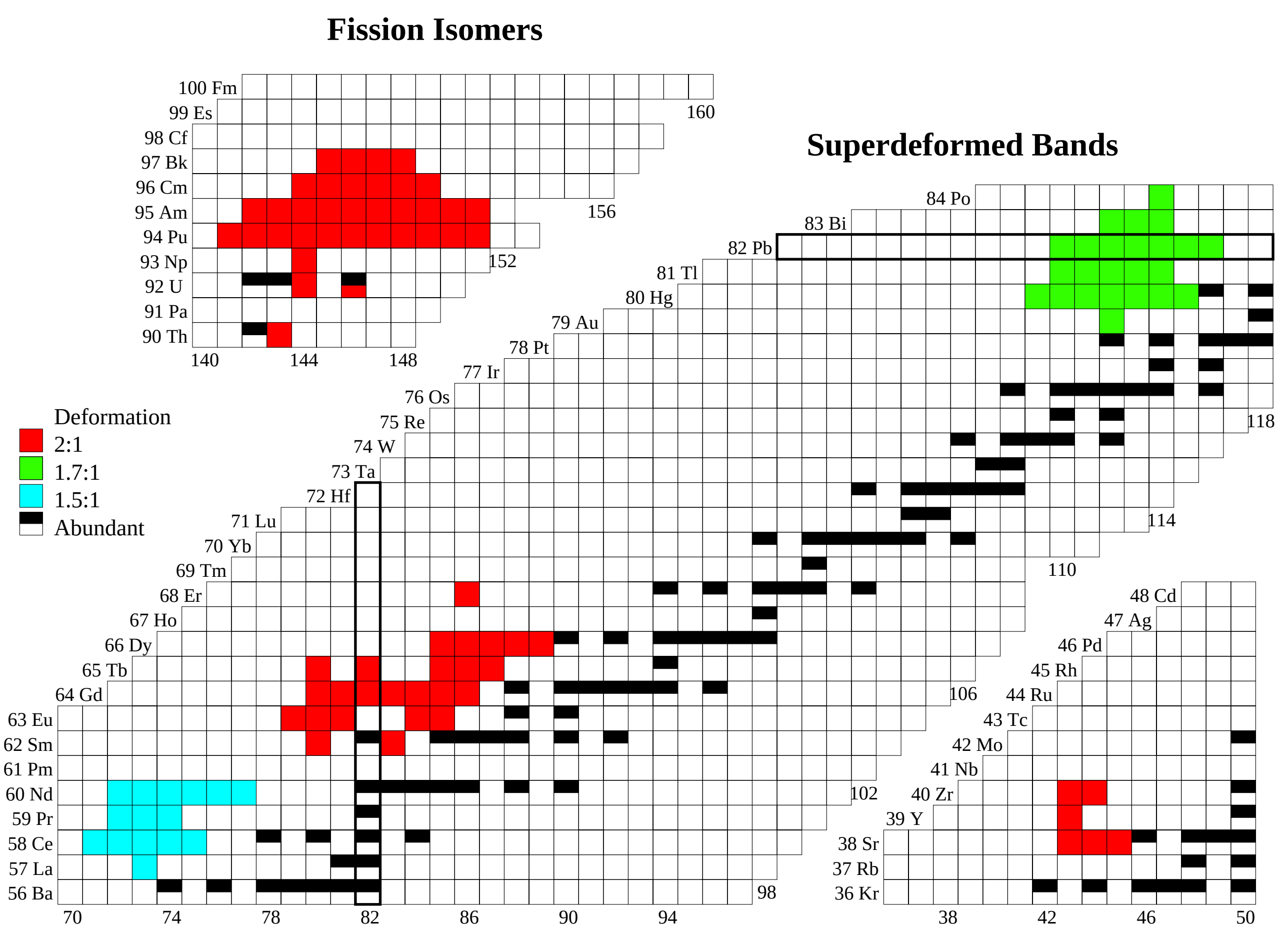

Introduction

A minimum in the second potential well of deformed nuclei was predicted by Strutinsky[1], and the associated shell gaps are illustrated in the harmonic oscillator potential shell energy surface calculations shown in the figure[2,3]. A strong superdeformed minimum in ^{152}Dy was predicted for β_2~0.65[4,5,6]. Subsequently, a discrete set of γ-ray transitions in ^{152}Dy was observed[7] and assigned to the predicted superdeformed band. Extensive research at several laboratories has since focused on searching for other mass regions of large deformation[8-12]. A new generation of γ-ray detector arrays (Gammasphere, Eurogam, and GASP) is already producing a wealth of information about the mechanisms for feeding and deexciting superdeformed bands. These bands have been found in four distinct regions near A=80, 130, 150, and 190. This research extends upon previous work in the actinide region near A=240 where fission (shape) isomers were identified and also associated with the second potential well[13]. A third strong hyperdeformed minimum at β_2~0.9 is also indicated in the figure and has recently been tentatively reported in ^{153}Dy[14,15]. Hyperdeformed bands reported in ^{147}Gd[16] were not confirmed at the Gammasphere Dedication Conference at Berkeley in December, 1995. Quadrupole moment measurements for selected cases in each mass region are consistent with assigning the bands to excitations in the second local minimum.

As part of our committment to maintain nuclear structure data as current as possible in the Evaluated Nuclear Structure Reference File (ENSDF)[17] and the *Table of Isotopes*[18], we have been updating the information on superdeformed and hyperdeformed nuclear bands. As of February, 1996, we have compiled data for 161 superdeformed bands and 47 fission isomers identified in 93 nuclides for this publication. This is an increase of 75 superdeformed bands and 20 new nuclides since the first edition in 1994[19]. Partial data for superdeformed bands and fission isomers are shown in the band drawings.

For each nuclide there is a complete level table listing both normal (taken from the ENSDF file) and superdeformed band assignments; level energy, spin, parity, half-life, magnetic moments, decay branchings; and the energies, final levels, relative intensities, multipolarities, and mixing ratios for transitions deexciting each level. Mass excess, decay energies, and proton and neutron separation energies are also provided from the evaluation of Audi and Wapstra [20].

For superdeformed and hyperdeformed bands we provide the following quantities.

Level energies: For SD bands, since the absolute level energies are not yet known, only relative values are given. In the drawings the SD bands are shown with a common baseline for convenient display of multiple bands in a nucleus.

Level half-lives: Measured values are quoted in the tables only.

Level spins: The spin value is generally given only for the first member of the SD band. This value is typically suggested by the authors and has some uncertainty (~1-2 ħ) associated with it. Since linking to normal states is mostly unobserved, except for assignments in ^{133,135,137}Nd, ^{194}Hg, and ^{194}Pb, there is no direct confirmation of these spins. The cascading transitions are all assumed as E2 which is consistent with angular correlation data and short level half-lives in several cases. The parities are not generally shown because of insufficient evidence at this time.

γ-ray energies: The energies are adopted from the most complete set of data for each band. We have not averaged values because uncertainties are not usually available. Typical energy uncertainties range from 0.1-0.3 keV for intense transitions to 1 kev for weaker γ-rays.

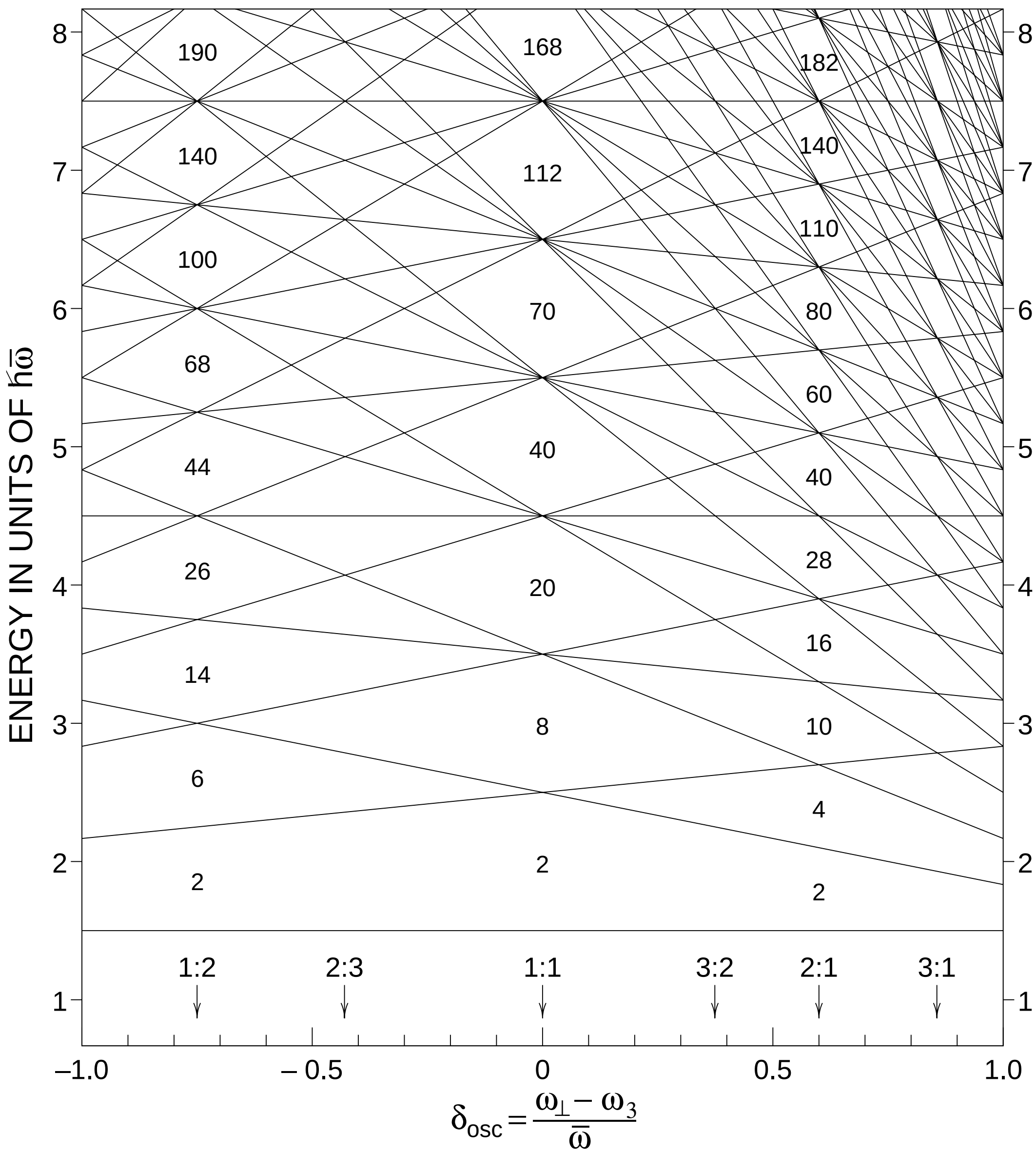

Figure Single-particle level energies calculated for an axially symmetric harmonic oscillator (from reference 2).

γ-ray intensities: The values given are total relative intensities normalized to ~1.0 for the most intense transition in a superdeformed band or, for multiple bands, to the most intense transition in the superdeformed band. These values are typically read off of the intensity figures in the papers. Correction for internal conversion is assumed to have been applied by the authors. When more than one measurement exists, the most complete set of intensities has been chosen. Absolute intensities can be obtained by multiplying the relative intensities by the %-feeding in Table I.

Moments: Transition Quadrupole moments for SD states are deduced from Doppler broadening of γ-rays. The SD quadrupole moment is typically an average value for the band corresponding to the intrinsic (transition) moment. For fission isomers the quadrupole moments are also intrinsic. The values appear in the summary tables only.

The following calculated quantities[21,22] are provided (E_γ in MeV):

Rotational frequency:

$$\hbar\omega(J)=\frac{E_\gamma((J+2)\rightarrow J)+(E_\gamma(J\rightarrow(J-2))}{4}\quad MeV$$

Kinetic moment of inertia[†]:

$$I^{(1)}(J)=\frac{4J}{E_{\gamma<}((J+2)\rightarrow J)+E_\gamma(J\rightarrow(J-2))}\quad \hbar^2 MeV^{-1}$$

Dynamic moment of inertia:

$$I^{(2)}(J)=\frac{4}{E_\gamma((J+2)\rightarrow J)-E_\gamma(J\rightarrow(J-2))}\quad \hbar^2 Mev^{-1}$$

The dynamic moments of inertia have been plotted as a function of rotational frequency at the beginning of the data section, and their values are also tabulated in the data tables.

We have not attempted to label bands according to particle or intruder configurations or according to their isospectral behavior. The reader is referred to the original papers for information about reactions populating these bands and fission isomers. References with keyword abstracts have been provided from the Nuclear Structure Reference (NSR) file[23]. They are divided into three sections for fission isomers, superdeformed band theory, and superdeformed band experimental. The theoretical references before 1986 were not completely scanned for superdeformation.

We express our gratitude to the many nuclear data evaluators for creating the ENSDF file, to the staff at the National Nuclear Data Center at Brookhaven National Laboratory for maintaining ENSDF, and to Dr. Murray Martin for providing a thorough review of this work. Many useful suggestions were provided by members of the high-spin physics groups at Lawrence Berkeley National Laboratory, McMaster University, and Oak Ridge National Laboratory, and numerous other researchers in the field. This work was supported by the Director, Office of Energy Research, Office of High-Energy and Nuclear Physics, Nuclear Physics Division of the U.S. Department of Energy under contract DE-AC03-76SF00098, subcontract LBNL no. 4573810; and by the Natural Sciences and Engineering Research Council (NSERC) of Canada.

[†]Approximate since spins are uncertain.

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