OAK RIDGE National Laboratory

Systematics of Alpha Decay Hindrance Factors and Configurations?

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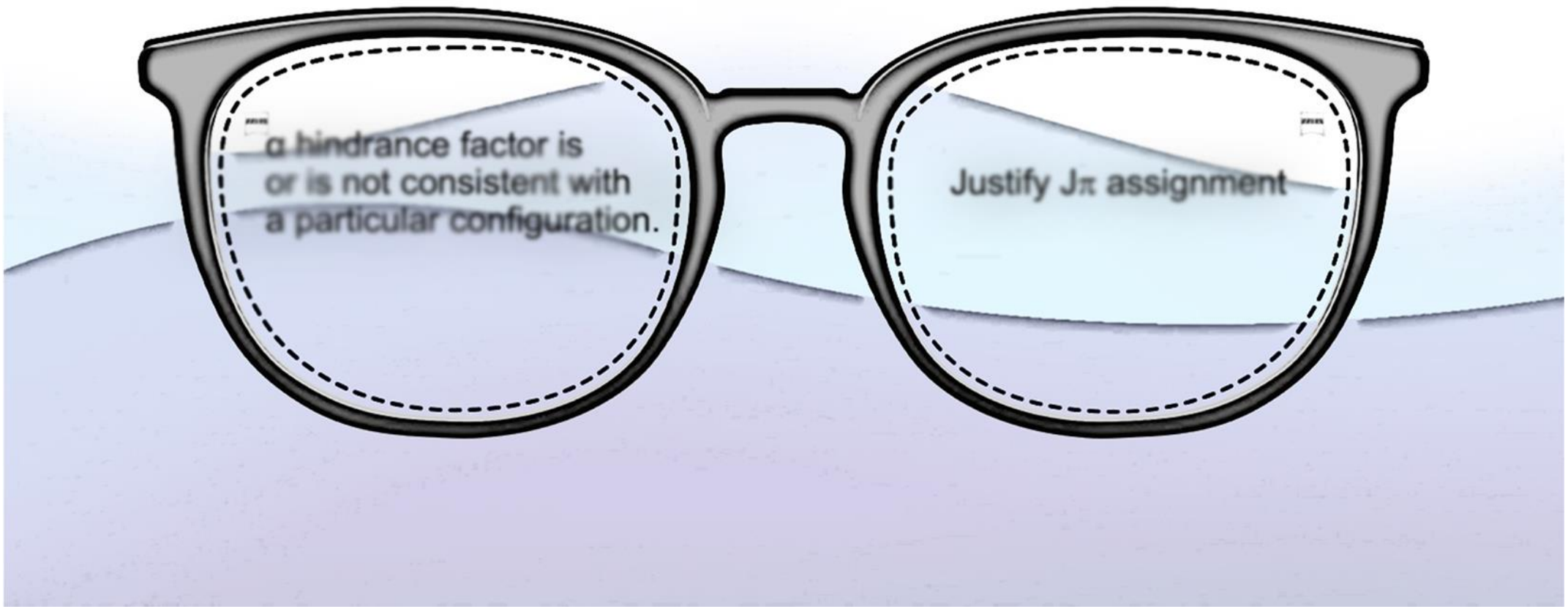
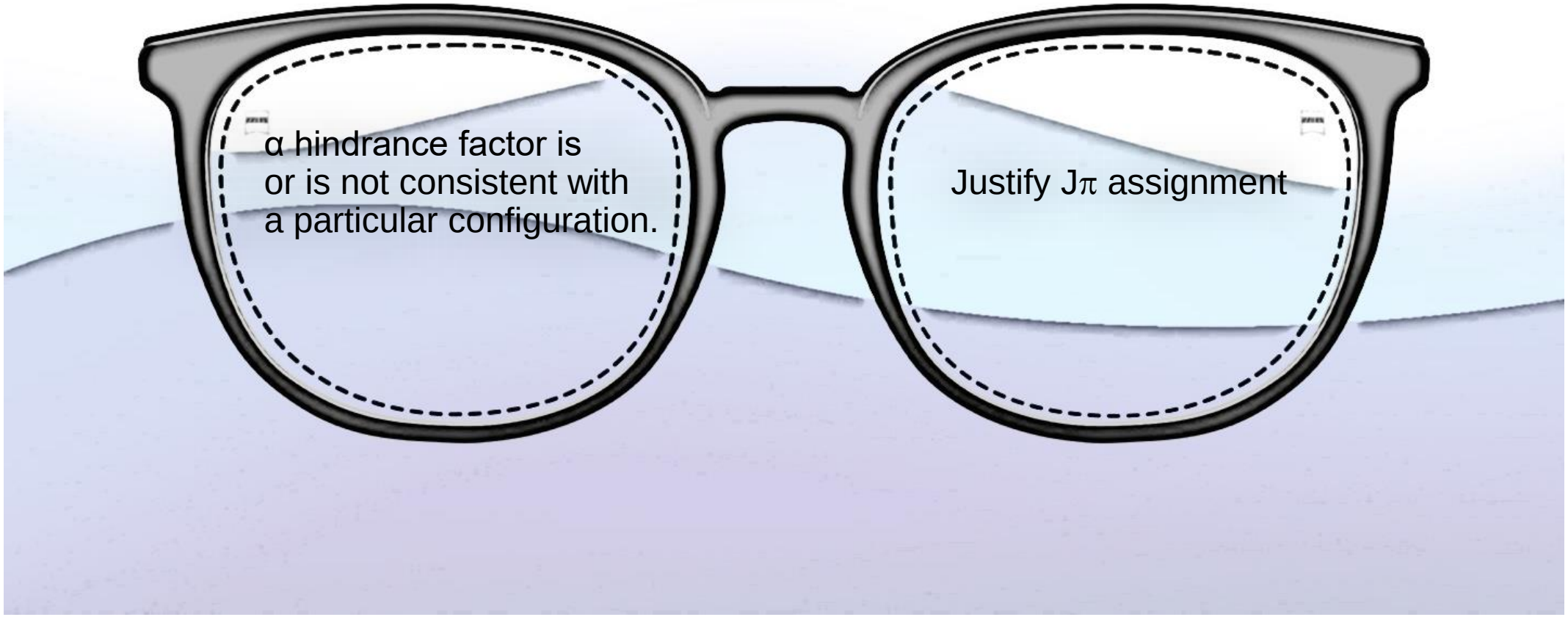
U.S. DEPARTMENT OF ENERGY

Systematics of alpha HF to deduce configurations and Jπ : No clear guidance



Systematics of alpha HF to deduce configurations and Jπ : Need guidance from experts in alpha decay and configuration



^{248}Bk: Adopted Levels (2014Ma86)

$^{248}_{97}Bk_{151}$-I

From ENSDF - Evaluated September 2014

Adopted Levels, Gammas

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	M. J. Martin	NDS 122, 377 (2014)	1-Sep-2014

Q(β^-)=841 *SY*; S(n)=5481 *SY*; S(p)=4743 *SY*; Q(α)=5775 *SY* 2012Wa38
The systematics uncertainty is 71 keV for all four entries.

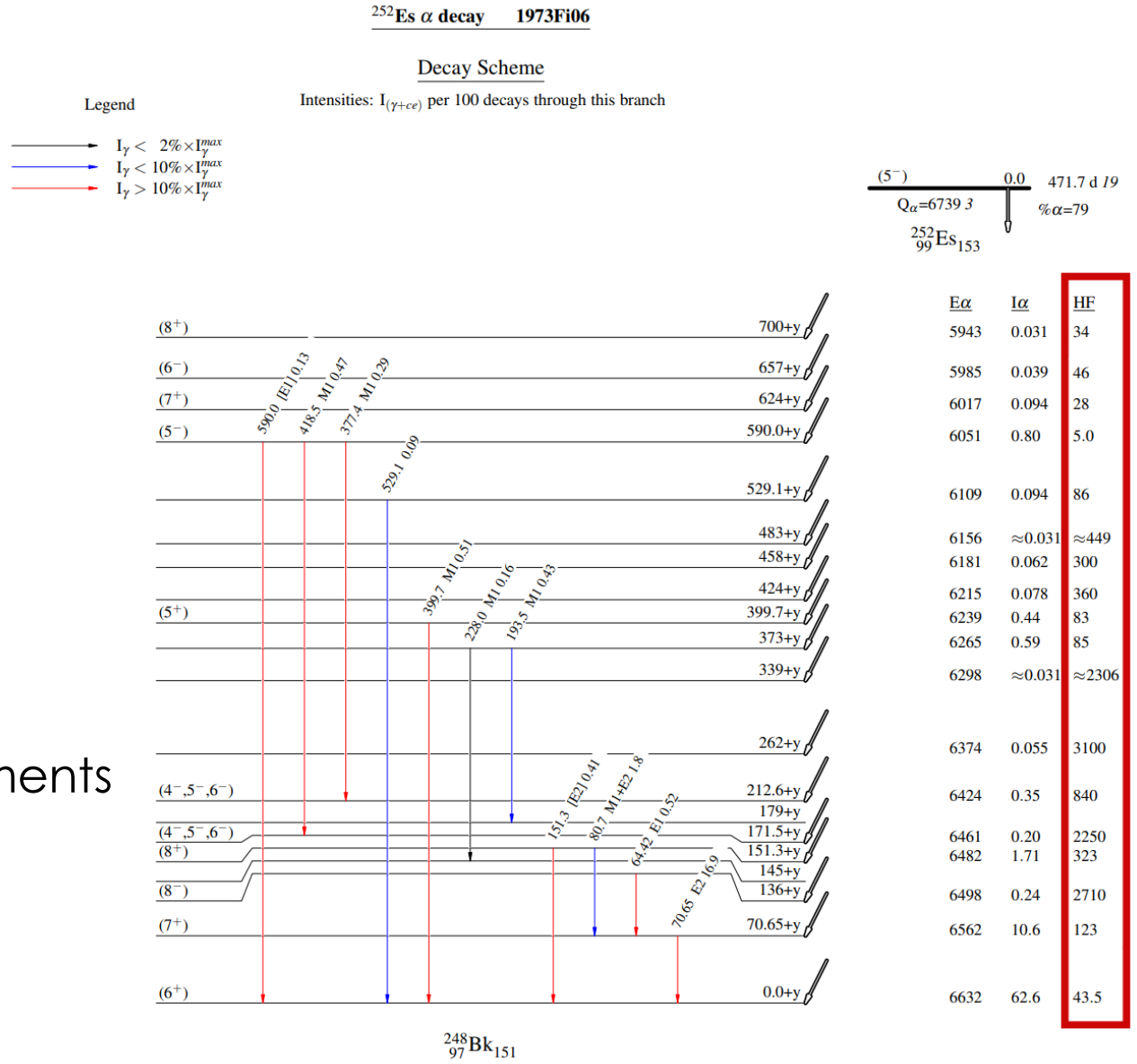
^{248}Bk Levels

Cross Reference (XREF) Flags

A ^{252}Es α decay

Several Jπ arguments supported by statements such as

"The α hindrance factor is consistent with the configuration"



^{252}Es α decay

^{248}Bk: from ENSDF Adopted Levels (2014Ma86)

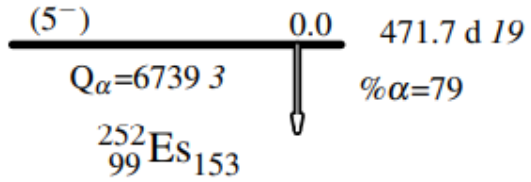
Odd Z, Odd N

Hindrance factor

from ^{252}Es α decay

Parent: ^{252}Es

Possible configuration
π3/2 [521]⊗ν7/2 +[613]



Kπ=6+, π3/2[521]⊗ν9/2[734]

E(level)	Jp	Configuration	HF	Comment
0.0+y	(6+)	π3/2[521]⊗ν9/2[734]	43.5	HF consistent with config.
70.65+y	(7+)		123	HF consistent with asgmt.
151.3+y	(8+)		323	HF consistent with asgmt.

^{248}Bk: from ENSDF Adopted Levels (2014Ma86)

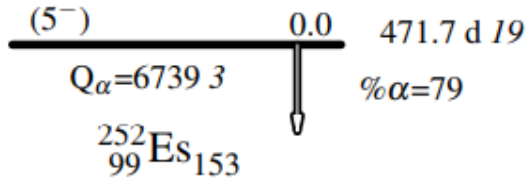
Odd Z, Odd N

Hindrance factor

from ^{252}Es α decay

Parent: ^{252}Es

Possible configuration
π3/2 [521]⊗ν7/2 +[613]



Kπ=5-, π3/2[521]⊗ν7/2[613]

E(level)	Jp	Configuration	HF	Comment
590.0+y	(5-)	p3/2[521]⊗n7/2[613]	5	HF consistent with config.
657+y	(6-)		46	HF consistent with asgmt.

^{248}Bk: from ENSDF Adopted Levels (2014Ma86)

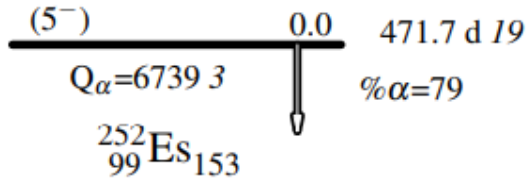
Odd Z, Odd N

Hindrance factor

from ^{252}Es α decay

Parent: ^{252}Es

Possible configuration
π3/2 [521]⊗ν7/2 +[613]



Kπ=7+, π7/2[633]⊗ν7/2[613]

E(level)	Jp	Configuration	HF	Comment
624+y	(7+)	π7/2[633]⊗ν7/2[613]	28	HF consistent with asgmt.
700+y	(8+)		34	HF consistent with asgmt.

^{248}Bk: from ENSDF Adopted Levels (2014Ma86)

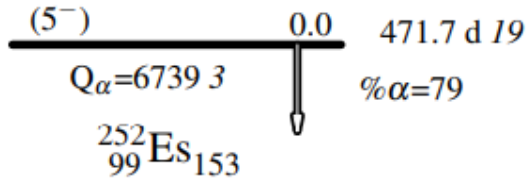
Odd Z, Odd N

Hindrance factor

from ^{252}Es α decay

Parent: ^{252}Es

Possible configuration
π3/2 [521]⊗ν7/2 +[613]



Alpha HF is NOT consistent with configuration

E(level)	Jp	Configuration	HF	Comment
136+y	(7+)	π7/2[633]⊗ν9/2[613]	2710	HF not consistent with config. HF should be larger
171.5+y	(4-)?	π3/2[521]⊗ν5/2[622]?	2250	HF not consistent with config. HF should be a factor 100 smaller

Nuclear Data Sheets General Policy

…A survey of the dependence of α-hindrance factors on asymptotic quantum numbers and the variation of α-hindrance factors within rotational bands is given for A≥229 in 1972El21

Survey of
Nuclear Structure Systematics for A ≥ 229*

Y. A. ELLIS and M. R. SCHMORAK
Oak Ridge National Laboratory, Oak Ridge, Tennessee 37830

Abstract: Log *ft* values for β- and ε-transitions and experimental hindrance factors for α-decays are presented for the A ≥ 229 mass region in a systematic way. For some favored and hindered α-transitions, comparisons of experimental hindrance factors with theoretical calculations are made. Band-head energies and rotational band parameters are given. Measured magnetic moments of odd-A nuclei are compared with those calculated using Nilsson wavefunctions. Experimental B(E2)↑ values to first 2^+ states in even-even nuclei are plotted as a function of mass number.

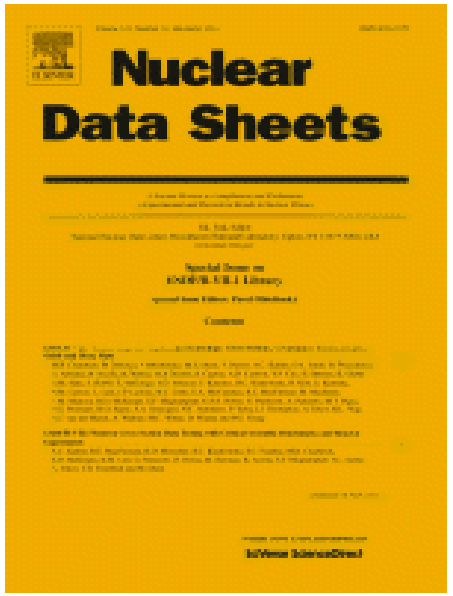
Acknowledgments: The compilers would like to thank D. J. Horen for his encouragement; and M. E. Bunker, S. G. Nilsson, C. W. Reich, and A. Wapstra for useful suggestions.

Summary of Bases for Spin and Parity Assignments

#35 Alpha Decay

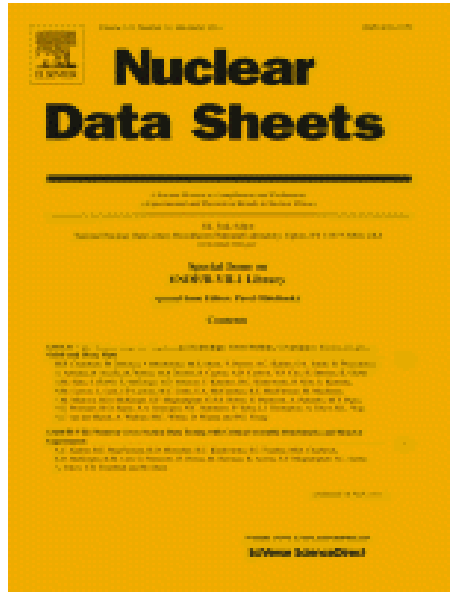
Observation of a "favored" α transition (HF<4) indicates that the two states involved have the same nucleonic configuration.

If a sequence of levels having "rotational-like" energy spacings is associated with the level fed by this favored transition and these levels have HF's that vary according to the established trend within rotational bands (1972El21), then this sequence can be considered to form a rotational band whose nucleonic configuration is the same as that of the alpha-decaying state.



Summary of Bases for Spin and Parity Assignments

#38 Alpha Decay



The hindrance factor for an α transition from the ground state of an even-even nucleus to the ground state of the daughter nucleus is 1.0 by definition.

For odd-A and odd-odd nuclei, hindrance factors <4 identify favored α transitions, and these connect states having the same spin, parity and configuration.

Jπ assignment using α HF and configuration systematics

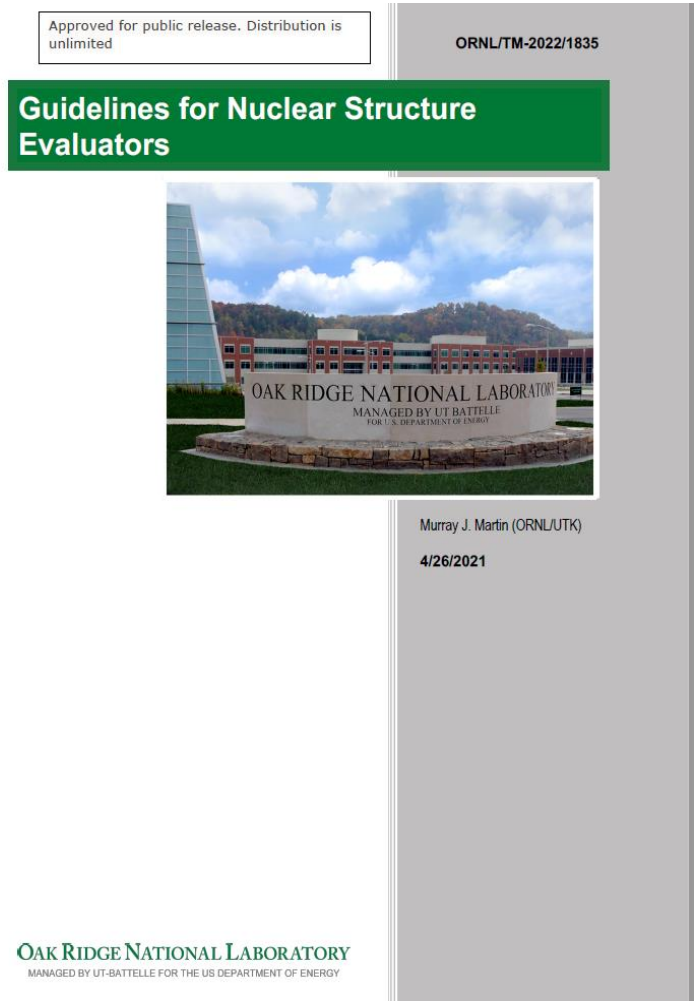
Guidelines for Nuclear Structure Evaluators by M. Martin

Systematics of alpha-decay hindrance factors can be used to deduce a variety of quantities, depending on what is known about a particular decay branch.

These quantities include Jπ and configurations, total alpha branching and branchings of individual groups, and the excitation energy of the level fed in the daughter nucleus.

See 1980Sc26* for a further discussion of these and other types of Systematics

It is clear from 1972El21 that in the deformed actinide region, all rotational bands have very characteristic alpha hindrance factor



A few examples of nuclides that use alpha HF arguments currently in the ENSDF database

Nuclide	Jπ		HF	Comment
^{226}Th	4+	^{230}U α decay Jπ (parent) =0+	12	HF consistent with Jπ.
^{226}Ra	(7+)	^{230}Th α decay Jπ (parent) =0+	~6.2	HF consistent with asgmt.
^{221}Ra	(7/2+)	^{225}Th α decay Jπ (parent) =3/2+	~213	HF consistent with being member of g.s. band
^{250}Bk	(4+)	^{254}Es α decay Jπ (parent) =(7+)	2190	HF consistent with asgmt. and config.
^{250}Bk	(5-)	^{254}Es α decay Jπ (parent) =(7+)	144	HF consistent with asgmt. and config.
^{250}Bk	(6-)	^{254}Es α decay Jπ (parent) =(7+)	160	HF consistent with asgmt. and config.
^{250}Bk	(3-)	^{254}Es α decay Jπ (parent) =(7+)	2350	HF consistent with asgmt. and config.

Other information

Presentation Material available online by Ch. Theisen

Empirical HF values

- HF = 1-4 : same initial and final single-particle state
- HF = 4-10 : similar initial and final states
- HF = 10-100 : different single particle states, same parity, same spin projection
- HF = 100-1000 : different single particle states, parity change, same spin projection
- HF > 1000 : different single particle states, parity change, spin flip

One needs a lot of statistics to observe a transition with a change of parity or spin flip

dapnia SPhN cea saclay

Alpha decay and Hindrance Factor

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Is this something that anyone is familiar with?
Can these be used to guide us in assigning Jπ?