# Demonstration of Original Alphad and Revised Alphad (Alphad +RadD)

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# Deduction of Radius Parameter

## Using RadD program

**RadD** https://www-nds.iaea.org/public/ensdf_pgm/analysis/radd/RadD.for

This RadD Program deduces the radius parameter ($r_0$) for Odd-Odd and Odd-A nuclei using the even-even radii of Y.A. Akovali [Nuclear Data Sheets, 84 (1998) 1], as input parameters. (Example: 217Po (Z=84, N=133))

Deduced radius parameter of even-odd, odd-even and odd-odd are also available in tabular form: (https://www-nds.iaea.org/public/ensdf_pgm/analysis/radd)

| | |
|---|---|
| Table 1: Even-Z, Odd-N | Table 3: Odd-Z, Odd-N |
| Table 2: Odd-Z, Even-N | Table 4: Even-Z, Even-N |

M.J. Martin (ENSDF Procedure

# ALPHAD (http://www.nndc.bnl.gov/nndcscr/ensdf_pgm/analysis/alphad/)

- This program calculates the alpha hindrance factors, theoretical half-lives and, for even-even ground state to ground state transitions, $R_0$ using Preston's spin-independent equations M.A. Preston, Phys. Rev. 71 (1947) 865.
- The hindrance factors and theoretical half-lives can be calculated for odd-odd and odd-A nuclei, provided that

$R_0$'s may be specified on an ALPHA comment record by "HF" in columns 10 and 11 and a dollar sign ("$") in column 12 or blanks in columns 12 through 19. The first value and uncertainty in columns 20 through 80 preceded by an R (" R"; case insensitive) and an equal sign ("=") or approximate sign (" AP ") will be taken as $R_0$.

## Sample ENSDF record pertains to radius parameter

222AC cA HF$ r{-0}({+222}Ac)=1.536 {I4} is used in calculations.

# Test Demonstrations: Original ALPHAD

**Alphad.exe**

Input Files

210Ra (Z=88, N=122)

217Po (Z=84, N=133)

194Bi (Z=83, N=111)

Output /Report Files

Output File

Report File

**Odd-odd and Odd-A nuclides**

- An evaluator has to deduce the radius parameter and then insert this radius parameter in alpha-decay data set with predefined ENSDF format.

**Even-even nuclides**

- The value of radius parameter obtained through ALPHAD program is only printed in alpahd report file, but not in alphad output file. The evaluator should insert this value in alpha-decay data to ensure its completeness.

## Revised Alphad (Alphad+RadD)

- **RadD code is appended in ALPHAD and this** revised ALPHAD (ALPHAD+ RadD) automatically calculates radius parameter and then use this radius parameter for further calculations.

- We have **NOT** **changed the logic of ALPHAD program** as **we used our own local variables,** which are different from the variables already used in the original ALPHAD.

## Features added in ALPHAD

### Even-Even nuclides

- For even –even nuclei, the earlier ALPHAD code prints radius parameter only in ALPHAD report file but not in ALPHAD output file. **The revised ALPHAD prints radius parameter in report as well as output file** to indicate what value of radius parameter has been used for calculation of HFs of even-even nuclei.

### Odd-Odd and Odd-A nuclides

- In case of **earlier ALPHAD code, we have to insert radius parameter in an ENSDF file** and then ALPHAD code deduced HFs, but now with the help of revised ALPHAD code, there is no need to give radius parameter for odd-odd and odd-A nuclides. The revised **ALPHAD** will automatically deduces radius parameter (using even-even radius parameters as inputs) and then calculate HFs and also write this deduced radius parameter value in the ENSDF output file.

The **comment lines about the value of radius parameter will appear just above the normalization record of a ENSDF dataset**. Hence, the position of lines containing radius parameter value is fixed in output files generated through revised ALPHAD code.

## Features added in ALPHAD

- Evaluator can give his/her own radius parameter for odd-odd and Odd-A nuclides .

- The format in which radius parameters is being written in the output file of revised ALPHAD code is same as given by evaluators in input ENSDFs of earlier ALPHAD code.

- An ENSDF alpha decay datasets executed through revised ALPHAD code, will have radius parameter as there are ~ 34 even-even datasets available in ENSDF database where radius parameter is not listed.

# Test Demonstrations

Input Files

210Ra

217Po

194Bi

218Ac

**Revised Alphad.exe**

Output /Report Files

Output File

Report File

# Status of update of 1998AK04 table of radius

- There are total 154 even-even nuclides for which radius parameters are available in 1998AK04
- But according to our recent survey of ENSDF & XUNDL data bases, presently there are total ~200 even-even alpha decay data sets for which radius parameter could be obtained.
- In addition to these newly observed ~46 new even-even nuclides, the radius parameters available in 1998Ak04 will also be modified due to major changes appeared in following quantities.
    - New and improved data for Q values
    - Half-lives of alpha-decaying even-even parent nuclei
    - alpha-decay branching ratios

**Present Status**

We have updated ~135 nuclides and first set of nuclides, containing updated systems and procedure applied for updation, has been given to Dr. Balraj for his comments and suggestions. We are expecting to complete this updation at the

# Working Example : Deduce the radius parameter of At (Z=85, N=117)

**Deduction procedure[1]**

**Input Data**

The radius of a given odd-odd nuclide $(Z,N)$ is deduced from the radii of odd-even nuclei $(Z,N-1)$ and $(Z,N+1)$ as follows:

**Step 1**: Deduce the radius of $(Z,N-1)$ by taking unweighted average of radius parameters of even-even nuclides namely $(Z-1,N-1)$ and $(Z+1,N-1)$.

**Step 2**: Deduce radius of $(Z,N+1)$ by taking unweighted average of radius parameters of even-even nuclides namely $(Z-1,N+1)$ and $(Z+1,N+1)$.

**Step 3**: Take unweighted average of odd-even radii obtained in steps 1 and 2 above, to get the required radius of a given odd-odd nuclide.

**[1] M.J. Martin, Calculation of radius parameter ($r_0$)for Odd-A and Odd-Odd nuclides (2007).**

Execute original Alphad and generate report and output file

Format

$R_0$'s may be specified on an ALPHA comment record by "HF" in columns 10 and 11 and a dollar sign ("$") in column 12 or blanks in columns 12 through 19. The first value and uncertainty in columns 20 through 80 preceded by an R (" R"; case insensitive) and an equal sign ("=") or approximate sign (" AP ") will be taken as $R_0$.

Sample record

**202AT cA HF$ r{-0}({+202}At)=1.5045 {I80} is used in calculations.**

# Thanks a lot for your attention !

## Solution

Radius parameter for ${}^{202}_{85}At$: In order to deduce the radius parameter of odd-odd ${}^{202}_{85}At$ nuclide, first deduce the radii of odd-even nuclides ${}^{201}_{85}At$ and ${}^{203}_{85}At$ as described in following steps (Step 1 & 2):

**Step 1:** Radius of ${}^{201}_{85}At$

$$r_0(85,116) = \frac{[r_0(84,116) + r_0(86,116)]}{2} = \frac{1.504_3 + 1.527_8}{2} = 1.5155_{55}$$

**Step 2**: Radius of ${}^{203}_{85}At$

$$r_0(85,118) = \frac{[r_0(84,118) + r_0(86,118)]}{2} = \frac{1.492_7 + 1.495_{14}}{2} = 1.4935_{105}$$

**Step 3**: Finally, the radius of given odd-odd nuclide ${}^{202}_{85}At$ is deduced as unweighted average of odd-even radii of ${}^{201}_{85}At$ and ${}^{203}_{85}At$ nuclides, obtained in step 1 & 2 respectively, i.e.

$$r_0(85,117) = \frac{1.5155_{55} + 1.4935_{105}}{2} = 1.5045_{80}$$

# Hindrance Factor and its significance

It is determined from the ratio of experimental alpha-decay half-lives over calculated half-lives. The value of this factor lies between 1 to 30000 which quantify the hindrance faced by alpha decay under consideration.

**1≤ HF ≤4**

If the hindrance factor is between 1 and 4 , the transition is called a favored transition. In such decays, the emitted alpha particle is assembled from two low lying pairs of nucleons in the parent nucleus, leaving the odd nucleon in its initial orbital.

**4< HF ≤10**

A hindrance factor of 4-10 indicates a mixing or favorable wave function overlap between the initial and final nuclear states involved in the transition

**10< HF ≤100**

Factors of 10-100 indicate that spin projections of the initial and final states are parallel, but the wave function overlap is not favorable.

**100 <HF ≤1000**

Factors of 100-1000 indicate transitions with a change in parity but with projections of initial and final states being parallels.

**1000 < HF**

Hindrance factor of >1000 indicate that the transition involves a parity change and a spin flip, that, the spin projections of the initial and final state are anti-parallel, which requires substantial reorganization of the nucleon in the parent when the alpha is emitted