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# EXTENSION OF THE $^{232}$Th BURNUP CHAIN IN THE WIMSD/4 PROGRAM LIBRARY

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Translated by the IAEA

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## 1. INTRODUCTION

In the WIMSD/4 program library [1] the $^{232}$Th burnup chain ends at $^{234}$U. The purpose of the present work is to extend this chain to $^{236}$U by modifying the $^{234}$U burnup data in the program library.

## 2. $^{232}$Th BURNUP CHAIN

The burnup chains for $^{232}$Th and $^{235}$U available in the WIMSD/4 program library are shown in Fig. 1 by solid lines, while the broken line indicates the change made in the $^{234}$U burnup data. The modifications needed in these data are given in Appendix A.

## 3. RESULTS

In order to analyse the influence of this modification on the behaviour of $k_{inf}$ and $^{235}$U number density as a function of time, we processed the TRX1 [3] problem with the LEOPARD [2] and WIMSD/4 programs, replacing $^{238}$U of the fuel by $^{232}$Th. It was necessary to make an adjustment in the initial number density of $^{235}$U, which was done by processing several times with the WIMSD/4 program in order to make the $k_{inf}$ value of the system slightly supercritical.

Figures 2 and 3 show graphs of $k_{inf}$ and $^{235}$U number density, respectively. These graphs show the results obtained with the WIMSD/4 program, using the old and new libraries, and with LEOPARD. Appendix B gives the input data used for the processing of the LEOPARD and WIMSD/4 programs.

## 4. FINAL COMMENTS

Although this modification needs a thorough analysis, Figs 1 and 2 show an improvement in the values obtained with the WIMSD/4 program and the new library in comparison with those derived from the LEOPARD program. Thus, the production of $^{235}$U by radiative capture of $^{234}$U should be considered in the $^{232}$Th burnup chain.

This improvement shows that the WIMSD/4 program library needs to be revised with a view to updating and inclusion of important materials like $^{237}$Np and $^{237}$U so that the burnup chains can be considered fully.

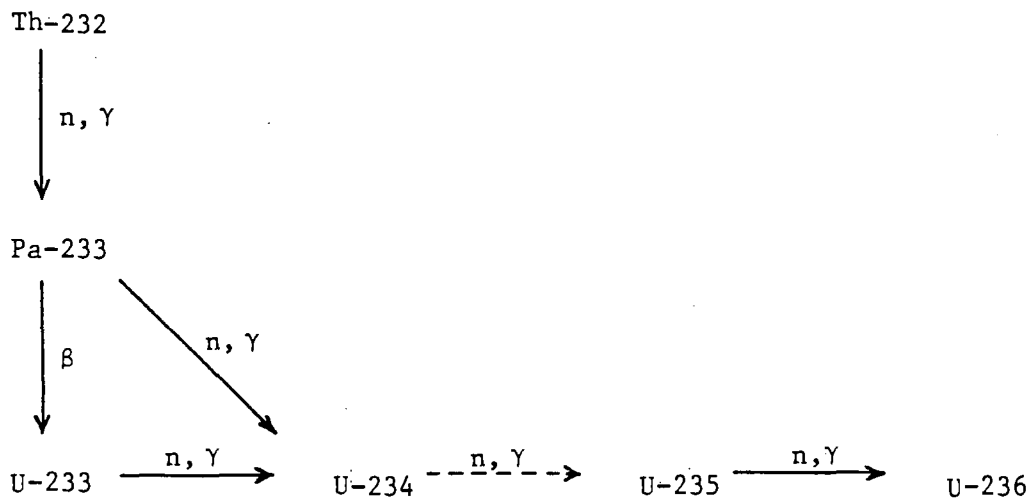


Fig. 1. $^{232}$Th burnup chain.

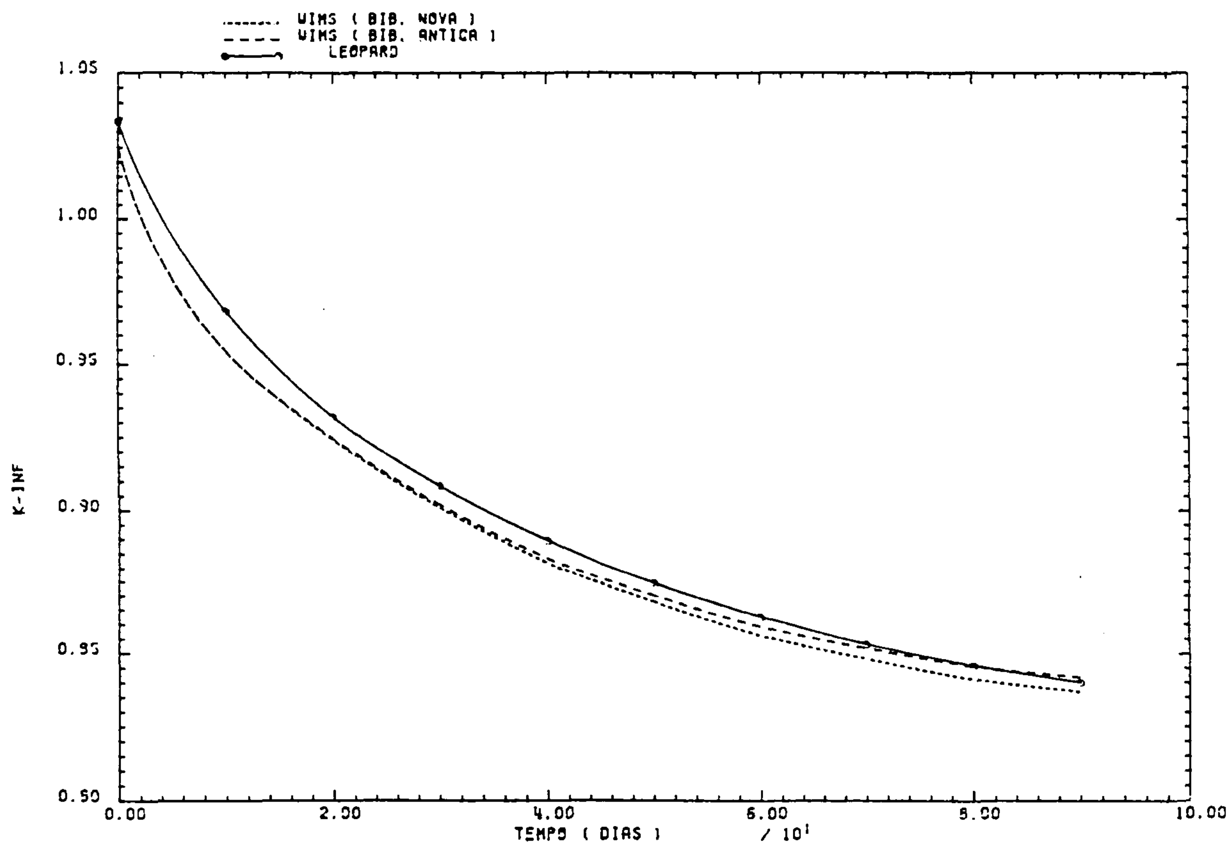


Fig. 2. $k_{inf}$ as a function of time. [Abscissa axis: time (days) ...... ]

- - - - - WIMS (new library)

— — — WIMS (old library)

._______. LEOPARD

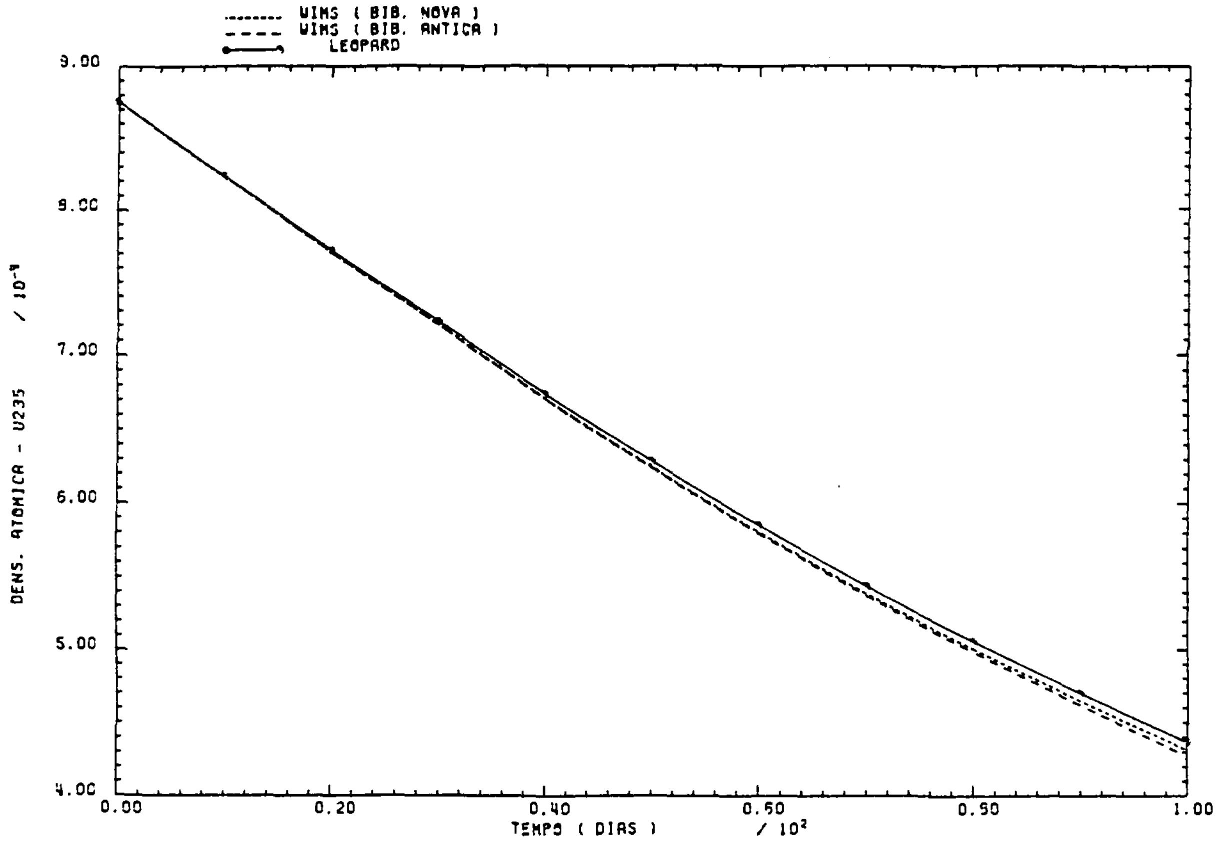


Fig. 3. $^{235}$U number density as a function of time.

[Abscissa axis: time (days); ordinate axis; $^{235}$U number density ...... ]

- - - - - WIMS (new library)

— — — WIMS (old library)

._______. LEOPARD

5. ACKNOWLEDGEMENTS

The author thanks L. Henrique Claro for the results generated by the LEOPARD program and for important discussions on the WIMSD/4 program.

## REFERENCES

[1] ROTH, M.J., MacDOUGALL, J.D., KEMSHELL, P.B., "The Preparation of Input Data for WIMS", AEEW-R538, Atomic Energy Establishment, Winfrith, Dorchester, Dorset, England (1967).

[2] BARRY, R.F., "LEOPARD - A Spectrum Dependent Non-Spatial Depletion Code for the IBM-7094", USAEC Report WCAP-3269-26 (1963).

[3] "Cross Section Evaluation Working Group Benchmark Specifications", BNL 19302, ENDF-202, Brookhaven National Laboratory, Upton, N.Y., USA (1974).


## APPENDIX A

### A.1. $^{234}$U burnup data in the old library

| | |
|---|---|
| | 2 |
| .00000000E+00 | 234 |

### A.2. $^{234}$U burnup data in the new library

| | | | | | |
|---|---|---|---|---|---|
| | 80 | | | | |
| .00000000E+00 | 234 | .10000000E+01 | 235 | .00000000E+00 | 0 |
| .18300000E-10 | 2 | .00000000E+00 | 83 | .00000000E+00 | 95 |
| .00000000E+00 | 99 | .00000000E+00 | 101 | .00000000E+00 | 1103 |
| .00000000E+00 | 103 | .00000000E+00 | 105 | .00000000E+00 | 1105 |
| .00000000E+00 | 108 | .00000000E+00 | 109 | .00000000E+00 | 113 |
| .00000000E+00 | 115 | .00000000E+00 | 127 | .00000000E+00 | 131 |
| .00000000E+00 | 133 | .00000000E+00 | 134 | .00000000E+00 | 135 |
| .00000000E+00 | 1135 | .00000000E+00 | 143 | .00000000E+00 | 145 |
| .00000000E+00 | 147 | .00000000E+00 | 1147 | .00000000E+00 | 2147 |
| .00000000E+00 | 148 | .00000000E+00 | 1148 | .00000000E+00 | 149 |
| .00000000E+00 | 150 | .00000000E+00 | 151 | .00000000E+00 | 152 |
| .00000000E+00 | 153 | .00000000E+00 | 154 | .00000000E+00 | 155 |
| .00000000E+00 | 157 | .00000000E+00 | 902 | .00000000E+00 | 235 |
| .00000000E+00 | 236 | | | | |

APPENDIX B

## B.1. Input data for the LEOPARD program

```
 * * * * * * CELULA TRX-1 + THORIO (TESTE) CTA/IEAV * * * * * *
 1  2  0  1  0  0  0  0  0  0  0  0  0  1  0  0  0  0
         18    8.753E-04         0.0         0.0         0.0
         62  4.72050E-02         0.0         0.0         0.0
          9          0.0 6.02500E-02         0.0         0.0
          2          0.0         0.0   3.338E-02         0.0
          1          0.0         0.0   6.676E-02         0.0
        777          0.0         0.0         0.0         0.0
        777          0.0         0.0         0.0         0.0
     300.00       300.00      300.00      300.00      0.0057
     0.4915       0.5753   1.8060952         0.0         0.0   0.0820313
     2250.0          0.0     10.4076
        1.0      411.209
          1     -900.000
          2     -900.000
          3     -900.000
          4     -900.000
          5     -900.000
          6     -900.000
          7     -900.000
          8     -900.000
          9     -900.000
         10     -900.000
        777          0.0         0.0         0.0         0.0
```

B.2. Input data for the WIMSD/4 program

```
 35000
CELL 6
SEQUENCE 2
NGROUP 18 2
NMESH 8
NREGION 4
NMAT 3 1
NREACT 2
PREOUT
INITIATE
*  TRX1 BENCHMARK
MATERIAL 1 -1 300 1 235.4 8.753E-04 2232.1 4.7205E-02
MATERIAL 2 -1 300 2 27 6.025E-02
MATERIAL 3 -1 300 3 2001 6.676E-02 16 3.338E-02
ANNULUS 1 0.4915 1
ANNULUS 2 0.5042 0
ANNULUS 3 0.5753 2
ANNULUS 4 0.9482 3
REGULAR 1
FEWGROUPS 2 4 6 8 10 12 14 16 18 20 22 24 27 45 55 63 68 69
MESH 3 1 1 3
POWERC 1 90. 10. 10
BEGINC
SIGPUNCH
BUCKLING 0.0 .0057
NOBUCKLING
LEAKAGE 5
THERMAL 4
DIFFUSION 2 3 1
BEEONE -1
DNB 1 0.0 0.0 0.0 0.0
DNB 2 0.0 0.0 0.0 0.0
DNB 3 6.676E-02 0.0 3.338E-02 0.0
REACTION 235.4 300 2232.1 300
PARTITION 45 69
PRINTC 1 1 0 1
BEGINC
```