

On the Anomalous Self-Shielding Factors of U-235 from ENDF/B-VI in the Unresolved Resonance Range

Andrej Trkov

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Problem Specification

Processing ^{235}U from ENDF/B-VI or JEF-2.2 with the UNRESR module of NJOY results in self-shielding factors, which at non-zero temperatures increase and are greater than one with increasing level of self-shielding.

Group averaged cross sections just below the unresolved resonance threshold show a normal behaviour, with self-shielding factors significantly lower than one.

Some effort was invested to check if there is some trivial error in the program. No serious error that would significantly affect the results was found.

Test input and sample output are attached.

Conclusions

The anomaly could be attributed to one of the following:

- A formatting error in the resonance parameters.
- Violation of some assumption in the statistical resonance theory in the case of this particular resonance parameter set.
- An unidentified error in the code.

Sample Input

```
-- U_235a Process U-235
moder / Convert data to binary on Unit-21
1 -21
'JEF-2.2 U-235' /
20 9228
0 /
reconr / Reconstruct x-sect from resonance parameters on Unit-22
-21 -22
'PENDF TAPE FOR U-235 FROM JEF-2.2 '/
9228 2 /
0.002 0. 0.005/ Reconstruction 0.2% (0.5% max)
'92-U-235 FROM JEF-2.2 '/
' PROCESSED BY NJOY-97.45+ '/
0 /
broadr / Doppler broaden to Unit-23
-21 -22 -23
9228 2 0 1 0 /
0.002 /
0. 293.
0 /
unresr / Doppler broaden /self-shield URP data to Unit-24
-21 -23 -24
9228 2 3 1
0. 293.
1.E10 4500. 200. /
0 /
groupr / Generate group averaged data on Unit-25
-21 -24 0 -25
9228 9 0 5 1 2 3 1
'92-U-235 FROM JEF-2.2 '/
0. 293.
1.E10 4500. 200. /
3 / Temperature 0.K
0 /
3 / Temperature 293.K
0 /
0 /
stop
```

Sample Results

```

1*****
*
*  $$  $$      $$  $$$$$$  $$  $$  *      *      *
*  $$$  $$      $$  $$$$$$$  $$  $$  *  nuclear  *  vers: 97.62  *
*  $$$$  $$      $$  $$$ $  $$$  $$$$  *  data      *  site: t2-lanl  *
*  $$ $$$$  $$  $$  $$  $$  $$$  *  processing *  mach: x86-lf90  *
*  $$ $$$  $$$$$$$$  $$$$$$$$  $$  *  system     *  date: 04/09/99  *
*  $$  $$  $$$$$$  $$$$$$  $$  *      *      *  time: 16:48:55  *
*      *      *      *      *      *      *      *
*      *      *      *      *      *      *      *
*****

```

moder...change the mode of an endf/b tape or njoy output tape 0.0s

put materials from various tapes on output tape -21

tape id for nout

JEF-2.2 U-235

processing endf or pendf tape.

nin	matd
---	----
20	9228

using endf-6 format

18.3s

reconr...reconstruct pointwise cross sections in pendf format

18.3s

unit for endf/b tape -21
unit for pendf tape -22

label for pendf tape

PENDF TAPE FOR U-235 FROM JEF-2.2

tape label

JEF-2.2 U-235

storage 17/100000

material to be processed	9228
reconstruction tolerance	0.002
reconstruction temperature	0.k
resonance-integral-check tolerance ...	0.005
max resonance-integral error	2.000E-07

descriptive cards for pendf tape

92-U-235 FROM JEF-2.2
PROCESSED BY NJOY-97.45+

processing mat 9228 in endf-6 format

92-U -235 NEA RCOM-AUG90 E. FORT, H.TELLIER

unresr...calculation of unresolved resonance cross sections 700.1s

storage 8/ 20000

unit for input endf/b tape -21
unit for input pendf tape -23
unit for output pendf tape -24

temperatures 0.000E+00
2.930E+02
sigma zero values 1.000E+10
4.500E+03
2.000E+02
print option (0 min., 1 max.) 1

mat = 9228 temp = 0.000E+00 700.2s

energy = 2.2500E+03
1.965E+01 1.964E+01 1.935E+01
1.194E+01 1.194E+01 1.190E+01
5.676E+00 5.668E+00 5.531E+00
2.038E+00 2.031E+00 1.923E+00
1.965E+01 1.962E+01 1.909E+01
energy = 2.5000E+03
1.926E+01 1.925E+01 1.899E+01
1.193E+01 1.192E+01 1.189E+01
5.400E+00 5.393E+00 5.270E+00
1.936E+00 1.931E+00 1.834E+00
1.926E+01 1.923E+01 1.876E+01
energy = 3.5000E+03
1.812E+01 1.811E+01 1.794E+01
1.187E+01 1.187E+01 1.184E+01
4.609E+00 4.605E+00 4.521E+00
1.644E+00 1.640E+00 1.576E+00
1.812E+01 1.811E+01 1.777E+01

energy = 2.5000E+04
1.411E+01 1.411E+01 1.409E+01
1.118E+01 1.118E+01 1.117E+01
2.194E+00 2.193E+00 2.187E+00
7.334E-01 7.332E-01 7.290E-01
1.411E+01 1.411E+01 1.407E+01
generated cross sections at 14 points 728.4s

mat = 9228 temp = 2.930E+02 728.4s

energy = 2.2500E+03
1.965E+01 1.966E+01 1.968E+01
1.194E+01 1.194E+01 1.194E+01
5.676E+00 5.678E+00 5.702E+00
2.038E+00 2.038E+00 2.042E+00
1.965E+01 1.966E+01 1.971E+01
energy = 2.5000E+03
1.926E+01 1.926E+01 1.929E+01
1.193E+01 1.193E+01 1.192E+01
5.400E+00 5.401E+00 5.425E+00
1.936E+00 1.936E+00 1.941E+00
1.926E+01 1.926E+01 1.932E+01
energy = 3.5000E+03
1.812E+01 1.813E+01 1.815E+01
1.187E+01 1.187E+01 1.187E+01
4.609E+00 4.611E+00 4.634E+00
1.644E+00 1.644E+00 1.650E+00
1.812E+01 1.813E+01 1.819E+01

energy = 2.5000E+04
1.411E+01 1.411E+01 1.412E+01
1.118E+01 1.118E+01 1.118E+01
2.194E+00 2.194E+00 2.201E+00
7.334E-01 7.336E-01 7.358E-01
1.411E+01 1.411E+01 1.413E+01
generated cross sections at 14 points 737.9s

usage 2832/ 20000

737.9s

groupr...compute self-shielded group-averaged cross-sections 737.9s

storage 23/400000

unit for endf/b tape	-21
unit for pendf tape	-24
unit for input gout tape	0
unit for output gout tape	-25
mat to be processed	9228
neutron group structure option	9
gamma group option	0
weight function option	5
legendre order	1
print option (0 min, 1 max)	1

run title

92-U-235 FROM JEF-2.2

temperatures (kelvin)	zero
	2.93E+02
sigma zeroes	infinity
	4.50E+03
	2.00E+02

neutron group structure.....epri-cpm 69 group

.
.
.

50	3.6726E+02	-	9.0690E+02
51	9.0690E+02	-	1.4251E+03
52	1.4251E+03	-	2.2395E+03
53	2.2395E+03	-	3.5191E+03
54	3.5191E+03	-	5.5300E+03
55	5.5300E+03	-	9.1180E+03

.
.
.

weight function.....epri-cell lwr

id wght	1/	184
id scr	2/	540

using endf-6 format

id nu	3/399924
xx nu	0

processing mat 9228

92-U-235 FROM JEF-2.2

id unr	3/399924
xx unr	849
xx unr	849
id flxc	4/ 1390
id buf	5/ 2390
id scr1	6/ 2746

finished with narrow-resonance flux to 2.0000E+07 ev
203106 points

xx scr1	-1
xx flxc	0
id ans	5/ 2401
id ff	6/ 2405
id prod	7/ 2474
id sig	8/ 2830

group constants at t=zero deg k
for mf 3 and mt 1 (n,total) cross section.

761.8s

enrgy lgend group constants vs sigma zero
group order infinity 4.500E+03 2.000E+02

50	0	2.909E+01	2.896E+01	2.719E+01
flux	0	3.337E-02	3.315E-02	2.937E-02
50	1	2.909E+01	2.884E+01	2.575E+01
flux	1	3.337E-02	3.294E-02	2.602E-02
51	0	2.526E+01	2.517E+01	2.388E+01
flux	0	1.737E-02	1.727E-02	1.552E-02
51	1	2.526E+01	2.508E+01	2.281E+01
flux	1	1.737E-02	1.718E-02	1.393E-02
52	0	2.271E+01	2.262E+01	2.142E+01
flux	0	1.778E-02	1.769E-02	1.606E-02
52	1	2.271E+01	2.254E+01	2.045E+01
flux	1	1.778E-02	1.760E-02	1.457E-02
53	0	1.874E+01	1.873E+01	1.850E+01
flux	0	1.820E-02	1.812E-02	1.666E-02
53	1	1.874E+01	1.872E+01	1.829E+01
flux	1	1.820E-02	1.805E-02	1.526E-02
54	0	1.759E+01	1.758E+01	1.744E+01
flux	0	1.862E-02	1.855E-02	1.713E-02
54	1	1.759E+01	1.758E+01	1.731E+01
flux	1	1.862E-02	1.848E-02	1.576E-02
55	0	1.657E+01	1.656E+01	1.648E+01
flux	0	2.111E-02	2.103E-02	1.950E-02
55	1	1.657E+01	1.656E+01	1.640E+01
flux	1	2.111E-02	2.096E-02	1.803E-02

group constants at t=zero deg k
for mf 3 and mt 18 (n,fission) cross section.

777.1s

enrgy group constants vs sigma zero
group infinity 4.500E+03 2.000E+02

50	1.200E+01	1.192E+01	1.080E+01
51	8.039E+00	7.989E+00	7.253E+00
52	6.022E+00	5.976E+00	5.313E+00
53	5.214E+00	5.207E+00	5.094E+00
54	4.318E+00	4.315E+00	4.246E+00
55	3.291E+00	3.289E+00	3.253E+00

group constants at t=zero deg k
for mf 3 and mt102 (n,g) cross section.

813.7s

enrgy group constants vs sigma zero
group infinity 4.500E+03 2.000E+02

50	4.291E+00	4.251E+00	3.723E+00
51	3.787E+00	3.758E+00	3.364E+00
52	2.996E+00	2.975E+00	2.669E+00
53	1.807E+00	1.802E+00	1.718E+00
54	1.413E+00	1.411E+00	1.363E+00
55	1.244E+00	1.243E+00	1.215E+00

processing mat 9228

92-U-235 FROM JEF-2.2

id unr 3/399924
xx unr 849
xx unr 849
id flxc 4/ 1390
id buf 5/ 2390
id scr1 6/ 2746

finished with narrow-resonance flux to 2.0000E+07 ev
59886 points

xx scr1 -1
xx flxc 0
id ans 5/ 2401
id ff 6/ 2405
id prod 7/ 2474
id sig 8/ 2830
822.9s

group constants at t=2.930E+02 deg k
for mf 3 and mt 1 (n,total) cross section.

enrgy lgend group constants vs sigma zero
group order infinity 4.500E+03 2.000E+02

50	0	2.909E+01	2.906E+01	2.839E+01
	flux 0	3.337E-02	3.315E-02	2.922E-02
50	1	2.909E+01	2.902E+01	2.775E+01
	flux 1	3.337E-02	3.294E-02	2.566E-02
51	0	2.526E+01	2.525E+01	2.496E+01
	flux 0	1.737E-02	1.727E-02	1.544E-02
51	1	2.526E+01	2.523E+01	2.467E+01
	flux 1	1.737E-02	1.718E-02	1.375E-02
52	0	2.270E+01	2.269E+01	2.248E+01
	flux 0	1.778E-02	1.769E-02	1.598E-02
52	1	2.270E+01	2.268E+01	2.228E+01
	flux 1	1.778E-02	1.760E-02	1.438E-02
53	0	1.874E+01	1.874E+01	1.877E+01
	flux 0	1.820E-02	1.812E-02	1.664E-02
53	1	1.874E+01	1.875E+01	1.880E+01
	flux 1	1.820E-02	1.805E-02	1.521E-02
54	0	1.759E+01	1.759E+01	1.762E+01
	flux 0	1.862E-02	1.855E-02	1.712E-02
54	1	1.759E+01	1.760E+01	1.765E+01
	flux 1	1.862E-02	1.848E-02	1.573E-02
55	0	1.657E+01	1.657E+01	1.659E+01
	flux 0	2.111E-02	2.103E-02	1.949E-02
55	1	1.657E+01	1.657E+01	1.661E+01
	flux 1	2.111E-02	2.096E-02	1.800E-02

group constants at t=2.930E+02 deg k
for mf 3 and mt 18 (n,fission) cross section.

828.1s

enrgy group constants vs sigma zero
group infinity 4.500E+03 2.000E+02

50	1.200E+01	1.197E+01	1.152E+01
51	8.040E+00	8.031E+00	7.864E+00
52	6.018E+00	6.012E+00	5.893E+00
53	5.215E+00	5.216E+00	5.239E+00
54	4.318E+00	4.320E+00	4.341E+00
55	3.291E+00	3.292E+00	3.308E+00

group constants at t=2.930E+02 deg k
for mf 3 and mt102 (n,g) cross section.

838.1s

enrgy group constants vs sigma zero
group infinity 4.500E+03 2.000E+02

50 4.292E+00 4.283E+00 4.118E+00
51 3.786E+00 3.782E+00 3.699E+00
52 2.996E+00 2.994E+00 2.952E+00
53 1.808E+00 1.808E+00 1.813E+00
54 1.413E+00 1.414E+00 1.419E+00
55 1.244E+00 1.245E+00 1.250E+00

xx ans -1
xx unr -1

usage 3756/400000
839.6s
