^{237}Np XS experimental validation. Proposal for JEFF3 modification

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Overview

- Trends from Integral measurements:
  - ^{237}Np sample oscillation in MINERVE (OSMOSE experiment)
  - Post Irradiation Experiment in UOx fuel; ^{238}Pu prediction content

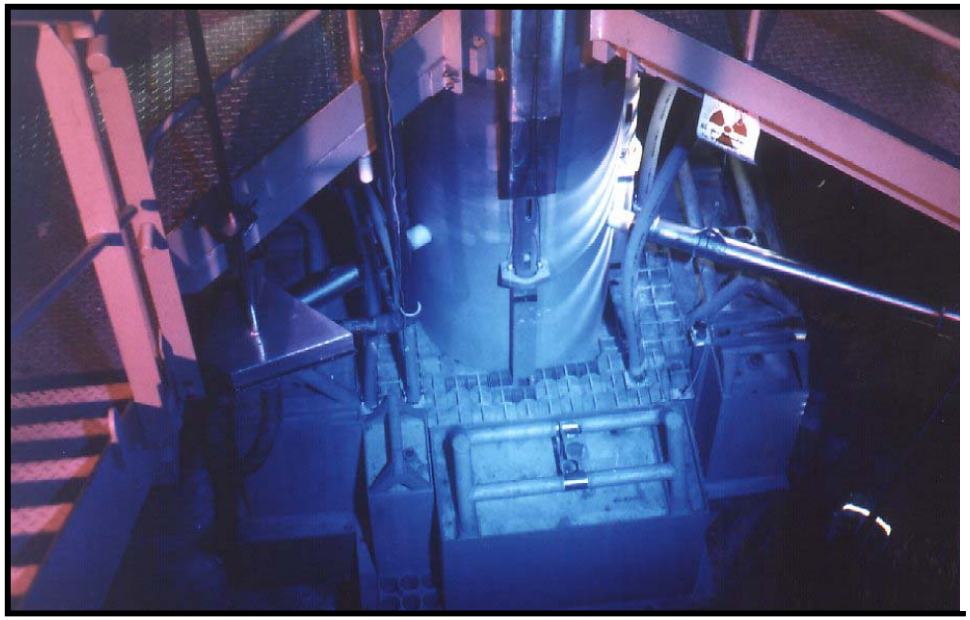
- Differential measurements:
  - available thermal capture XS

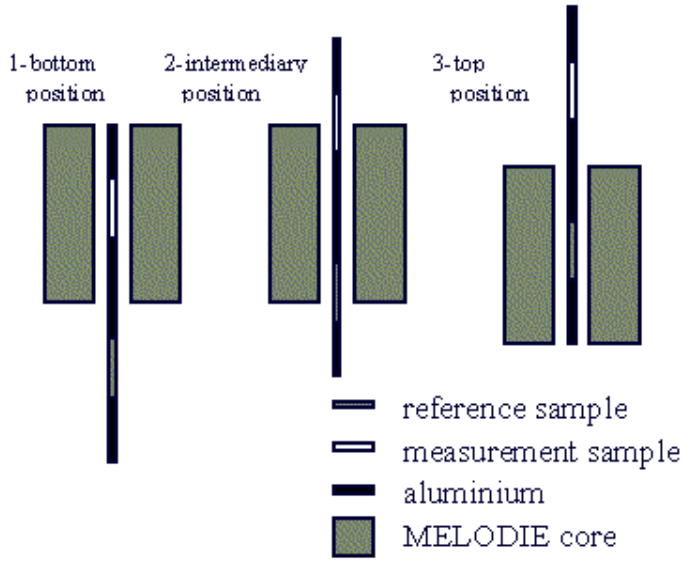
OSMOSE Experiment performed in MINERVE Facility

Reactivity variation due to sample oscillations in a thermal UO_2 spectrum (^{232}Th, $^{233,234,236}U$, ^{237}Np, $^{238,239,240,241,242}Pu$, $^{241,243}Am$, ^{244}Cm).

Cylindrical column of pellets (ϕ=8.1mm; h=95mm) made of UO_2 matrix doped with Actinide.

Admixed masses of the two ^{237}Np samples: 0.1g and 0.6g.





^{237}Np Qualification Results

(C/E-1) in%	JEF-2.2	JEFF-3.1
^{237}Np (0.1g)	-9.9 ± 2.5	-14.4 ± 2.5
^{237}Np (0.6g)	-7.3 ± 1.9	-12.2 ± 1.9
Mean Value	**-8.6 ± 1.8**	**-13.3 ± 1.8**

OSMOSE interpretation points out the need to increase ^{237}Np(n,γ) thermal and resonance integral of JEFF-3.1 by about +13%±2% (1σ)

Exact Perturbation Theory supplies the sensitive energy range for this modification.

Breakdown of the ^{237}Np poisoning worth in MINERVE is the following :

40 are thermal neutron induced	$0.eV < T_n < 0.25eV$
30 are « epithermal » neutron induced	$0.25eV < T_n < 0.625eV$ 1^{rst} resonance
30 are « slowing-down » neutron induced	$0.625eV < T_n < 20.MeV$

Chemical assays in French PWR-UOX assemblies

Chemical assays of ^{238}Pu content in LWR-UOx fuel with low burnup (<20GWj/t, 5 independant fuel pins) show recurrent underestimation using JEFF3.1:

- (C/E-1) = –1% ± 1% for ^{236}U prediction
- (C/E-1) = –1% ± 3% for ^{237}Np prediction
- (C/E-1) = –8% ± 4% for ^{238}Pu prediction

This is mainly due to an underestimation of ^{237}Np(n,γ) cross-section by about 10% ±4% (1σ)

Differential Trends: thermal XS.

Evaluated Thermal Capture Cross-Sections:

JEF-2.2:	181b
JEFF-3.1:	162b

Experimental Capture Cross-Sections:

KATOH (2003):*	142 ± 3 b	
JUROVA (1984):	158 ± 4 b	
KOBAYASHI (1993):	158 ± 3 b	
ESCH (2005):	168 ± 5 b	
TATTERSALL (1960):	169 ± 3 b	
SMITH (1957): (=BNL)	170 ± 22 b	
BROWN (1956):	172 ± 7 b	
WESTON (1981):	175 ± 5 b	
KOBAYASHI (2005):	181 ± 2 b	
EBERLE (1971):	184 ± 6 b	
SHCHERBAKOV (2005):	185 ± 7 b	
SCHUMAN (1969):	185 ± 12 b	
MINI-INCA (2003):	180 ± 5 b	(JEFDOC-1138)

*: the sample activation analysis using Wescott energetic decomposition with Cadmium cut-off is very doubtful due to:

- large uncertainty (15%) on gamma peak emission probability after Activation Product disintegration ($^{238}Np \rightarrow ^{238}Pu$)…
- cadmium energy cut-off (~ 0.50eV) is too close to resonance peak (E_0=0.49eV)

Conclusion on ^{237}Np(n,γ) evaluation in JEFF3.1

•Recent Integral trends are consistent with Differential measurements.

•Independant integral trends points out that an increase of JEFF-3.1 **^{237}Np(n,γ) thermal and epithermal cross sections is required**:

+12% ± 2%

in agreement with previous JEF2.2 evaluation