NUCLEAR DATA VERIFICATION USING GALILEE AND TRIPOLI-4

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## GALILEE-1 Code : GALVANE Module (GALilée Verification of the Accuracy of Nuclear Evaluations)

<table>
<thead>
<tr>
<th>Inconsistencies</th>
<th>Library (# nuclei / #nuclei with DD)</th>
<th>JENDL40 (406 / 3)</th>
<th>JEFF32 (472 / 169)</th>
<th>JEFF33 (562 / 328)</th>
<th>ENDFB7R1 (423 / 41)</th>
<th>ENDFB8 (557 / 114)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass comparison (&gt; 1 MeV)</td>
<td></td>
<td>4</td>
<td>24</td>
<td>12</td>
<td>27</td>
<td>26</td>
</tr>
<tr>
<td>Resonance parameters</td>
<td></td>
<td>0</td>
<td>9</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Q-reactions (&gt; 500 keV)</td>
<td></td>
<td>5</td>
<td>53</td>
<td>31</td>
<td>92</td>
<td>93</td>
</tr>
<tr>
<td>Anisotropy</td>
<td></td>
<td>5</td>
<td>35</td>
<td>2</td>
<td>39</td>
<td>33</td>
</tr>
<tr>
<td>Radioactive production</td>
<td></td>
<td>1</td>
<td>41</td>
<td>95</td>
<td>14</td>
<td>17</td>
</tr>
<tr>
<td>Missing gamma production for radiative capture</td>
<td></td>
<td>139</td>
<td>104</td>
<td>1</td>
<td>138</td>
<td>142</td>
</tr>
</tbody>
</table>
328 Nuclei with Radioactive Production
- Inelastic scattering (MT4):
  Final state with $\text{Exc} > 0 \text{ MeV}$ and $\text{LFS} = 0$ (GS identification): 85 evaluations
  TALYS correction?
- Inconsistencies between GP data and JEFF33/DD for ID state (Energy Level) or Excitation Energy value

$\Delta \text{ID STATE J33-GP} / \text{J33-DD} : 95$
$\Delta \text{ENER STATE J33-GP} / \text{J33-DD} : 5$

Delta ID STATE J33-GP / ENDFB8-DD : 33
Delta ENER STATE J33-GP / ENDFB8-DD : 7

Delta ID STATE J33-GP / ENSDF : 31
Delta ENER STATE J33-GP / ENSDF : 5

$\rightarrow$ Source of inconsistencies for depletion calculations $\rightarrow$ Corrections in JEFF33/DD?

ENDF/B-VIII: (114 nuclei). No problem with MT4 final states
Delta ID STATE ENDFB8-GP / ENDFB8-DD : 17
Delta ENER STATE ENDFB-GP / ENDFB8-DD : 0
OUTGOING PARTICLE KINEMATICS / ENERGY BALANCE

- JEFF-3.3/MF5 : Cd isotopes, (n,2n) and (n,3n) reactions for various incident energies : 
  \[ \sum E_n > E_{\text{available}} \]

- MF6, MT91 (continuous inelastic scattering) :
  JEFF-3.3 / TENDL15 : 335 nuclei with \( E_\gamma < E_{\text{exc at threshold}} \)
  ENDF/B-VIII : 102 nuclei (\( E_\gamma < E_{\text{exc}} \))

- MF6, Gamma production : Discrete probability + continuous probability \( \neq 1 \) :
  JEFF-3.3 : 5 nuclei   ENDF/B-VIII : 7 nuclei

- MF6 used for discrete inelastic scatterings (MT51-90). 
  JEFF-3.3 : 56 nuclei
  ENDF/B-VIII : 95 nuclei
Gamma production in MF6 should be moved in MF12
Solution : generate MF4 (neutron angular distribution) + MF12 (gamma production)
JEFDOC-1841 (2017) : 31 nuclei in JEFF-3.3

- MF6 for inelastic scattering : Yield gamma < 1. (Take care of metastable nucleus production)
  JEFF-3.3 : 65 nuclei
  ENDF/B-VIII : 106 nuclei

- MF12 : gamma production (inelastic scatterings, (n,p),...) : incoherence MF3 / MF12 level states
  ENDF/B-VIII : 39 nuclei. Iron isotopes from CIELO
MF12: MT69, MT70, MT72, MT73, MT74, MT79, MT82, MT83, MT84, MT86, MT87, MT88, MT89: unknown gamma transition, unknown excited state.

MF3 MT55 Excited Energy 2.959973e+06  
MF12 MT55 Excited energy  2.959973e+06  
MF12 MT69: decrease towards an excited state of 2.959972e+06

MF3 MT60 Excited Energy 3.445349+06  
MF12 MT60 Excited Energy: 3.445349e+06  
MF12 MT69: decrease towards an excited state of 3.445348e+06
MF2/MT151 B8 = MF2/MT151 B7 from 2.5 keV to 30 keV
B8 : URR LSSF=1 ; B7 : URR LSSF=0
JEFF-3.3 URR from 4 keV to 30 keV ; LSSF=1. 1st Inel : 7.8 keV
U238 ratio TP CALENDF (Sum / Eval)
Libraries:

- Use of MF12 (Transition probabilities) instead of MF6 for gamma cascade (discrete inelastic scatterings) → Improvement of Analog simulations

- Unit Base Interpolation for outgoing energy distribution (MF5, MF6, MF15) → Energy balance

- Depletion calculations: DD and GP should be in agreement

- Kinematics of outgoing particles at high energy (> 20 MeV) should be improved

- URR data. PURR doesn’t treat reactions in addition to MT2, MT18, MT102, “MT1”
ICSBEP BENCHMARKS : U, MIXT FAST (TRIPOLI 4)

Flattop-25
Big-10
Godiva
ZPR-U9
ZPR-16%

Legend:
- JEFF-3.3
- JEFF-3.2
- ENDF/B-VII.1
- ENDF/B-VIII
- JENDL-4.0
ICSBEP BENCHMARKS : PU FAST (TRIPOLI 4)

Pu Fast

±500 pcm

JEZEBEL

JEZEBEL-40
ICSBEP BENCHS: U, MIXT THERM (TRIPOLI 4)
ICSBEP BENCHMARKS : PU THERM (TRIPOLI 4)
Comparison to Mass Excess (NUBASE2012) : $\Delta > 1 \text{ MeV}$.

Cd106, Cd113, Ce141, Eu155, I135, La139, Ru103, Ru104, Ru105, Th230, Xe134

→ Corrections on AWR + Q + Thresholds (MF4, MF5, MF6, ....)