

Status of the JEFF project

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Arjan Koning

NRG

1755 ZG Petten, The Netherlands

General

The objective of the Joint Evaluated Fission and Fusion (JEFF) file project of the OECD/NEA is to develop and promote the use of high quality evaluated nuclear data sets in standard formats for a wide range of scientific and technical applications. The JEFF project assesses the needs for nuclear data improvements and addresses those needs by initiating the necessary measurements, evaluations and benchmarking efforts. It is a collaborative effort between NEA Data Bank member countries. In practice, mainly European countries participate in the project, since the OECD-members USA (ENDF/B) and Japan (JENDL) have their own nuclear data file projects. While the objective of the JEF-2.2 library (1992) was to achieve improved performance for existing reactors and fuel cycles, its successor, the JEFF-3 project, aims to provide users with a more extensive set of data for a wider range of applications. Apart from existing reactors and fuel cycles, innovative reactor concepts (GEN-IV), transmutation of radioactive waste, medical applications, various non-energy related industrial applications, and fusion are envisaged as scientific activities that can benefit from JEFF. The European Fusion File (EFF) and the European Activation File (EAF) contribute to this initiative.

Organisation

The JEFF Scientific Coordination Group (SCG), whose members are nominated by the Nuclear Science Committee Executive Group, has responsibility for the overall management of the project. The technical activities are organised in different Working Groups. The current organisation of JEFF is as follows:

- Chair : Arjan Koning, NRG
- Working Group chairs:
 - Experimental activities : Peter Rullhusen, IRMM
 - Radioactive Decay and Fission Yield data: Olivier Bersillon, CEA/DAM
 - Fusion data (EFF group) : Robin Forrest, UKAEA
- Secretariat : Ali Nouri, NEA Data Bank

JEFF meetings are generally held twice per year. It consists of a general (plenary) session that deals with evaluations, processing and benchmarking. In addition, there are parallel sessions for the Working Groups and a meeting for the SCG.

Recent developments

A. General

Robert Jacqmin, JEFF chairman since 1999, has ended his three-year term in 2003 and stepped down as chairman. The SCG has elected Arjan Koning as his successor.

Ali Nouri, responsible for JEFF as NEA Data Bank representative, will end his contract at NEA in June 2004. Mark Kellett, active as EFF secretary in the past years, has left NEA in September 2003.

B. Highlights from the JEFF meetings

The JEFF meeting of November 17-19, 2003 took place at the OECD and NEA Headquarters in Paris, with 33 participants. The JEFF meeting of May 10-12, 2004 took place at the International Energy Agency Headquarters in Paris, with 34 participants. Some highlights are given below.

1. Evaluations

Work is underway to produce improved evaluations for the Ti isotopes (Vienna, EFF), the W-isotopes (FZK, Vienna, EFF), the Ca, Sc, Fe, Ge, Pb and Bi isotopes (NRG), U-238, Rh-103 and I-127,129 (CEA). These evaluations are expected to become part of the next release JEFF-3.1.

A number of minor problems have been identified following the JEFF-3.0 GP file processing and benchmarking. These include

- various nuclides in JEFF-3.0 with a negative background cross section
- 7 isotopes with wrong (n,na) spectra
- errors in the total energy release in various actinides
- a new Be-9 evaluation, with corrected (n,gamma) and (n,2n) channels
- problems in the secondary energy spectrum of Cr-52
- Unknown processing problems for a few nuclides

These problems should be solved before the JEFF-3.1 release.

Modifications are implemented into the GLUCS code (Vienna, EFF) to avoid a systematic underestimation of cross sections when fitting inconsistent and highly correlated experimental data. Additional work has now started on covariance determination based on nuclear models (Vienna).

It was decided to upgrade the decay constants for all actinides in JEFF-3.1 to an 8-group structure, as recommended by WPEC SG6. J. Rowlands has provided a precise recipe for the adoption of the delayed neutron yields, relative abundances and spectra. In JEFF-3.0, only U-238 and Pu-239 have 8 groups, the others 6. The other world libraries have 6 groups for all nuclides.

2. Validation and benchmarking

Following the release of JEFF-3.0 in April 2002, various benchmark tests have confirmed the expected performance improvements over JEF-2.2. However, they have also confirmed that the reactivity of small low-enriched Uranium systems is underestimated by about 500 pcm with JEFF-3.0. Possible reasons for this underestimation have been identified as U-238 inelastic scattering and a slight overestimation of the U-238 capture cross section. A new U-238 evaluation has been constructed (CEA) which results in a significant improvement of k-eff values. Very extensive automated benchmarking tests have been set up, which probes the current quality of the

new data file. These include MCNP (NRG), TRIPOLI (CEA) and APOLLO (CEA) criticality calculations for an unprecedented set of benchmark cases. Near-future revisions of JEFF-3 will be immediately tested with this scheme. WPEC SG22 (“ueval”) has contributed significantly to these improvements. Additional validation is now possible with a Monte Carlo approach to calculating the effective delayed neutron fractions (NRG), and improved thermal scattering data (UT Stuttgart). Concerning reactivity in UO₂ pins (CEA), JEFF-3.0 improves the isotopic ratio prediction of Post Irradiation Experiments.

3. Activation data and codes

The JEFF-3.0/A library (a translation of EAF-2003 into the ENDF-6 format) contains activation data for 774 target nuclei in the energy range below 20 MeV. Some 12,617 excitation functions are included. The ENDF utility codes were used to check the library, which was also processed, using NJOY-99.65+. The data are stored in MF3,8,9,10.

The Intermediate Energy Activation File IEAF-2001 contains interaction data for incident neutron energies up to 150 MeV and nuclei up to Z=84. A pseudo-fission product library was developed for use with the FISPACT inventory code. The official version of FISPACT will be changed to enable this. The activation code EASY-2003, which contains FISPACT, is now validated with new data for CuCrZr and W as well as ENEA and JAERI heat measurements.

4. Decay data and fission yields

Work on the decay data and fission yield file for JEFF-3.1 has started. CEA has devoted a special person (M. Kellett) to this task, in order to deliver a complete and well-validated decay data file for JEFF in the spring of 2005. In the last update, 16 activation decay data files were completed. Consistency checks on decay energy balance showed a very good agreement. Further updates were possible with new evaluations from the UK (Winfrith) and with the release of NUBASE2003. Also, new decay data evaluated files were produced at LNHB (CEA Saclay). The current version of the decay data file is almost ready for extensive validation. One major upgrade to be done concerns the completion of the spectra data. These can be extracted as much as possible from ENSDF. Decay heat benchmarks are being set up at BNFL and CEA/Cadarache. A special website for the decay data library, JEFF3T2RDD, has been set up at the NEA Data Bank.

5. Experiments

The experimental Working Group now works under a clear mandate that connects the experimental activities to the user requests from JEFF. After each JEFF meeting the participants agree on a short list of high-priority requests for nuclear data. Currently, these are:

- (n,gamma) on Hf isotopes between 1 and 100 eV, with 2% accuracy, for naval reactor studies
- thermal U-235 fission spectrum (discrepancies exist)
- Pu-239(n,gamma) and Pu-239(n,f) between 0.01 and 0.5 eV, with 2% accuracy
- Am-241,242m(n,gamma) in the resonance range
- Gd-155,157(n,gamma) at thermal energies, with 2% accuracy
- U-238(n,gamma)
- O-16(n,alpha) between 2 and 7 MeV

Other ongoing experimental activities for low-energy neutrons take place in Geel and CERN:

- inelastic scattering on Cr-52, Pb and Bi-209 with the (n,n')g technique (Geel)
- Activation cross sections for Zr, Ni-58 and Cr-50 (Geel)
- Capture and transmission: Pb-206, Bi-209, Rh-103, Pu-240, Pu-242 (Geel)
- Capture: Fe-56, Au-197, Sm-151, Bi-209, Pb-204, Pb-206, Pb-207, Pb-208, Th-232, La-139, Mg-23, Mg-24, Mg-25, Os-186, Os-187, Os-188, Zr-isotopes, U-233, U-234, U-236, Np-237, Pu-240, Cm-241, Cm-245 (CERN).

6. Fusion (EFF)

Important ongoing evaluations for EFF were already mentioned under 1. (Evaluations).

Experiments for the Test Blanket Module (TBM) are being performed in Italy. Two breeder blanket concepts for ITER are being considered: the helium cooled pebble bed (HCPB) and the helium-cooled lithium-lead (HCLL) blanket. A collaboration between JAERI, ENEA and TUD has resulted in a choice for HCPB. The associated MCNP models have been constructed and calculations have been carried out for the neutron spectrum, background and shielding optimisation, total tritium production, nuclear heating, etc.. Additional computational analyses have been performed with DORT and SUS3D (Kodeli), in particular for the sensitivity of the detector response and Li-6 production to nuclear data.

Promising results are obtained for the activation analysis of a 0-55 MeV neutron benchmark on Eurofer. (FZK). The need for high-energy activation cross sections is evident.

Decay heat measurements were performed (Pillon) to validate the activation file EAF-2003. Beta and gamma heat measurements were shown. Both good and very poor agreement with the activation file was found. Finally, decay heat benchmarks showed that EAF-2003 gives a clear improvement over EAF-4.1=FENDL/A-2 (Menapace).

From JEFF-3.0 to JEFF-3.1

The next release of the library, JEFF-3.1, is foreseen for May 2005. There is a request from the (French) nuclear industry to start validating the new JEFF library in the fall of 2005. This means that there is now one year left for the selection, compilation and validation of the isotopes for the JEFF-3.1 data file. It has been decided to strive for the construction of the starter file, JEFF-3.1T, by the next JEFF meeting, November 22-24 2004. The general-purpose neutron data file will probably consist of the following:

1. New data files for neutrons:

- Ca-40, 42, 43, 44, 46, 48 (0-200 MeV, NRG)
- Sc-45 (0-200 MeV, NRG)
- Ti-46, 47, 48, 49, 50 (0-20 MeV, IRK Vienna)
- Fe-54, 56, 57, 58 (0-200 MeV, NRG)
- Ge-70, 72, 73, 74, 76 (0-200 MeV, NRG)
- Rh-103 (0-20 MeV, CEA/Cad)
- W-182, 183, 184, 186 (0-20 MeV, IRK Vienna, end of 2005)
- Pb-204, 206, 207, 208 (0-200 MeV, NRG)
- Bi-209 (0-200 MeV, NRG)
- U-238 (0-30 MeV, CEA)
- Am-241 (thermal, CEA)
- Many nuclides ((n,gamma) and (n,f), N-TOF)

2. Update of source evaluations of JEFF-3.0 (e.g. JENDL-3.2 → JENDL-3.3)
3. Alternative choices for source evaluations if there is a clear indication to change them.

The development of the decay data and fission yields file for JEFF-3.1 will go in parallel with that of the general-purpose file. The final data file is foreseen for April 2005.

The activation file EAF-2004 will extend to an upper energy limit of 60 MeV. Since the associated EASY-2004 code system will continue to use the EAF data format, new MT numbers have been introduced. The nuclear model code TALYS has been used extensively to extend existing reactions and to introduce new reaction classes. For the release of JEFF-3.1, however, the official activation file JEFF-3.1/A will be equal to EAF-2003 in ENDF-6 format.