INTERNATIONAL EVALUATION COOPERATION
PROGRESS REPORT OF THE SUBGROUP ON
"239Pu FISSION CROSS SECTION BETWEEN 1 KeV AND 100 KeV"

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Abstract :

We present the current status of our efforts to try to solve the problem of the discrepancy in measurements of the ^{239}Pu fission cross section in an energy range of particular importance in FBR calculations.

The researches are progressing along two axes :

- Critical examination of WESTON's measurements with the objective of performing additional experiments to confirm the conclusions of the subgroup.
- Examination of all other sources of information relating to the fission cross section including the competitive cross section data (when existing) and integral data.

To finalize the investigation, it is envisaged that a new ^{239}Pu fission cross section measurement will be carried out in conditions to be defined in the course of the present study.

In 1984 WESTON and TODD published [1] the results of a ^{239}Pu fission cross section measurement in the range 20 eV to 100 KeV performed in excellent energy resolution conditions. While analysed as being excellent in the resolved range [2], WESTON's data in the unresolved range appear to be significantly lower (5 %) than almost all measurements and all the recent major evaluations (JENDL3, ENDFB6, JEF2) see fig. 1.

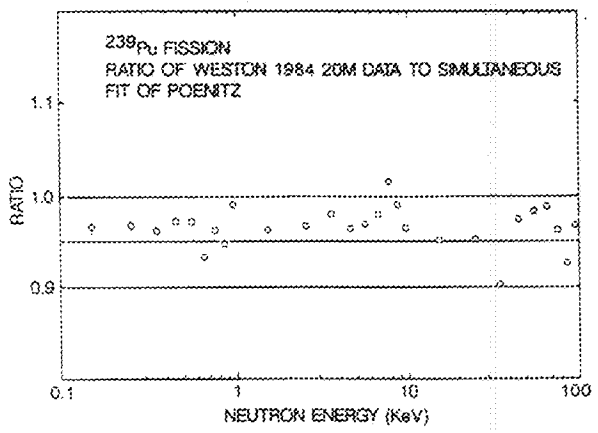

Fig. 1 : Ratio of WESTON's data (1984) to simultaneous fit of POENITZ

If confirmed this difference would induce significant discrepancies in Keff, control rod worth or void coefficient calculations for FBRs for which the range 1 KeV - 100 KeV is of important sensitivity.

This explains the interest of the NEANDC/NEACRP task force which set up a subgroup to try to understand and possibly solve this problem.

The following scheme of work has been adopted :

1 Critical examination of the WESTON and TODD experiment.

2 Reevaluating the ^{239}Pu data taking into account new information not used in the above cited evaluations such as microscopic data recently produced and chosen selected integral information.

3 Global analysis of phases 1 and 2 so as to be able to produce a qualitative explanation and, possibly, a set of recommended data.

1 - CRITICAL EXAMINATION OF THE WESTON AND TODD EXPERIMENT

This is a T.O.F. experiment performed with ORELA, using a multiparallel plate fission chamber ; the shape of the neutron flux was measured relative to a $^{10}BF_3$ chamber up to a neutron energy of 1 KeV and to a ^{6}Li glass scintillator at higher energies. The flux internormalization was made in the energy interval 100 eV - 1000 eV with a statistical uncertainty less than 0.1 %. Finally the σ_f curve was normalized to the thermal value. For this experiment conceived for a measurement at high energy, the following aspects were considered to detract from such way of normalization : sample thickness self absorption, dead time. On the other hand, the fission integral for the interval 100 eV - 1000 eV (I_f = 8996 b.eV) is known only with a fairly rather significant uncertainty (1.9 % for normalization, 1 % systematic, 0.15 % statistical). The comparison with the I_f values obtained from GWIN's measurements (I_f = 9268 b.eV) [3] and (I_f = 9365 b.eV) [4] reveals a 4 % difference not in contradiction with the above quoted errors. But since GWIN's measurements are affected by a large uncertainty (11 %) in the ^{10}B content of the neutron flux counter, they have not been considered as absolutely reliable references. Therefore it has been decided to plan experimental programs both at OAK-RIDGE and GEEL to check this normalization point.

Nevertheless the possibility of energy dependent sources of discrepancy is not totally to be excluded, although the fission cross section of ^{235}U measured in the same experiment is consistent with measurements and evaluations.

2 - 239Pu REEVALUATION BASED ON NEW OR ADDITIONAL INFORMATION

2.a. New microscopic information

Transmission data have been obtained at ORELA by J. HARVEY et al [5] with good energy resolution (1.6 ns/m to 0.1 ns/m from 0.5 eV to several hundred KeV), three samples cooled to liquid nitrogen temperature whose thicknesses were chosen to be a good compromise between opposite conditions to get on the one hand accurate experimental data and at the same time

only moderate self screening effects. They have been analysed to derive first a resonance parameter set up to 2 KeV recognized as being of excellent quality (no need of a MT-3 cross section in the resolved region, validation on integral experiment) and second a total cross section up to 500 KeV [6], referred to in the following as DERRIEN's σ_t.

This σ_t curve appears to be in agreement with the POENITZ et al experimental data [7], but significantly lower (3 % - 4 %) than ENDFB6 and JEF2. The difference results, in our judgement, from the self screening correction and also from the better quality of the raw transmission data. That's the reason why we have considered the data-base formed by POENITZ's and DERRIEN's data as a reference in the range 1 KeV - 500 KeV in the procedure to produce a new Optical Model Parametrization (OMP).

This parametrisation, which is to be used in coupled channel calculations, has been derived in the same way as the one used in the JEF2 evaluation [8]. In what follows both parametrizations will be referred to respectively as OMP90 and OMP86.

All other reference data being identical (σ_t above 500 KeV, angular distributions) the consideration of the new σ_t data-base led to the renormalization of the real and the imaginary parts of the potential, the ranges of the effective interactions and the spin-orbit potential being unchanged.

The quality of the fit is improved over the whole energy range compared to the previous situation.

It must be stressed that the new potential is totally consistent with the parameters in the resolved range thanks to the so called "SPRT" method.

With this new OMP, the fit is globally improved : the neutron scattering angular distributions (see fig. 2 below) but essentially the total cross section above 0.5 MeV in an energy range rich in data ; see fig. 3.

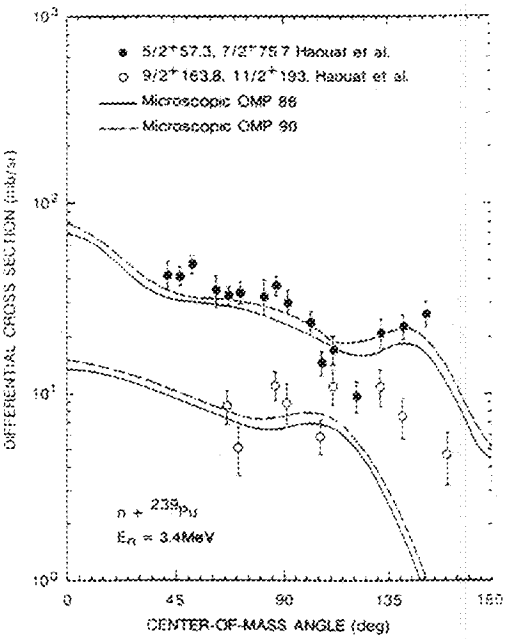

Fig. 2 : Comparison of experimental inelastic scattering cross sections at 3.4 MeV with data calculated with OMP86 and OMP90

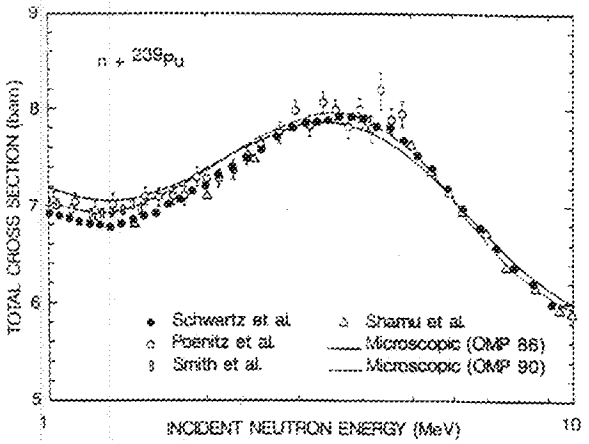

Fig. 3 : Experimental total cross sections compared with data calculated using OMP86 and OMP90

With respect to above cited evaluations, changes appear essentially below 3 MeV but they are significant : a 5 % lower σ_t between 0.5 MeV and 1.5 MeV, a 10 % - 15 % lower compound nucleus formation cross section as a result of a lower σ_t and the adoption of a greater scattering radius (9.45 fm against 9.15 fm) :

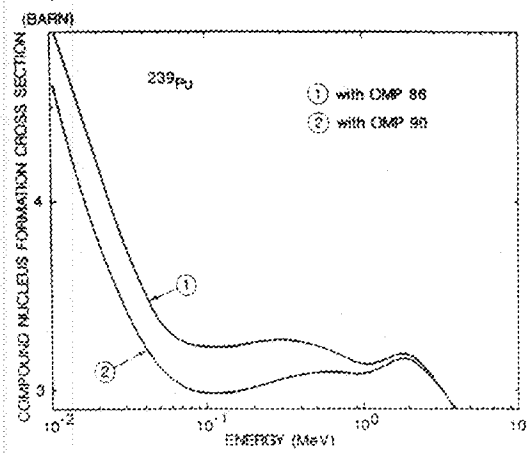

Fig. 4 : Comparison of the compound nucleus formation cross section obtained by using OMP86 (curve 1) and OMP90 (curve 2)

Using it to describe the neutron channel two model evaluations are underway using the POENITZ evaluation (ENDFB6) on the one hand and WESTON's data on the other as fission data bases. The difficulty in the last case lies in that :

1 The fission data base is formally truncated above 100 KeV.

2 There are no reliable experimental data for the competitive cross section (σ_c, $\sigma_{n,n'}$, σ_{ne}) or when existing (alpha) they are not very helpful in solving the present dilemma. The same conclusion applies more or less at higher energies so that it is difficult to draw conclusions for the range of interest from conclusions in the higher energy range. Fortunately it has been possible to reproduce WESTON's data without any change in the fission channel distribution above the ground state. Approximate agreement with JEF2, is obtained at 1 MeV an energy where the old and new OMP practically coincide.

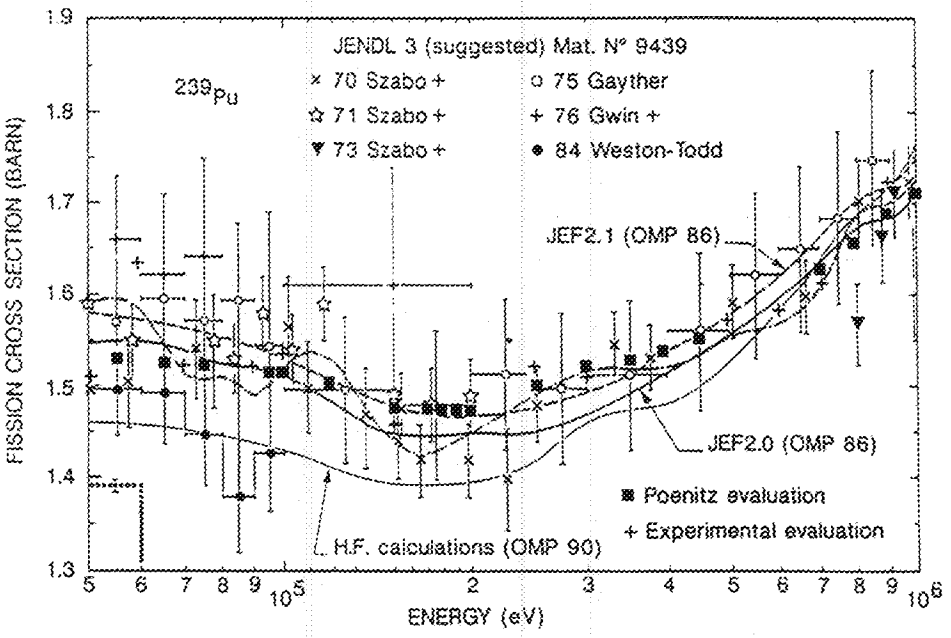

Fig. 5 : Experimental fission cross section data compared with the model calculations (OMP90) based on WESTON's data

This means that the fission data-base is the same above 1 MeV for both model evaluations. It is also concluded that if the true fission cross section is WESTON's it should also be lower than the present evaluations over a larger energy range and this should be confirmed by an additional experiment.

In the future, when both evaluations are complete and available in ENDFB6 format they will be validated against clean integral data obtained from :

- JEZEBEL, JEZEBEL-Pu, FLATTOP-Pu (sensitivity range : 50 KeV < E < 10 MeV).

The microscopic data will be processed in 33 groups and SN transport calculations performed in P_3S_{16} (with a correction to account for the S_N effect).

- The set of experiments performed on Pu fuelled criticals, MASURCA, SNEAK, ZEBRA, considered in the JEF2 benchmarking (sensitivity range : 1 KeV < E < 1 MeV).

The microscopic data will be processed in 1968 groups and resonance structure within these groups represented by probability tables. Since the selected experiments are asymptotic flux (fundamental mode conditions) the neutronics calculations will be cell calculations using the new European cell code ECCO.

Sensitivity calculations and a statistical adjustments procedure will locate the energy regions where microscopic and integral data disagree and will quantify the amplitudes of the disagreement.

3 - GLOBAL ANALYSIS OF PHASE 1 AND 2

Phases 1 and 2 will demonstrate the degree of consistency of microscopic and integral information in the present state of art but a final conclusion is dependent on the availability of the results of the experiments planned at GEEL and OAK-RIDGE.

The production of recommended data also depends on the possibility of carrying out a new measurement in experimental conditions to be defined in the frame of this task force.

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