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INDC INTERNATIONAL NUCLEAR DATA COMMITTEE

Progress Report

of the Nuclear Data and Nuclear Physics Activities

at the Energy Research Centre at Petten (The Netherlands)

January 1979 - April 1980

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Progress Report for the Period January 1979 - April 1980 of the Nuclear Data and Nuclear Physics Activities at the Energy Research Centre at Petten (The Netherlands).

Petten, April 1, 1980.

I. Nuclear Data for Fast Reactors (H. Gruppelaar)

1. Introduction

The Dutch nuclear data project for fast reactors consists of three programmes:

1. Evaluation of neutron cross sections for fission products.
2. Evaluation of neutron activation cross sections for nuclides in the primary cooling circuit of fast power reactors.
3. Study of preequilibrium models for application in design calculations of fusion reactors.

The project is performed in the framework of a cooperation between Germany, Belgium and The Netherlands on fast breeder reactor development. In the field of fission-product nuclear data there is also close cooperation with evaluation groups in the USA (HEDL), France (CEA-Cadarache) and Italy (CNEN-Bolgona).

2. Evaluation of neutron cross sections for fission products

The so-called RCN-2 evaluation of neutron cross sections for fission-product nuclides has been completed for 43 nuclides. Most data are contained in a 3-volume report |1|. The complete data file (in KEDAK format) is available from the NEA Data Bank at Saclay.

From this evaluation capture group cross sections (Russian 26-group structure) have been evaluated, together with 26x26 covariance matrices. These capture group constants have been adjusted to fit integral measurements performed in the five cores of the Dutch STEK-facility. The adjusted group cross sections and their covariances are given in three volumes of a report |2|. Further improvements of these data have been obtained by including the activation measurements performed at CFRMF (Idaho) in the adjustments; results are given in two volumes of |3|. Some of the results obtained so far have been used in the ENDF/B-V fission product data file |4|. The adjusted RCN-2A group cross sections has also been intercompared with the French CARNAVAL-IV adjusted fission-product group cross sections |5|. An important application of the RCN-2A data file is the calculation of pseudo fission-product cross sections |6|.

Recently, some work has been devoted to calculate the contribution of (n,p) and (n,α) reactions to fission-product cross sections |7|. Another contribution to the NEANDC "Specialists' Meeting on Neutron Cross Sections of Fission Product Nuclei", held at Bologna, December 1979, deals with the analysis of resolved resonance parameters of some fission-product nuclides |8|.

Other evaluation activities performed at Petten concern cross sections for natural elements in the fission-product mass range. So far, neutron cross sections for Nb, Mo, Rh, Ag, I, Nd and Sm have been obtained.

3. Evaluation of neutron cross sections for nuclides in the primary cooling circuit of a fast power reactor

Radionuclides in the Na coolant of the primary cooling circuit of a fast breeder reactor may originate from activated coolant materials, cover-gas nuclides or corrosion products. The radionuclides are produces in several ways, e.g. by (n,γ), (n,p), (n,np), or (n,2n) reactions, but are partly removed by neutron absorption. In order to calculate the radioactive inventory of the coolant one needs to know the nuclear cross sections. For a number of nuclides evaluated activation or absorption cross sections are lacking. Priority-1 or -2 requests for the further development of the DeBeNe fast reactors are: activation and/or absorption cross sections for: ^{22}Na, $^{38,40}Ar$, ^{50}Cr, ^{54}Fe, $^{58,62,64}Ni$, ^{58m}Co, ^{64}Zn and ^{112}Sn. At present the neutron cross sections for ^{64}Zn (impurity in coolant), ^{50}Cr, ^{54}Fe, ^{62}Ni and ^{64}Ni have been evaluated. Results for ^{58m}Co are in progress. At the Topical Discussion on "Progress in Neutron Cross Section Measurements and Evaluations Concerning Structural for Fast Reactors" (NEANDC meeting at Geel, Sept. 26, 1979), some results of evaluations for the corrosion products of stainless steel have been presented |9|.

4. Study of preequilibrium models for application in design calculations of fusion reactors

Previous work performed at ECN resulted in an exact matrix method to solve the master equation involved in preequilibrium theory. Recently, this method has been extended to solve the so-called generalized mater equation, which is used to describe angular distributions. In refs. |10,11| the mathematical details are given. The theory has been tested with a large set of experimental data for neutron inelastic scattering cross sections, induced by 14.6-MeV neutrons |12|.

5. Recent reports and publications

|1| H. Gruppelaar, Tables of RCN-2 fission-product cross section evaluation, vol. 1, ECN-13 (1977), vol. 2, ECN-33 (1977) and vol. 3, ECN-65 (1979).

|2| J.W.M. Dekker, Tables and figures of adjusted and unadjusted capture group cross sections based on the RCN-2 evaluation and integral measurements in STEK, vol. 1, ECN-14 (1977), vol. 2, ECN-30 (1977) and vol. 3, ECN-54 (1979).

|3| J.W.M. Dekker and H.Ch. Rieffe, Adjusted cross sections of fission-product nuclides from STEK reactivity worths and CFRMF activation data, vol. 1, ECN-28 (1977) and vol. 2, ECN-55 (1979).

|4| R.E. Schenter, D.L. Johnson, F.M. Mann, F. Schmittroth and H. Gruppelaar, Evaluations of fission product capture cross sections for ENDF/B-V, contributed paper Int. Conf. on Nuclear Cross Sections for Technology, Knoxville, Oct. 1979.

|5| H. Gruppelaar, P. Hammer and L. Martin-Deidier, Intercomparison of adjusted data sets for capture cross sections of fission products, Invited paper presented at the NEANDC Specialists' Meeting on Neutron Cross Sections of Fission Product Nuclei, Bologna, Dec. 12-14, 1979.

|6| R.J. Heijboer and A.J. Janssen, Status of pseudo fission-product cross sections for fast reactors; sensitivity study for sodium void effect, Invited paper presented at the NEANDC Specialists' Meeting on Neutron Cross Sections of Fission Product Nuclei, Bologna, Dec. 12-14, 1979.

|7| H. Gruppelaar and B.P.J. van den Bos, The contribution of (n,p) and (n,α) reactions to fission-product capture cross sections, Contr. paper presented at the NEANDC Specialists' Meeting on Neutron Cross Sections of Fission Product Nuclei, Bologna, Dec. 12-14, 1979; see also ECN-78 (1979).

|8| G. Delfini and H. Gruppelaar, Maximum likelihood analysis of resolved resonance parameters for some fission product nuclides, Contr. paper presented at the NEANDC Specialists' Meeting on Neutron Cross Sections of Fission Product Nuclei, Bologna, Dec. 12-14, 1979; extended version to be published as ECN-report.

|9| H. Gruppelaar and H.A.J. van der Kamp, Evaluation of neutron cross sections of some corrosion products of stainless steel, Contr. to the "Topical Discussion on Progress in Neutron Cross Section Measurements and Evaluations Concerning Structural Materials for Fast Reactors", NEANDC-meeting, Geel, Sept. 1979.

|10| J.M. Akkermans, Angular distributions in exciton and hybrid models for preequilibrium reactions, Phys. Lett. 82B (1979) 20.

|11| J.M. Akkermans and H. Gruppelaar, Calculation of preequilibrium angular distributions with the exciton model code PREANG, ECN-60 (1979).

|12| J.M. Akkermans, H. Gruppelaar and G. Reffo, Angular distributions in a unified model of preequilibrium and equilibrium neutron emission, to be published in Phys. Rev. C (1980).

II. Activities of the FOM-ECN Nuclear Structure Group at ECN, Petten

(K. Abrahams)

1. General

Neutron beams extracted from the high flux reactor have been used for capture-gamma ray spectroscopy, with as special feature the assignment of spins to excited nuclear states. To this purpose four experimental setups have been built, two of which are at present under reconstruction. Shell model calculations on neutron rich nuclei are made on the CYBER-175 computer.

2. Instrumental

2.1. The intense thermal beam (10^9 $cm^{-2}s^{-1}$), installed at the previous thermal column has been equipped with a pair spectrometer of high resolution (5.3 keV FWHM at 7.4 MeV).

2.2. The nuclear orientation setup is under reconstruction to extend the temperature range below 5 mK at a field of 8.5 T.

2.3. A filter setup is being constructed to extract 2 keV and 24 keV neutron beams.

2.4. The intense polarized beam (2.10^7 $cm^{-2}s^{-1}$) has been in use for gamma-ray circular polarization measurements.

3. Experimental

Gamma ray energies and intensities have been determined for the product nuclei: ^{24}Na, ^{28}Al, ^{46}Sc, ^{52}V, ^{56}Mn, $^{57,59}Fe$, $^{64,66}Cu$ and ^{142}Pr. Polarized targets have been used to assign spins to about 50 states of ^{28}Al, ^{46}Sc, ^{52}V, ^{56}Mn and ^{142}Pr. All results are in the process of being reported in open litterature (see list of publications).

4. Theoretical

Shell model calculations have been published on $^{54,55,56}Fe$.

5. Publications 1979

|1| R. Vennink and P.W.M. Glaudemans, The Shell Model and Collective Structure in $^{54,55,56}Fe$. Accepted by Zeit. f. Phys.

|2| R. Vennink, J. Kopecky and P.M. Endt, Investigation of the $^{56}Fe(n,\gamma)^{57}Fe$ and $^{58}Fe(n,\gamma)^{59}Fe$ reactions. Submitted to Nucl. Phys.

|3| H.I. Liou, R.E. Chrien, J. Kopecky and T. Konter, Study of the $^{45}Sc(n,\gamma)$ reaction. Accepted by Nucl. Phys.

|4| J. Kopecky, R.E. Chrien and H.I. Liou, Resonance Neutron Capture in ^{52}Cr. Accepted by Nucl. Phys.

|5| P.P.J. Delheij, A. Girgin, K. Abrahams, H. Postma and W.J. Huiskamp, The $^{27}Al(n,\gamma)^{28}Al$ reaction studied with polarized neutrons and polarized aluminium nuclei. Accepted by Nucl. Phys.

|6| P.P.J. Delheij, K. Abrahams, W.J. Huiskamp and H. Postma, The $^{55}Mn(n,\gamma)$ reaction studied with polarized neutrons and polarized maganese nuclei. Accepted by Nucl. Phys.

|7| J.B.M. de Haas, Radiative capture of polarized neutrons in ^{51}V and ^{141}Pr nuclei. ECN-79.