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MODERN STATE OF THE SOCRATOR SYSTEM

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Abstract: This paper reviewes the status of constant provision system for the atomic reactors and shielding calculations - the SOCRATOR system Three subsystems of SOCRATOR system - MICRO, MACRO and INDEX, and their banks of data are descriebed. Some results of this system examinations are given and discussed.

(SOCRATOR, group constants system provision, reactor and shielding calculations, banks of data, fast critical assemblies)

In the USSR the calculations of nuclear fast reactors are being carried out at the present time using the ARAMACO-S1 constants system. It includes the BNAB-78 26-group constant set /1/ suplemented in 1980-1985 by the new data for those nuclides the constants of which have not been revised earlier. The comprehensive investigations of the 26-group approximation uncertainties have been carried out /2/. These ones are found to be smaller and do not exceed the uncertainties connected with inaccurate knowledge of neutron data today and nearest future. At the same time the methodical uncertainties of the 26-group approximation restrain the realization of accuracy reserves contained in using the macroscopic experimental data for increasing the accuracy of calculational predictions. This has served as an incentive for creating and developing the System Of Constant pRovision for the ATOmic Reactors and radiation shielding calculations - the SOCRATOR system.

The SOCRATOR system involves three subsystems. The first of them is the MICRO subsystem which provides the maintenance of an evaluated neutron data library (information about this library is given in a separate paper presented to this conference) and the treatment of these into the group constants. In addition, the data concerning photon-matter interaction are stored here. The two independent codes GRUCON /3/ and NJOYES are used for the treatment of evaluated nuclear data into the group constants. The code GRUCON is a domestic development and the code NJOYES is the NJOY known code /4/ adaptation performed on ES computer and obtained further development.

The comparison of different group constants calculated with the help of two independent codes has allowed to reveal and estimate some errors in the algorithms of retreatment and vagueness in the sence of the same ENDF procedures. The participation in the IAEA test /5/ has allowed to reveal small incorrectnesses in calculating average cross-sections. There is also examined the identity of intergroup transition probability and angular momenta matrixes obtained with the help of the GRUCON and NJOYES. The resonance self-shielding factors and their doppler increments are more complex in computational respect. For these functionals of neutron cross-sections the fair agreement has been obtained only in the region of resolved resonances. There are disagreements in self-shielding factors calculated by the GRUCON and NJOYES and at the present time the accuracies of calculating these factors in the unresolved resonance region are being investigated.

The SOCRATOR second subsystem is a MACRO. It involves a binary data banks:

- 301-group system of neutron constants with the subgroup representation of the cross-section unresolved resonance structure. This library contains 226 groups in the slowing-down region (20 MeV to 4.65 eV) and 75 groups in the region of thermalization. The energy grid is made coincident with the BNAB grid by dividing each group of BNAB into a number of multigroups of u=0.06 width. Moreover, the library involves the constants being adequate to the adopted ones for calculating reactors and shielding in the ARAMACO-S1 constant system;
- 33-group constants of photon formation in neutron reactions as well as photon-matter interactions;
- 28-group constants for energy release calculations.

All these data have been obtained in the frames of the MICRO subsystem on the base of the evaluated data libraries. According to our estimations the use of coarse group approximation for calculating the photon sources, photon propagation and energy release do not distort the calculational results but simplify the calculations and the control of quality of the data used.

The first version of the multigroup constant system has been constructed on the basis of the ENDF/B-IV data library (only the data for uranium-235 have been taken from ENDF/B-V). At the present time the multigroup constants have been obtained on the basis of the domestic library of the evaluated neutron data as well, however, the experience of their practical use is not gained up to the present.

The program modules of the MACRO subsystem provide a preparation of the multigroup constants for calculation: accomplish the accounting of resonance self-shielding in gomogeneous and heterogeneous media, the calculation of macroconstants, constants being necessary for calculating the functionals of neutron field (reaction velocities, reactivities, photon sources), the constants for calculating photon fields. There are the modules of a convolution of the 301-group constants into the coarse group ones using the given or calculated 301-group neutron spectra.

Besides the 301-group library of constants the 28-group library being identical to the used one in ARAMACO-S1 is involved in the data bank. The difference is only in the algorithms of calculating elastic slowing-down cross-sections.

In the Fig.1 are shown the calculation results of a series of the fast critical assemblies distinguished by a neutron fraction with energy below 10 keV in the spectrum of a core.

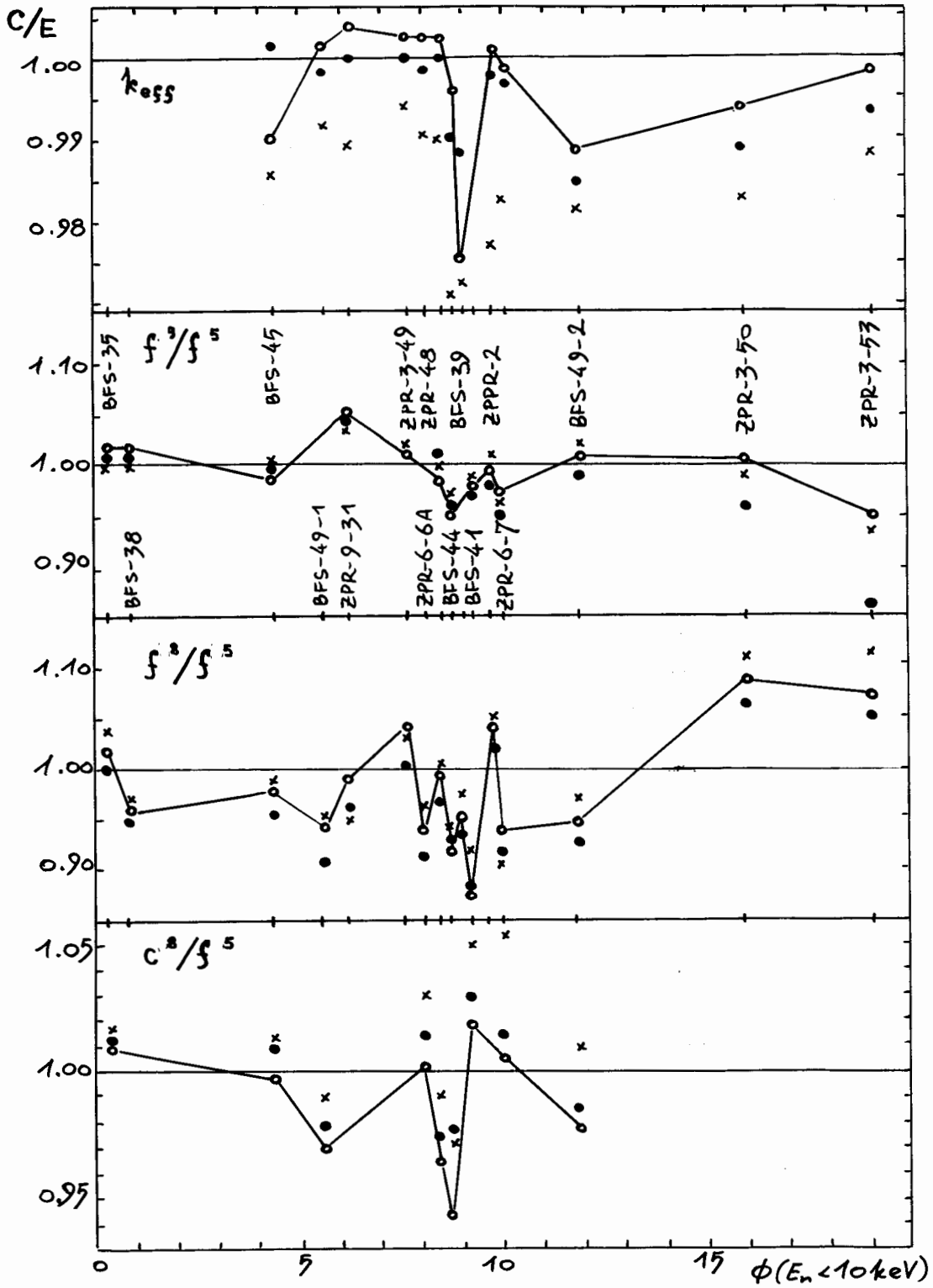

Fig.1. A comparison of calculated results using different group constants with experimental data on fast critical assemblies : o—o -BNAB-78-ARAMACO , ● -BNAB-78-MULTIC , × -ENDF/B-MULTIC.

The characteristics of assemblies and the experimental data have been taken from the library of evaluated macroexperiments of the SOCRATOR system. Results marked as (a) were calculated on the basis of ARAMACO-S1 system. A set of calculations (b) and (c) is carried out in the frames of the MACRO subsystem: (b)- with the use of the 28-group library; (c)- with the use of the 301-group constants obtained from ENDF/B-IV (see above).

The differencies between the series of (a) and (c) are due to a difference in the algorithms of the elastic slowing-down cross-section calculation and are well corresponded to the expected ones /2/. The differencies between the results of calculating versions of (b) and (c) are due to both the accounting of energy dependence of cross-sections inside the BNAB groups in the version of (b) and the difference of input neutron data. Note, that the cal-

ulation-experimental differencies,when using ENDF /B-IV, have been obtained markedly greater than we have expected on the basis of the calculation experience, the results of which have been taken into consideration of developing BNAB-78 /1/. The reasons of this are not clear as yet.

The SOCRATOR third subsystem is the INDEX (Inaccuracy of Neutron Data reducing using EXperiments on critical assemblies) /6/. The INDEX subsystem is based on the two main data banks: the LUND is the Library of Uncertainties of Neutron Data which contents covariation matrixes of group constants and the LEMEX is the Library of Evaluated Macroscopic EXperiments. A base of the present version of the LUND library is formed by the data on group constant uncertainties given in the book /1/ and now expanded into the 26-groups and the greater number of neutron cross-sections. The LEMEX library contains the data more than about 400 values measured on the 45 fast critical assemblies. More than one half of all the values included in this library has been measured on the 15 Soviet BFS and KBR fast critical assemblies. Also the LEMEX includes the data on the measurements of cross-sections on a fission spectra (including removal cross-sections) and the results of cross-section ratios measurements fulfilled by the isotop transmutation technique with the fuel samples irradiated in the BN-350 reactor cores. The data of each experiment are reduced to the conditions of a calculational model of that experiment: the gomogeneous regular geometric form (usually spherical) with point detectors and samples. The uncertainties of experimental data include the ones of reducing to the calculational model. In the LEMEX library are stored also the results of calculations of the observed values on a base system of the constant provision, now it is the ARAMACO-S1 and further - the multigroup constant system. The characteristics of the critical assembly models to be calculated are stored in the form of calculated assignments for the prescribed reactor calculation codes. The sensitivities of measured values to group constants have been calculated with their help. The results of these calculations carried out partly on the base of a generalized perturbations theory and in a complex cases by way of the direct variations of group costants are stored in the LSENS Library of SENSitivity coefficients. In the INDEX system libraries are also stored the data on the banchmak calculational fast breeder reactor models. This allows to estimate the accuracy of design calculations and possibilities of its incease when realizing one or another experimental programs and so on. The necessary statistical calculations are carried out with the help of the CORE code which is also used for adjustment the group constants on the base of a macroscopic experiment data analysis. However, the conclusions about the required constant shifts obtained as a result of adjustment are used by us, as a rule, only for the localization of discrepancies between the macro- and microscopic data on neutron cross-sections with the aim of further resolution of the revealed contradictions. The INDEX subsystem has been used when testing the ARAMACO-S1 costant system provision. Now the testing of the 301-multigroup constant system will be carried out with the help of this one. The expected time of putting the 301-group constant system into operation in the design calculations is in the nineties. It is assumed that this system of constant provision will be used in calculating the reactors of different spectral classes as well as the neutron calculations of radiation shielding, thermonuclear machines and so on.

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