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SUMMARY OF THE SYMPOSIUM ON APPLICATIONS OF NUCLEAR DATA IN SCIENCE AND TECHNOLOGY

12-16 March 1973

PARIS

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This summary of the symposium has been submitted to Atomic Energy Review where it will be published in an abbreviated form.

The Symposium on Applications of Nuclear Data in Science and Technology was held on 12-16 March 1973 in Paris. It was a gathering of scientific and technical people of many different specialities who came to discuss a matter of common interest: The nuclear data requirements for various areas of application and the status of compilations and evaluations. The presentation and discussions of 72 papers during 16 regular sessions and a summary session served to review the subject in a rather comprehensive manner, although some areas of application (e.g. reactorphysics) could not be included in the programme.

1. Background

A few words should be devoted to the background of this somewhat unusual Symposium. Since many years, that part of nuclear data which is related to neutron-induced reactions is fairly well organized in all the aspects of concern to the major field of application, namely reactor technology. The development of the technology for utilisation of the nuclear fission process as a source of energy was one of the first areas where the large-scale use of computers was introduced. The volumes of data involved required an elaborate organization from surveying the requirements for new data to measurement, compilation of experimental data, evaluation of the data and finally the processing of data for subsequent input into reactor computer programmes. Such programmes are often oriented towards a very special application, such as the design of the reactor core, the design of bulk reactor shields, the economic use of fuel (fuel burn-up) or the protection of man and materials from the negative effects of radiation.

The two first Geneva Conferences on Atomic Energy in 1955 and 1958 gave the signals to true international cooperation, as on those occasions most of the previously classified data were released by the great powers - that was the "period of pacification" of neutron data. Today, we can be reasonably sure that practically all experimental nuclear data are unclassified.

Since several years, the International Nuclear Data Committee (INDC) functions as a body to advise the Director General of IAEA on all matters related to nuclear data. Perhaps the most important contribution to world-wide cooperation has been the committee's coordinating function made possible by the selection of members in key positions in their home countries. Several years ago, the members of INDC came to realize that the separation between neutron and non-neutron nuclear data had some great disadvantages which were aggravated by a certain degree of alienation between nuclear physicists in the two areas. Parts of the causes for this situation were differences between the two fields in most countries as to administration, funding and organization.

The committee finally proposed in 1969, that the Agency should organize "a small symposium ... not later than 1973" in order to bring together the compilers and evaluators of data in all branches of nuclear data. One may wonder over the long interval of four years which was proposed, but the suggested meeting required, in order to be useful, quite extensive preparations. In contrast to the conferences on Nuclear Data for Reactors (Paris 1966 and Helsinki 1970) the symposium was meant to deal with the full scope of nuclear data rather than only neutron data, and furthermore, the idea was that the measurements of data were to be of only marginal interest. A small consultants meeting in November 1970 proposed the formation of an International Working Group on Nuclear Structure and reaction Data (IWGNSRD) which subsequently met in Vienna in March 1972, in order to lay the ground-work for a better understanding of problems related to the various compilations and applications of all kinds of nuclear data. This was essential if the symposium should be able to live up to its expectations. The programme committee for the symposium was then set up with members from IWGNSRD as well as from INDC.

During the preparation work it became evident that the symposium would have to deal with the matters of data with a view primarily to the application of data in the various disciplines in science and technology, rather than to the compilation and evaluation of the data. The data producers knew too little about how the data users used the data and vice versa, and the data compilations that were used often left much to be desired. The programme committee attempted to achieve a balance between reactor and other applications as well as between applications and the compilation/evaluation work itself. As a result, four of the sixteen regular sessions were devoted to applications related to nuclear energy: Reactor technology, fusion research, safeguards, and future technology requirements. Seven sessions were devoted to other applications: Life sciences, chemistry, accelerator and space shielding, various other applications, and three sessions on activation analysis. Five sessions, finally, dealt with topics related to the data itself: Data centres, evaluated data files, fission product data, large-volume-data compilations and application-oriented compilations.

2. Criteria of choice

In his keynote address [99]*, Dr. A.M. Weinberg referred to the two kinds of motivation which are the driving forces behind scientific work. The compiler of data may be motivated by a desire to find scientific regularities and new insights or to help other scientists in his own field; this is the internal motivation akin to the Newtonian view of science. He may, on the other hand, be motivated by a desire to make the knowledge accumulated within his field useful to scientists in other fields and to those who apply science to the useful arts; this is the external motivation akin to the Baconian view of science.

There is a trend, these days, to favour the Baconian view of Science, more than before. This has to some extent been caused by the recent stagnation of the growth rate of science, be it measured in terms of numbers of active scientists, of annual production of scientific papers, or of appropriations for research in national budgets. This levelling off of the growth rate was predicted already in 1962 by D. deSolla Price (1), and it is at present instrumental in the attempts to make the limited available funds work with a maximum of efficiency on a short term. Weinberg predicted in his talk a strong and growing need for externally motivated nuclear data compilations over the next several decades. This would contirue the trend which is already quite pronounced. Quoting his earlier papers on similar subjects (2), he made a plea for greater efforts on basic data compilations because of their key role for the application-oriented evaluation work. This need for more support to compilations of nuclear structure and decay data was repeatedly confirmed during the rest of the symposium. His talk served also as an interesting reminder that

*Reference numbers in parentheses are given in the list of references at the end. The numbers given in square brackets refer to paper numbers at the symposium. For paper number 99, for example, the full reference number is IAEA/SM-170/99. A "D" refers to discussions, an "S" to the Summary session.

the internal criteria should not be forgotten; the applications of data in the "pure" sciences (e.g. astrophysics) were not well represented at the symposium. He also made a plea for compilation work to be regarded as a scientific endeavour in its own right, pointing to several occasions when substantial scientific progress has been made as a direct consequence or even part of such work.

3. Applications related to nuclear energy

3.1 Future technology requirements

Already during the first session on future technology requirements an example of Dr. Weinberg's notion of the creative data work was given in the Bifold nuclear power source concept [39], the origin of which was credited to the data acquisition work for radioactive decay heat sources. During this session some conceptual studies were presented together with data requirements for further work on these studies. Fissioning plasmas [53], fusion-fission (hybrid) reactors [56] and the radioactive decay heat source which can be operated for peak power output as a fission chain reactor (Bifold) are all exciting concepts which are potentially viable subjects for considerable future efforts in research.

The data needs are, by and large, similar to those of reactor technology, but for each concept a special emphasis is of course given to its particular problems. The notorious problem of neutron data between 7 and 14 MeV remains a severe difficulty. Neutron capture and subsequent gamma emission for D, Be, O, Fe, ^{232}Th and ^{238}U need urgent attention, as well as the (also notorious) $\bar{\nu}(E_n)$ and neutron fission spectrum data. Data needed in particular for the designs discussed here were delayed neutron spectra (n,2n), and (n,3n) data, data for scattering kernels for hydrogen up to temperatures around 4000K and also data on Doppler broadening (particularly in the unresolved resonance region) up to the same temperatures. The proposed use of the more exotic isotopes ^{234}U and ^{238}Pu, makes, of course, data for these nuclides particularly interesting. A surprisingly great deal of attention was given - as it was also during many other sessions - to the great needs for data on the border-line between nuclear and atomic data. Even though it was claimed that radiation damage calculations can be made with sufficient accuracies for "conventional" reactors the "step out into the unknown" seems to always raise this problem, be it a question of fissioning plasmas (particularly for transparent materials for the nuclear laser), of thermonuclear fusion or of the irradiation limits of fuel elements in fast reactors.

3.2 Reactor technology

The application of neutron data in reactor physics calculations involves rather complex procedures. In view of the expensive penalties which will be incurred due to - in comparison with non-reactor applications - even rather small uncertainties in certain key data it is self-evident that great efforts are made on the acquisition of data information on all relevant quantities in the design of a reactor [69,38]. The integral experiments provide examples of where empirical and calculated data showdiscrepancies which are sometimes rather disturbing. [38D].Various examples in the recent history of nuclear data show that this sort of discrepancies is most often the first indication that something is wrong; during recent years the reactor community had examples of this kind in the problems of fission neutron spectra, of $\bar{\nu}(E_n)$ and of the capture-to-fission ratio of ^{239}Pu; a reasonable solution has been found only to the last one of the three.

During the last few years several attempts have been made to establish formulae giving the relationships between the uncertainties in the nuclear data input to the reactor calculations and the uncertainties in the calculated reactor parameters (breeding ratio, critical mass, reactivity, etc.). This relationship is a basic prerequisite for the determination of priorities in national nuclear data measurement programmes. The formulae will be useful for a full cost-benefit analysis of the nuclear data measurement programmes. Such analysis has received increasing attention in recent years as the costs are sky-rocketing for removing the last few percent of uncertainties of some essential data by highly sophisticated experiments. Reactor technology seems rather unique as it partly lends itself to this kind of cost-benefit analysis. It might however, be a useful tool in the management of other branches of technology where nuclear data are applied. L.N. Usachev et al described in their paper [91] the particular application of this method to fast reactors for which the breeding ratio is one parameter of paramount importance. The relationship between input and output inaccuracies in reactor calculations is essential to the request lists for nuclear data measurements, which were mentioned repeatedly during the discussions. The request lists are reviewed by national data committees with a view to assure a reasonable credibility of the requested accuracies and priorities. W.W. Havens Jr.[4]reviewed the development of the US Nuclear Data Committee (USNDC), the European-American Nuclear Data Committee (EANDC) and the International Nuclear Data Committee (INDC). He described the coordinating roles of these committees and how, under the auspices of USNDC the US request list was created. The request list of EANDC later on developed into a full-fledged information system, RENDA. The IAEA has assumed responsibility for the publication of a world-wide RENDA to be known as WRENDA. This list will be a request list for neutron nuclear data measurements consisting of three parts:Fission reactor, fusion reactor, and safeguards development.

3.3 Fusion research and safeguards

Safeguards is of special interest for IAEA because of the Agency's responsibility for international safeguards under the non-proliferation treaty (NPT). For both fusion research and safeguards data needs have been subject for review already, and lists of requests for nuclear data measurements needed for applications in these areas have been compiled by the Agency. In the case of safeguards, the applications of nuclear data are limited to the development of instrumentaion, although fuel burn-up calculations and isotope analysis of spent fuel elements are matters of some interest. At present the non-destructive assay techniques are the most promising areas of development of safeguards where nuclear data may need some improvements. C. Weitkamp [78]presented a survey of methods which are being developed for safeguards, and he gave three groups of methods which need better nuclear data than presently available. In category A the feasibility of the method depend on data which are not available; neutron capture gamma-ray spectroscopy and gamma-ray resonance fluorescence belong to this category. In category B data are needed for normalization of measured values, like in the cases of calorimetry and α-spectrometry. Category C data are needed primarily for the calculation of corrections in relative measurements. For fuel burn-up calculation and isotope correlation analysis (which are of interest not only to safeguards) it seems not yet quite clear whether the present difficulties are due mostly to uncertainties in nuclear data, or to deficiencies in the methods. Generally the half-lives of several isotopes seem to be needed with higher accuracies.

The possibility of controlled fusion chain reactions can be investigated only with the greatest difficulties,[49]because there is a barrier in "the grossly incomplete knowledge of reaction cross sections for light nuclei at low energies" (3). Thermonuclear fusion, although primarily a technological problem, is riddled by the lack of data for predictions of e.g. tritium breeding as related to the previously mentioned general lack of neutron data between 7 and 13 MeV [21,49]. Here, at last, we might however see a small encouragement. This energy range is since a long time a major problem area of neutron physics because no-one has managed to produce monoenergetic neutrons in this range, and because attempts to use continuous neutron spectra have met with almost insurmountable difficulties. G.B. Yankov [22]proposed to use the normal neutron sources, D-D, D-T and T-P reactions as well as alpha and ^{3}He incident particles to achieve improved data from continuous-spectrum neutrons by optimizing the incident particle energy. This seems very promising and, although the programme for making neutron cross section measurements at these energies might be a rather costly undertaking, the fact that the data is needed for a large variety of applications in fission as well as fusion reactor development may lead to that the experiments will be realized.

4. Non-energy applications

4.1 Activation analysis

Activation analysis techniques have found a large variety of applications in science and technology, from archeology and forensic studies to physiology and safeguards. The very nature of this technique as a tool, which is most often offered as a service to the community on a commercial basis, makes it primarily a matter of routine operations, but also a considerable rate of development and innovation can be noticed at present. [93]. The scope of the symposium was limited to new activation techniques which need, for feasibility or for further refinement, improvements in accuracies of nuclear data. It was, however, still felt to mean a somewhat pressed time-table to have only three sessions for the topic.

Ph. Albert [93] reviewed the state of the art in his presentation of "Modern trends in activation analysis". The need for nuclear data compilations was the subject of a survey presented by V. Kriván. [60]. Evidently the problem of availability of data, in this case, is primarily a matter of presenting data in handbooks of various kinds. As virtually every particle that can be produced can also be used for some kind of activation method, the volume of data that may be needed by the analysts encompasses practically all numerical data in nuclear physics and indeed a great deal of atomic data as well. Therefore the presentation of the data to the analysts is mainly a matter of selecting the data of interest to each individual branch of the field, according to which tools they use and which source of particles they have.

For neutron activation analysis, which uses a spectrum of neutrons in a reactor or from a neutron generator, one can distinguish between methods of two categories [36]. When the material to be analysed is qualitatively known, the analysis consists of a comparison with an irradiated sample of quantitatively known composition. These are relative measurements and therefore dependent only on relative data; here the needed data are mostly related to the flux determination in the positions of irradiation. When, on the other hand, the composition of the material is not known, a library of nuclear data is needed for identification of the isotopes in the sample as well; this concerns generally absolute methods. The limiting factor appears to be the accuracy of neutron capture cross sections and of absolute γ-ray intensities [36,32,77].

In contrast to the situation in neutron activation analysis the charged particle and photon analyses do not use a source consisting of a wide spectrum, but the probing particles (or photons) are of one or several dintinct energies. These methods have the advantage, that in optimum irradiation conditions the inaccuracies or other penalties arising from competitive reactions can be minimized. In order to determine the best conditions, however, a knowledge of threshold values and excitation functions is essential. The problem, as regards data, is in this case that useful compilations would have to be rather comprehensive [66,10]. In addition the stopping powers for charged particles appear to be essential [33], and where experimental data are missing the analysts must rely on calculations and estimates based on theory [10]. It was stressed by I. Mitchell [33] that stopping power measurements and evaluations are often subsidiary to the main purpose of a research project and the information will not be readily found in the literature on the basis of any existing documentation system such as the Nuclear Science Abstracts. Furthermore, it is most often not possible to separate between inaccuracies due to poor stopping power data from other sources of error. This is related to the apparent reluctancy on the part of experimenters, to give full information on the data that they used as input in their calculations.

Photonuclear (Bremsstrahlung) activation analysis can be used in the search for trace elements in copper ore. This technique was described in the paper by Sujkowsky [17].It can be taken as an example of an area where satisfactory user-oriented compilations are lacking. The application of the betatron, which is the facility used for this analysis, can be extended to other analyses as well and is claimed to be a versatile instrument in quality control for other industrial applications if the required tabulations of nuclear data were available.

The need for frequently updated handbooks of nuclear data with their contents carefully adjusted to each subfield of activation analysis was clearly demonstrated on several occasions during the symposium [60,11,48,SD].

4.2 Life sciences

The need for "handbooks" containing excitation functions was shown to be great not only for activation analysis. Also when using radioisotopes, for example, in medicine, such tables are necessary [3,71,70,92].The production of radionuclides is dependent upon knowledge of details of excitation functions of the nuclides involved in the process. In order to reach high abundance of a certain isotope it may be important to select an optimum energy of the particle source where the occurrance of competing reactions have relatively low probability. In the case of production of isotopes in a reactor, a detailed knowledge of the production cross section, particularly its resonance structure, is essential [92].The secondary captures represent most often a serious limit to the production of radioisotopes. With some techniques, such as circulating targets, the secondary capture can be brought to a minimum, but the details of the cross sections are essential in the preparatory analysis.

A major area of application of radioisotopes is the life sciences, particularly medicine. The use of radiopharmaceuticals is increasing at a very high rate at present. The requirements in purity are very strict for any agent which is to be introduced in the human body. Damaging impurities of chemical or radioactive nature must be excluded as far as possible. The generator produced radionuclides are particularly suited for medical applications [92].The "daughter" nuclide, with its short half-life, is chemically separated from the "parent" nuclide (with a longer half-life) at the location where (and immediately before) the isotope will be used. The radionuclide generator is a tool which provides short-lived isotopes with high specific activity, and which entails a minimum of undesired dose rate. For the development of techniques for the presently known generators - about a dozen have been reported - the data needed are half-lives, decay gamma energies, production reaction corss sections as well as similar data for interfering nuclides [92].Presumably the list of useful generators can be extended when the techniques have been further refined, but a great deal of nuclear data measurements properly summarized and evaluated in compilation work will be required. The attempts to predict the relative biological effectiveness (RBE) of neutron radiation with calculations have, so far, not been successful [59].That was ascribed to insufficient knowledge of certain categories of neutron data, which may appear a bit surprising. The energy distributions of secondary particles in the reactions (n,α), (n,p), etc. are needed for this purpose whereas for reactor applications such data is of secondary interest [59D].

In a few larger accelerators such as BLIP (200 MeV Brookhaven Linac for Isotope Production) and LAMPF (800 MeV Los Alamos Meson Physics Facility) higher energies and in some cases heavy ion bombardment have extended substantially the range of possibilities for medical physics development. Unfortunately, there was no paper presented at the symposium on the use of, and need for new data for application to problems related to medical application of facilities, although reference was made to them during the discussions [92D]. These made it evident that nuclear data requires considerable attention for this area of application, and it is probable that it will involve a substantial amount of new measurements.

4.3 Accelerator shielding

The Los Alamos Meson Physics Facility provided, however, a topic for a contributed paper during the session on accelerator and space shielding [45]. Deep penetration of neutrons, a characteristic of shielding design studies, represents a kind of neutron transport theory with its very particular features. Neutrons scattered elastically in small angles have lost nearly no energy in the process and remain part of the "direct" beam from the neutron source. Because of the strong anisotropies in scattering at higher energies it is essential that the angular distributions of the scattered neutrons are known with good accuracies. At a proton source energy of 800 MeV, LAMPF represents an extreme in neutron shield design studies. Various Monte Carlo techniques and the discrete ordinate method have been employed to analyse the transport of neutrons. At present it would seem as if point kernel and removal cross section techniques could be made adequately accurate. The basic data needed for this purpose is obviously the total neutron cross sections and the neutron elastic, inelastic, (n, 2n) etc cross sections, energy and angular distributions in the whole range from the upper end of reactor application ($\approx$ 14MeV) up to 800 MeV for a variety of shield materials.

The shielding calculations for the 500 MeV TRI-University Meson Facility (TRIUMF) show great similarities with those of LAMPF. The paper presented by I.M. Thorson[35] emphasized instead, however, the estimates of hadronic cascades, which involve - as far as shielding is concerned - the recourse to empirical formulae such as those by Rudstam and by Silverberg and Tsao for the activity production. Both the mentioned facilities will themselves, when they have operated for some time, have provided a great deal of experimental data needed in this area. For the future programmes at the same and other similar facilities it is imperative that the compilation and evaluation of the data follows in step with the experimental programme.

4.4 Space applications

The space applications of nuclear data are, at present, primarily a matter of space radiation shielding, and as such rather similar to accelerator shielding as described in the context of LAMPF and TRIUMF [42].The radiation environment is most complex near the sun while for missions outside the Mars orbit, as well as for all soft-landing missions, the primary source of radiation requiring shielding studies may be the man-made energy sources.

Of other applications in space the most important ones are in instrumentation, for example the X-ray fluorescence spectrometer (XRFS) planned for soil analysis on Mars with the Viking lander mission in 1975. X-ray data such as fluorescent yields, mass absorption and scattering coefficients are needed to the highest attainable accuracy. An improvement in present accuracies seems possible and would be highly welcomed for this application. Further instrumentation for future missions involve X-ray diffractometry requiring X-ray coherent scattering data, gamma-ray spectrometry, neutron detection, as well as ^{14}C tracer techniques. Most of these techniques are adoptions of geological assay methods, whereas the neutron detection will be used for evaluation of effects of cosmic radiation in atmospheres, and the carbon tracer is needed for studies related to the possibility of metabolic processes on Mars [42].

4.5 Other applications

Among various applications of nuclear data the tracer studies in industry attracted astonishingly little attention. Such studies related to nuclear data are mostly in the development of instruments. The large volumes of data involving gamma ray energies and intensities from neutron capture are sources of information for the calibration of solid-state detectors such as the Ge(Li) detector [23], but also for applications of assays in nuclear geophysics. [75,17].

5. Compilation and evaluation of data

5.1 Surveys of data needs

The authors of the well-known Table of Isotopes C.M. Lederer and J.M. Hollander have made a review of the nuclear data uses and needs primarily in the areas of application of radioisotopes [46]. The responses to their questionnaire indicated that this category of users, as expected, have two major sources of information: The "Table of Isotopes" and one of the several existing wall charts of nuclides. Significantly, even the very extensive simplification in the presentation of data in the "Table of Isotopes" seems not to go far enough for some users, and this was also brought out in the ensuing discussion. Evidently the wall charts should be able to provide one answer to the problem, but in spite of the fact that several such charts of different origin exist, (about half a dozen are currently used), there is no specialization of them for some broad areas of application. Unfortunately the authors of such charts were not well represented at the symposium. It remains a task for future international cooperation to attempt to find a better use of available resources.

Another survey of data use, with the help of a questionnaire - in activation analysis - has been made by H. Münzel and W. Michaelis; this was not submitted to the symposium but referred to in the discussions [11D] (it will be published as a report; INDC(GER)-12/U). That survey was made in conjunction with the publication of a compilation designed for users in the field of charged-particle activation analysis. H. Münzel[11] presented instead a paper about his compilation. He described the difficulties primarily related to the excitation function part of his compilation. Experimental cross section data compilations are almost non-existent in contrast to the situation for neutron data. A great deal of work on semi-empirical systematics must be done to close the large gaps of "missing" data [10,11]. This has been done quite successfully in this compilation to meet present reasonable needs, although it remains to be reviewed what further improvements should be made to meet the demands of all the different kinds of users.

5.2 Compilations of large-volume data sets

It is well known that gamma ray spectroscopy has been revolutionized by the introduction of the modern solid-state detectors such as lithium-drifted germanium and sodium iodide detectors. These high-resolution detectors have created a situation where the data compilers in the community have completely lost the race against the compact volume of experimental data [37].

Gamma lines in a spectrum provide a tool for "fingerprint" identification of small quantities of isotopes much the same way infra-red spectroscopy can be used for identification of chemical bonds, and one can find applications of absolute activation analysis wherever small concentrations need to be detected [44,76]. In addition the spectra contain substantial information about the level schemes of the nuclides. Safeguards and shielding are areas where neutron capture and non-elastic gamma-ray spectra will play an important role.

5.3 Data centres

The nuclear data centres have, and will increasingly have, a key role to play in the transfer of data from producer to user, as well as in the transfer of information on requirements back to the producers of data. The four neutron data centres * have functioned, for some time already, in this capacity on a world-wide basis [4]. The Nuclear Data Project at the Oak Ridge National Laboratory plays a similar role in the area of nuclear structure and decay data in about the same manner as the Brookhaven neutron data centre (at that time called Sigma Center) did until the other

* National Neutron Cross Section Center -Brookhaven, USA
Centr po Jadernym Dannym -Obninsk, USSR
Neutron Data Compilation Centre -NEA, Saclay, France
Nuclear Data Section - IAEA, Vienna, Austria

three centres' formation in the early sixties. D. J. Horen presented a review[47] of the Project's operations, status and plans. The Nuclear Data Project is the focal point for the interaction between many compilers outside and in the centre. The main product of the centre, the Nuclear Data Sheets, has been published at the average rate of about twenty A-chains per year during the last five years. The present rate is a bit higher, but the turn-around time for the evaluations is still of the order of ten years, which means that most of the Sheets are out-dated, and that a user must consider additional literature and make evaluations himself. Considering the tremendous tasks of the Project and the limited size of the centre, it is not surprising that the status is discouraging, but there are also reasons for some optimism. The collaboration between the Project and a few compilers/evaluators all over the world is encouraging, and it is clear that several "repackaged data" or application-oriented data compilations have been made possible by services such as the reference lists of the Project. The collaboration is still deeper in a few cases, such as with the Table of Isotopes (Hollander and Lederer) and the Atomic Mass Adjustment (Wapstra and Gove).

It was eminently clear already during the meeting of IWGNSRD in 1972 and confirmed during the symposium that the basic data compilations by the Nuclear Data Project and related groups are essential as input to most application-oriented compilations/evaluations. The most urgent goal in international cooperation is to assist the efforts of accomplishing more up-to-date basic evaluations like the Nuclear Data Sheets [47D,SD].

In the USSR two centres for nuclear data compilation were recently established; the Nuclear Structure Data Centre at the Leningrad Nuclear Physics Institute in Gatchina under the auspices of the USSR Academy of Sciences and the Centre for the Collection, Evaluation and Dissemination of Non-Neutron Nuclear Data at the Kurchatov Institute near Moscow under the auspices of the USSR State Committee on the Utilization of Atomic Energy. The centres' operations were described by I.A. Kondurov [25] and F.E. Chukreev [24] respectively. In the Soviet Union there is evidently an appreciation of the need for close international cooperation in this area, and appeals were made to IAEA to make efforts toward a coordination and sharing of work between its Member States, thus extending its sphere of active interest also to other-than-neutron data. Deputy Director General

A. Finkelstein stated that the Agency will explore its possibilities of contributing to progress in this area in consultation with INDC [SD].

5.4 Fission product data

The particular complexity of the problems in the area of fission product data was illustrated by the six papers on different topics related to fission products. The difficulties in evaluation of this kind of data call for a special effort to resolve some of the problems involved. Also, during the discussions, some of the basic approaches to evaluation of experimental data were, in a general way, subjected to scrutiny [94D]. IAEA will convene a panel meeting on Fission Product Nuclear Data, from 26 to 30 November this year in Bologna, to review the use and status and testing of these data and the "preview" which the symposium provided seemed to demonstrate the urgent need for such review.

5.5 Evaluated neutron data

Another example from and more specific to the neutron data field was provided in the session on evaluated neutron data files. In contrast to the fission product data this kind of data files are at the heart of the neutron data centres [50]. In the evaluation of neutron data, the centres play primarily a coordinating role. O. Ozer described the functions of the Cross Section Evaluation Working Group (CSEWG) in USA and its relationship with the user community [50]. The evaluated data file ENDF/B represents a large investment of funds and manpower, and the whole framework of the cooperation between many institutes for the evaluation of the data is indeed complex. Also during this session there was a great deal of discussions on principal questions in the evaluation process. [38D]. There was, for example, interesting discussion on the influence of integral data on the evaluation of differential data. This discussion reflects the differences between the approach of national programmes in different countries, and we have certainly not yet heard the last word in this discussion.

6. Symposium summary

The final session began with a paper by W.B. Lewis [98] summarizing the symposium, and leading the panel discussion on the topic "Where does nuclear data go from here?" W.B Lewis concluded that the tasks facing the compilers are great, and an international cooperative approach would be the only way in which some of the urgent problems can be resolved. The subject matter of the symposium being of an unusual kind, he felt that the meeting had brought out a great deal of new information and better understanding of the problems related to the compilation and evaluation of nuclear data. On the basis of the papers presented and the discussions which had taken place, it should be possible to begin purposeful work on improving the situation in nuclear data compilation, preferably in international cooperation.

The panel discussion [SD] took up, among other subjects, the problem of how best to establish the feedback of information on needs for data, for compilations, etc. from data users to the producers. Request lists such as those existing in the neutron data field are useful but have certain limitations, and also other means of channeling the feedback information should be explored. Obviously the information feedback mechanism for non-neutron nuclear data should be adapted to each particular field of application. The emphasis should be on <u>data</u> rather than measurements, as the review of the need for some particular kind of data would usually entail both measurement and evaluation; the two can often not be separated.

The role of IAEA in the task of coordinating national activities as well as encouraging the links between basic and applied compilers was emphasized. The restructuring of national as well as international nuclear data committees was welcomed, and the participants left the symposium with a distinct feeling that there is reason for a certain amount of optimism. The importance of the basic compilations to the applied fields was demonstrated with unexpected clarity, and the subject for urgent action on a world-wide basis to improve the situation in the area of nuclear structure and decay data remains the, by far, most important conclusion of the symposium.

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