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DESCUSSION OULY

COMPILATION ACTIVITIES OF THE IAEA

IN, THE FIELD OF NUCLEAR DATA

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ABSTRACT

With primary emphasis in the field of data (cross-sections, etc.) for neutron interactions important to the design of reactors of various types, a system of compilation is discussed in terms of (a) the collection of "raw" data from experimenters, (b) its analysis and the coordination of various measurements of the same or related quantities, as well as "gap-filling" where insufficient measurements exist, and (c) of preparation of the resulting data for use in particular types of reactor calculation. Possible rôles for the IAEA in these connections are considered, and wider areas of possible activity are briefly discussed. Finally, the rossible initiation, with Agency support, of international activities in the field of compilation at a location or locations to be decided, is discussed.

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1. Introduction

In a previous IAEA panel (Dec 1961) several possible types of activity in connection with Nuclear Data were discussed. Activities of the committee types - for co-ordinating measurement programmes, e.g., or for exchanging lists of measurements needed or of facilities for measurements - are not considered in the present document; they are a separate part of INDSWG's activities. In the matter of compilations, one suggestion which emerged in December 1961 was that the Agency set up an "indexing" system to aid the actual compilers of data - this was a proposal covering a quite wide area within nuclear physics. Other alternatives will involve a deeper cultivation of what would - initially at least - have to be a narrower area of the field. It would appear reasonable, if a more narrowly-defined field is to be selected, to choose those nuclear data which are of more immediate importance to the peaceful uses of atomic energy - in the present context this means reactor design. The needs of other peaceful uses - thermonuclear, for example - can be similarly treated as and when they become clear.

In the present paper, therefore, we concentrate on proposals involving the actual handling of numerical data in a restricted field - which incidentally should include "indexing" within this field.

2. Compilation centres and their function

There are already several contres involved in compilation work of this type and we need to ask why another one is required. At Brookhaven, for example, BNL-325 has become almost a periodical, and a number of other laboratories have produced other compilations at various times with varying scope and emphasis. The primary case for an agency centre for, or activity in, compilation of nuclear data, is to ensure that data from all countries is readily available, either to compilers or in a compiled form, on an equal and reciprocal basis. In principle this is easy and occurs automatically, through scientific journals and otherwise, but in practice this is not always so. The technical developments of recent years, exemplified by the use first of 100-channel and more recently of 2048- and 4096-channel time-analysers, and other related and similar equipment, is rapidly changing the picture. With increasing experimental resolution, the mass of data to be compiled is continually increasing at an ever-increasing rate; journals no longer can print (even in the compressed form of small graphs)

the full information gained in many investigations, and only occasionally a laboratory report listing all the numbers obtained from a measurement becomes generally available. Even if it is, modern methods of data-handling on this scale involve the use of a punched paper tape or of cards (or an equivalent) and a number-listing is an awkward chain in any numerical processing procedure.

It must, of course, be asked whether the data for reactor design need pass through such a procedure - whether this multiplicity of numbers is actually needed. Cortainly a technical journal may well contain only a simple conclusion, such as "within the statistical accuracy of this work, the level density of either spin state is proportional to 2J + 1". If that is all the thousands of numbers have achieved, and the rest of the detailed information obtained in the experiment is not needed, then indeed compilation is a relatively simple matter. However, our intention is that, at least for major constituents of a reactor including the fuel (fissile and fertile isotopes), moderator (if any) and structural materials, all the detailed cross section (or similar) information obtained from experiments should be considered as valuable - to a degree of detail which depends on the neutron energy - and should be available both to other experimenters in the same field and to reactor designers or their intermediaries, the special-purpose compilers of data for reactor design.

THIS POINT MERITS SOME DETAILED DISCUSSION.

3. Stages of processing data for reactor calculation

From the previous discussion it should become clear that the measured data can be handled in a number of ways, e.g. by giving a detailed curve (cr its numerical equivalent) as a function of energy or by quoting only resonance parameters, or by a combination of both (e.g. stating $\sigma(E)$ in detail only at the lower energies).

Whichever method is adopted, the following stages are involved

(1) Reduction of experimental results (correcting for intensity variations, subtracting background etc.) to a form which can be called "<u>raw_data</u>".

Note: perhaps we should include an even earlier stage (called stage (0)),viz., knowing what has been measured and by whom - this is the "<u>indexing</u>" function mentioned above.

(2) "Digestion" of raw data - this may include

(a) Coordination of the results of different experimenters' results for the same, or related $(e \cdot \underline{e}, \underline{\sigma}, \underline{\sigma}, \underline{\eta}, \underline{\alpha})$ quantities. It may also include re-normalization in some cases

(b) choosing suitable presentations - parameters, detailed information, etc. - for various energy ranges, designed to facilitate stage (3).

(c) assigning numerical values to parameters when used, and

(d) producing "best guess" values from theory or interpolation for energy ranges where the measurements have not yet been made, or are of inadequate accuracy or resolution.

(3) "<u>Preparation</u>" of data for particular reactor computations or types of reactor computation (e.g. multi-group constants, or for particular digital computer codes).

It may be noted that in this system BNL-325 must be regarded as including some "digestion" features in so far as a single curve is chosen through many points often deriving from several different experiments - also in listing "world's best values" for the principal fissile isotopes.

None of the subdivisions of the work proposed above is actually clear-out; they are put forward to guide discussion. Nor are the broad outlines of this system of categories put forward as original - they have been discussed already in several national and international data committees.

4. Existing compilation activities and IAEA proposals

The International Atomic Energy Agency believes that it can play a useful role in the field of nuclear data, but it does not wish to try to supersede presently existing

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data-compilation centres - rather it would like to cooperate with them. It may be that a regional centre for "raw data" in Europe would be a useful addition to what is now available, and in such a rôle it would hope to cooperate with the existing centre in the US and any other similar centres which may exist. Such a centre could be a mail-box with "indexing" and perhaps data-filing facilities, perhaps storing numerical data on magnetic tapes in computing machine (e.g. IBM) format, as well as on punched cards and/or punched paper tape.

It would be foolhardy, however, to deny that difficulties exist - it is understood that some of these difficulties are felt even at the most firmly established centres. Primarily they are problems of shortage of skilled manpower and of the psychology and value-system of physics. If the work contemplated is mere librarianship of data, not too much skill may be needed but probably little or none will be available - such work is not inherently attractive to a physicist. Therefore no results or at least no worth-while results - would accrue from setting up such a data collection centre; existing centres might do the job better. Only the indexing function, perhaps, if sufficiently complete, might be useful. But the problem of collecting data from experiments and arranging compatible formats is not in fact, at the present time, as straight-forward as it might appear, and in the absence of some well-qualified staff it is probable that nothing useful would happen.

It is therefore proposed to investigate whether the IAEA, by providing a budgetary and personnel nucleus, could act as a catalyst in setting up an international data compilation centre, presumably in Europe. The hope would be that cooperation with the staff of the host-country's laboratory, and with the support of IAEA fellowships plus the attachment of staff from time to time from other interested countries, a worth-while activity would result. Vienna is not prescribed as the site of such operations for reasons to be given later.

Such a centre, to be worth-while, must be above a certain "critical size". Also, it should be in a location which would be attractive in itself, to aid in the recruitment (for shorter or longer terms) of staff and visiting physicists; the academic respectability of compiling or digesting data for the mundane (if peaceful) applications of nuclear physics is so low that some counteracting incentive is needed - one might say essential if staff of adequate quality is to be attracted on a continuing basis. The occasional devoted individual or lucky accident is no adequate basis for a practical institution in the world of today. It is proposed for discussion that such a centre, to have a reasonable hope of success, must also be located in close proximity (physical and intellectual) to an active research centre where there exist both good computation 1 facilities and where work is in progress using neutron time-of-flight techniques of an advanced type for data measurement - preferably both for higher (Van-de-Graaff) and lower (fast chopper or linke) neutron energy ranges. We assume - subject to investigation - that an international team could be accommodated in at least one such location in Europe, and that local cooperation and access to facilities would be forthcoming. On this basis the IAEA is currently asking for a financial provision to initiate such a centre.

5. Proposed or possible functions of such a centre

If finances and a location with suitable facilities is available, all that is needed is staff. In order to attract good staff, a too closely defined programme is undesirable, and it is suggested that within the field of "digestion" of data the four subheadings (a) to (d) of (2) of § 3 above should be adopted and work carried on within these fields according to the abilities, inclinations and specialities of the staff available at any given time - some latitude being given for other relevant theoretical investigations. Only a general directive aiming at dealing with the more useful type of data should be imposed. Thus if a resonance analysis technique using a digital computer had been developed, it would be silly to confine its use to Al, Fe, Zr, Pu and U because these were the important reactor materials - work on (say) Pr of Pm or some other isotopes or elements should also be undertaken if suitable data existed, and the staff wished to do it.

The work of the centre would of necessity include some operations within the field of stage (1), collecting raw data; however the "preparation" stage (no (3) of § 3 above) is not specifically proposed as part of the programme of the centre since most preparation programmes are specific to particular reactor applications, and are thus less suitable as a basis for international cooperation. Naturally, however, any country especially interested in this work could attach some member of its own staff to work with the centre with particular problems in mind. The end product of stage (2), and therefore generally of the international centre, should be a complete statement of the variation of the cross section or the quantity concerned as a function of energy, in as much detail as possible or necessary over the useful range of energy, generally up to about 10 or 15 MeV. Since the original experimenter would have to produce the raw data, the main function of such a centre as far as stage (1) ("raw data") was concerned would be to ensure that such data was collected and filed (with the experimenter's remarks on reliability, etc.); it would also attempt, as far as possible, to collect the data in some uniform format or in one of as few formats as possible, depending on the type of measurement concerned. This is not altogether straight-forward problem and would probably involve (at least initially) some quite detailed discussions. "Indexing" would be an automatic by-product of this activity, but should be somewhat extended to cover related types of data even though multi-channel time-of-flight techniques - and the concomitant numerically complex results - were not involved.

It is hoped that one of the attractions of such a centre would be the availability of special data-handling programmes at a computer site, together with libraries of previous measurements, so that attractive possibilities would exist for visiting staff to reanalyse or coordinate existing data, or check theoretical predictions against these - and in particular experimenters might be encouraged to bring their newly-measured data to such a centre and analyse it there hopefully they could also be persuaded to co-ordinate it with older similar or related measurements and produce a re-digested version of the quantities concerned. Otherwise there is a real danger of results which have actually been obtained not being reduced into an available form simply due to the load represented by the data-handling operations on the time of the experimenter concerned.

6. Discussion and conclusion

The above is proposed for discussion. It is realized that the location of this work is a subject where there may be conflicting requirements; as a communication centre Vienna has advantages but for more detailed work in the "digestion field" a flourishing research atmosphere is demanded. The IAEA would welcome support for proposals in the lines outlined, and would hope to be able to give some support in the way of staff and facilities but only on a modest scale, which it is hoped could be augmented by collaboration and attachment. Even with such augmentation however, it is not intended to sponsor anything large enough to be called a separate Laboratory or Institute. No attempt has been made to discuss detail, e.g. of the formats suitable or to be used in recording data. Also, the form of any publications to be issued would have to be discussed among experts - whether lists or graphs of the actual data available, or of samples of this, or of data sources and a catalogue of what was held in archives, for example. Advice would be sought on such matters, and the methods in use or planned to be adopted in already-established compilation centres would of course be taken into account. But more important for discussion at this time are the relation of these proposals to work in progress already, as well as all the general factors involved in the practicability, and within practicable limits, the choice, of possible or desirable locations for such operations.

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