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INDC INTERNATIONAL NUCLEAR DATA COMMITTEE

SIXTH MEETING OF THE IFRC SUBCOMMITTEE ON ATOMIC AND MOLECULAR DATA FOR FUSION

IAEA Headquarters, Vienna

27-28 September 1990

SUMMARY REPORT

Prepared by R.K. Janev

March 1991

IAEA NUCLEAR DATA SECTION, WAGRAMERSTRASSE 5, A-1400 VIENNA

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Abstract

The 6th Meeting of the IFRC Subcommittee on Atomic and Molecular Data for Fusion was held on September 27 and 28, 1990, at the IAEA Headquarters in Vienna. The present Summary Report contains a brief Proceedings and the Conclusions and Recommendations of the Meeting.

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1. INTRODUCTION

The 6th Meeting of the IFRC Subcommittee on Atomic and Molecular (A+M) Data for Fusion was convened on September 27 and 28, 1990, at the IAEA Headquarters in Vienna. The Meeting was opened by Dr. J.J. Schmidt, Head of Agency's Nuclear Data Section. The Meeting was attended by the all members of the Subcommittee and two representatives of the IAEA A+M Data Unit (AMDU) professional staff (see Appendix 1: List of Participants). Dr. Y. Kikuchi, as a new member of the Subcommittee from JAERI, Japan, successor of Dr. N. Shikazono, was cordially welcomed in the Subcommittee membership. After adoption of the Meeting Agenda (see Appendix 2), the Meeting was chaired by Dr. R. McKnight, the IFRC A+M Subcommittee chairman.

2. MEETING PROCEEDINGS

2.1. Report to the IFRC and IFRC Recommendations Related to A+M Data Activity

In his introductory talk, Dr. R. McKnight provided information on his report given at the 27th IFRC Meeting (January 1990) on A+M data activities (see Appendix 3), and on the positive reactions of the IFRC to the report. He reminded the Subcommittee of the two IFRC recommendations regarding a) increase of the IAEA AMDU manpower by one professional (recommendation to the IAEA Director General), and b) finding ways for enhancement of the co-operation of IAEA AMDU and DCN with the ITER Team (recommendation to the Subcommittee). With respect to the first recommendation, the necessary action has already been taken (through Dr. Brennan, the IFRC Chairman) resulting in a positive response of the IAEA: a new p-4 professional position has been attached to the IAEA AMDU, effective as of Spring 1992. Regarding the second IFRC recommendation, a letter by Dr. R. McKnight was sent to Dr. Tomabechi (chairman of the ITER Managing Committee) initiating appropriate actions. No reply was received to that letter.

2.2. Report on the IAEA AMDU and A+M DCN Activities

The Head of the IAEA A+M Data Unit reported on the Unit's and A+M DCN activities in the period September 1988 - September 1990. The report covered the status and achievements in all major areas of activity (bibliographic and numerical databases, ALADDIN system development, data publication, exchange and dissemination) and also included an analysis of the current manpower situation in A+M DCN and future AMDU and DCN activity plans. The full text of the Report is given in Appendix 4. The Subcommittee with satisfaction took note of the recent expansion of A+M DCN membership (15 co-operating centres and groups within the Network), consolidation of the programmatic scope of data compilation and evaluation activities, definitive establishment of ALADDIN as a data storage and exchange system, enlargement of the co-ordinated data evaluation and data generation base (about 40 laboratories and groups outside DCN are involved in these activities and 60 participants/year take part in IAEA organized meetings), increased output of compiled and evaluated data, and strengthening the interaction with the fusion community. The report has been approved and the AMDU and DCN activities were assessed as highly successful both in terms of performance and usefulness to the fusion programme. The Subcommittee then analyzed and discussed in more details the most important areas of AMDU and DCN activity, the scope and priorities for the future work (having also in

mind the long-term ITER R+D programmes), and formulated specific recommendations to the AMDU, A+M DCN and the IAEA regarding the discussed matters. The summaries of these discussions are given below.

2.3. Numerical Databases

The present IAEA databank for fusion consists of two types of evaluated data: collisional A+M data and particle-surface interaction (PSI) data. All data are ALADDIN formatted and stored in the ALADDIN system. The list of evaluated data files is given in Attachment 1 of Appendix 4. Not all of these data have status of "recommended" data. Nearly complete databases exist for H, He, H_2, H_2^+, C^{q+}, O^{q+}, Fe^{q+} and e-Ti^{q+}, as well as for physical sputtering and backscattering involving hydrogen and helium isotopes and self-ions on fusion relevant elemental materials. The up-dating of these databases is a continuing activity of the IAEA AMDU. All available evaluated data files have been distributed to over 70 data users, together with the ALADDIN Manual.

The Subcommittee strongly endorsed the orientation of the A+M data centres and the IAEA AMDU in producing evaluated sets of data, along with their data compilation work. It has also been strongly stressed that, besides producing evaluated databases on classes of processes (e.g. the recommended data file on electron impact ionization) or specific elements, or group of elements, (e.g. the databases for C^{q+}, O^{q+} and Fe^{q+} ions), production of purpose-oriented databases (such as that for H-beam penetration into fusion reactor plasmas) for direct use in specific fusion application should also be pursued. Examples of such purpose-oriented databases would be databases for Li- and He-beam penetration, radiation cooling rates for the common impurities, hydrogen recycling, etc.

2.4. ALADDIN System

The establishment of ALADDIN as a data storage and exchange system represents an important achievement of the A+M data activity during the last two year period. The present structure of ALADDIN, containing spectroscopic, A+M collisional and PSI data blocks, was regarded as adequate for the present scope of data storage and exchange needs. The Subcommittee suggested a firm consolidation of the system in the data centre practices within DCN and in the data exchange with fusion research users. In this context, the Subcommittee agreed with the conclusion of the 9th DCN Meeting on keeping the ALADDIN structure "frozen" for a certain period of time.

2.5. Data Compilation and Evaluation Activities

The Subcommittee reviewed the data compilation and evaluation activities carried out by the A+M data centres and IAEA AMDU during the past two years. (A list of the highlights of these activities is given in Attachment 3 of Appendix 4). In view of the limited manpower and funding situation in the data centres, this activity was assessed as highly successful. The data evaluation part of this activity (which partly depends on expertise outside the data centres) is directly related to the available funding level, and under the present funding conditions, it is not quite adequate to follow the dynamics of fusion A+M data needs. The Subcommittee, therefore, strongly endoreses the orientation and the actions of the IAEA AMDU to make use of the existing

Agency's mechanisms (co-ordinated research programmes, research contracts, experts' meetings, visiting experts, and individual consultants) to enhance the data evaluation effort.

2.6. Co-ordinated Research Programmes and Research Contracts

The purpose of Co-ordinated Research Programmes (CRPs) and the Research Contracts (RCs) is to provide additonal support to the data compilation and evaluation activities and to generate required data for fusion which either still do not exist or have inadequate accuracy. The RCs usually complement the content of CRPs or are selected to fulfill certain specialized tasks.

The Subcommittee discussed the progress made so far within the CRP on "A+M data for fusion edge plasmas" and endorsed the publication of an interim report on the results of this CRP in the "Nuclear Fusion Supplement on A+M and PSI data for fusion" next year. The Subcommittee was informed that the CRP on "Plasma-interaction induced erosion rates of fusion reactor materials" has started its work in August with 11 participants, and that the earlier recommended CRP on "Atomic data for medium- and high-Z impurities" has just been initiated.*

The Subcommittee endorsed the scope and objectives of these CRPs. The Subcommittee took note of the subjects and research objectives of Research Contracts granted to laboratories from developing countries. (A List of the Research Contracts and their principal investigators is given in Attachment 4a of Appendix 4).

2.7. Experts' Meetings and Visiting Consultants

The Specialists' Consultants' and Advisory Group Meetings organized during the 1989-1990 period for co-ordination and in support of data compilation, evaluation and generation activities served well their purpose. The high attendance of these meetings (on average 15 to 20 participants per meeting), despite the lack of Agency's support for at least half of them, is a good indication of the viability of the data programmes and established strong interaction with atomic and fuison communities. The subjects of the experts' meetings (see Attachment 4b of Appendix 4) adequately reflect the priorities in the present scope of data activities.

The Subcommittee finds also highly useful the practice of inviting consultants on individual basis to assist the IAEA AMDU in the data evaluation work (Drs. E.W. Thomas, W. Eckstein during 1990) and ALADDIN development (R. Hulse, A. Faenov, during 1990).

2.8. Bibliographic Database

The Subcommittee took note of the regular, bi-annual bibliographic publication of the "International Bulletin on Atomic and Molecular Data for Fusion", the input for which comes mainly from the Oak Ridge A+M data centre. Small additions to this input also come from the Kurchatov Institute and AMDU, and non-systematic coverage check-ups are done with the GAPHYOR Bulletin.

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* This CRP has been in the meantime approved by the IAEA Director General.

Publication of CIAMDA III is to be decided on the basis of a substantial accumulation of A+M bibliographic material and the availability of manpower in the IAEA AMDU. It would be convenient if the publication of CIAMDA III is synchronized with the large Technical Committee Meeting on "A+M and PSI Data for Fusion Reactor Technology" planned for 1992.

2.9. Data Publications

The Subcommittee was informed about the publications of data centres containing compiled or evaluated data which appeared during the last two years. (A List of these publications is provided in Attachment 5 of Appendix 4). While the volume of compiled/evaluated data is impressive, it is necessary to subject the data to an international quality assessment procedure to arrive at recommended sets of data.

The Subcommittee was also informed about the preparation of the first two volumes of the "Nuclear Fusion Supplement on Atomic and Plasma-Material Interaction Data for Fusion". The first of these volumes scheduled for the end of this year, will contain data on PSI processes, while the second will be devoted to A+M data for fusion edge plasmas. The preparation of the compendium on recommended atomic database for H-beam penetration into fusion plasmas by the IAEA AMDU is in a final stage, and the Subcommittee endorsed the adopted format.

2.10. Programmatic Scope and Priority Strategy of Future Data Activities of IAEA AMDU and DCN

The current programmatic scope of IAEA AMDU and DCN data activities includes:

a) Spectroscopic and collisional A+M data for all major plasma constituents (including impurities) and processes,
b) Data related to all particle-surface interaction (PSI) processes, defining impurity generation, material erosion and hydrogen (helium) retention and release.

Apart from this, the IAEA AMDU is exploring the possibilities for establishing a co-ordinated activity on compilation and evaluation of plasma-material interaction data related to the thermal response of plasma facing materials.

While recognizing the strong interrelation of the above three data areas for a self-consitent analysis or modelling of the performance of several critical reactor subsystems, the Subcommittee underlines the differences in the character of the corresponding databases and the diversity of required expertise. The experience with the compilation and evaluation of PSI data in part of the DCN is quite extensive (ORNL, NIST, JAERI, recently also Kurchatov Institute), and the initiated activity on establishment of recommended databases for PSI processes has already produced the first results (nearly finished databases for sputtering and backscattering, CRP on erosion rates). Regarding the activity in the area of thermal response of plasma facing materials, the Subcommittee has adopted the conclusions and recommendations of the Consultants' Meeting on "Thermal Response of Plasma Facing Materials and Components" (Vienna, 11-13 June, 1990; Summary Report, IAEA(NDS)-237/M6, pp.10-11). (This Consultants Meeting, recognizing the need for a systematic compilation and critical evaluation of the existing data on thermo-mechanical

properties of plasma facing reactor materials, has recommended co-ordination of such an activity by the IAEA. The suggestion of that Meeting was to postpone a similar IAEA activity in the data generation area until future developments show that such an activity would be beneficial).

Within the above scope of activities, the Subcommittee adopted the following priorities in the near-term and medium-term programmes of the DCN and IAEA AMDU:

A) Near-term programmes (1991-1992)

1) A+M data for edge plasmas (continuation of the ongoing CRP),
2) Atomic data for medium- and high-Z impurities (in particular for Si, Ti, Ni, Mo and W; with continuing improvements of the existing Fe database),
3) Establishment of A+M databases for Be and B,
4) He-beam database for alpha particle diagnostics,
5) Erosion rates for plasma facing materials (ongoing CRP),
6) Radiative cooling rates for Be, B, C, O, Ti and Fe.

B) Medium-term programmes (1993-1998)

a) A+M data activities

1) Databases for medium- and high-Z impurities,
2) Specialized databases related to power and particle exhaust (e.g. cooling rates for medium- and high-Z impurities),
3) Databases for specific impurities related to the materials of the innovative divertor concepts (e.g. Ga, Li, Sn, ..., if interest for such concepts is increased).

b) PSI data activities

1) Databases for hydrogen and helium recycling (combined A+M and PSI processes),
2) PSI processes related to hydrogen isotope trapping and detrapping (data collection and critical analysis),
3) Erosion data for new candidate divertor plate materials (as become identified).

c) PFM data activities

- Co-ordination of the efforts on collection and critical evaluation of thermo-mechanical data for plasma facing materials.

The above priorities are set by an analysis of the anticipated needs in the research on the upgraded versions of currently operating machines (JET-next phase, JT-60U, ASDEX-U, ...) and on the basis of elaborated ITER R+D long-term programmes (see Appendix 5).

2.11. Meetings planned for 1991 and 1992

In order to implement the near-term programme outlined in 2.10, the organization of the following meetings by the IAEA AMDU has been recommended (or endorsed, if previously planned):

Meetings in 1991

1. 1st RCM on "Plasma-interaction induced erosion of fusion reactor materials",
2. CM on "A+M database for Be and B impurities",
3. AGM "10th A+M DCN meeting",
4. AGM on "A+M data for medium- and high-Z impurities",
5. CM on "He-beam database for alpha particle diagnostics".

Meetings in 1992

1. 2nd RCM on "Plasma-interaction induced erosion of fusion reactor materials",
2. 2nd RCM on "A+M data for fusion edge plasmas",
3. AGM: "11th DCN Meeting",
4. TCM: "7th IFRC Subcommittee meeting",
5. CM on a subject related to ITER R+D short-term needs (subject to be determined by the IAEA AMDU),
6. TCM on : "A+M and PMI data for fusion reactor technology".

Detailed objectives of these meetings are given in Appendix 6. It has been agreed that the TCM on "A+M and PMI data for fusion reactor technology" should have the character of the two major similar meetings held in Culham (1976) and Fontenay-aux-Roses (1980), should summarize the current status of A+M and PWI databases for fusion, analyze the international co-operation on data production, collection and evaluation, and determine the long-term objectives of this activity in the context of fusion reactor design needs. About 50-60 participants should be invited to the meeting and it should be held at one of the major fusion laboratories.

2.12. Relation to the ITER EDA R+D programmes

Despite the fact that no immediate decision can be expected on the continuation of ITER CDA into an ITER EDA phase after the termination of the current ITER CDA phase in December 1990, the Subcommittee shared the opinion that the established ITER long-term R+D programmes adequately reflect the critical physics and technology areas in the fusion reactor development for which additional database information is required. The ITER R+D programmes may, therefore, serve as a guidance for the selection of the priorities in the DCN and IAEA AMDU data activities.

If and when the decision regarding ITER EDA will be taken, the IFRC Subcommittee, in line with the IFRC recommendation mentioned in 2.1, will consider in detail the possibilities and the forms of a stronger programmatic correlation and involvement of A+M and PWI data activities with the ITER R+D programmes.

2.13. DCN manpower situation

The Subcommittee analyzed the manpower situation in the Data Centre Network (Appendix 7) in view of the volume of the A+M, PSI and PMI data needs in the current fusion research and, in particular, with respect to the increased data requirements of the ITER R+D programme. Both the volume of required A+M, PSI and PMI data and the time scale on which these data should be provided to the fusion research community indicate that the current manpower potential in the data centres is insufficient to meet the data demands. An increase of the manpower in the data centres by 50% is recommendable if the needs of ITER EDA for A+M and PSI data are to be met effectively and in a timely manner.

3. Summary of the Meeting Conclusions and Recommendations

The main conclusions, endorsement and recommendations of the Subcommittee meeting are summarized as follows:

1) Despite the manpower and funding problems, the A+M Data Centre Network and the IAEA AMDU in the past two year period have produced remarkable results in terms of data compilation and evaluation, mutual co-ordination of the activities, firm consolidation of the ALADDIN data storage and exchange system and provision of data to fusion community.
2) The growth of the A+M DCN membership and the enhanced interaction and co-operation with the atomic physics community are positive elements in the development of the A+M data activity and instrumental for the increase of the volume of numerical databases and data generation for fusion. The orientation of the IAEA AMDU on involvement of atomic physics community in the data production and evaluation activities through Co-ordinated Research Programmes, individual research contracts and experts' consulting is strongly endorsed.
3) Production of numerical recommended databases remains the main objective of this activity, and enhancement of the data evaluation work should be further pursued. The present level of the bibliographic data activity is adequate.
4) The present scope of the data activity is programmatically coherent and covers in a self consistent manner a broad number of mutually related fusion research and reactor design issues. Expansion in the area of material properties data should be limited to plasma facing components and be kept within the recommendations of the Advisory Group on "Thermal Response of PFM" (IAEA(NDS)-237/M6).
5) It is recommended that the near-term priorities defined in Section 2.10, be implemented as fully as possible. The meetings endorsed for 1991 and 1992 (Appendix 6) serve this purpose.
6) At its present level, the manpower potential in the Data Centre Network is insufficient to provide a dynamic response to the growing A+M data needs of fusion research. Meeting the A+M data needs of ITER EDA would require a 50% increase in the DCN manpower.
7) In order to ensure an effective implementation of the near-term programmes defined in Section 2.10, the Subcommittee recommends to the Director General:
   a) Extension of the duration of the current CRP on "A+M data for fusion edge plasmas" for additional two years (due to its strong relevance to the ITER design),
   b) Reclassification of the Consultants' Meeting of the A+M DCN into an Advisory Group Meeting* (due to a substantial increase of the DCN membership).

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* In the meantime, this recommendation has been endorsed by the IAEA Director General.

Appendix 1

6th Meeting of the IFRC Subcommittee on
Atomic and Molecular Data for Fusion

September 27-28, 1990, Vienna

LIST OF PARTICIPANTS

Dr. V.A. Abramov	Institut Atomnoi Energii I.V. Kurchatova, Ploshchad I.V. Kurchatova, Moscow D-182, 123182, U.S.S.R.
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Dr. M.F.A. Harrison	AEA Technology, Reactor and Strategic Studies Division, Culham Laboratory, Abingdon, Oxfordshire OX14 3DB, U.K.
Dr. Y. Kikuchi	Nuclear Data Center, Japan Atomic Energy Research Institute (JAERI), 2-4, Shirakata-Shirane, Tokai-mura, Nakagun, Ibaraki-ken 319-11, Japan
Dr. R. McKnight	Division of Applied Plasma Physics, ER-542, GTN, U.S. Department of Energy, Washington, D.C. 20545, U.S.A.
Prof. A. Miyahara	National Institute for Fusion Science, Nagoya 464, Japan
Prof. R.K. Janev	IAEA, Atomic and Molecular Data Unit, Wagramerstrasse-5, P.O. Box 100, 1400 Vienna, Austria
J.J. Smith	IAEA, Atomic and Molecular Data Unit, Wagramerstrasse-5, P.O. Box 100, 1400 Vienna, Austria
Dr. J.J. Schmidt	IAEA, Nuclear Data Section, Wagramerstrasse-5, P.O. Box 100, 1400 Vienna, Austria

Appendix 2

6th Meeting of the IFRC Subcommittee on
Atomic and Molecular Data for Fusion

September 27 and 28, 1990, Vienna, Austria

MEETING AGENDA

Thursday, September 27

09:30 - 09:45: Opening

Session 1: Introductory Items

09:45 - 10:00:
- Adoption of Agenda
- Subcommittee Membership
- Election of Meeting Chairman

Session 2: Report on IAEA AMDU and A+M DCN activities

10:00 - 10:30: Report of A+M Data Unit Head

10:30 - 11:00: Coffee break

Session 3: Programme implementation

11:00 - 12:30: Analysis of programme results and activities status

1. Status of databases
2. Status of ALADDIN system
3. Current data compilation and evaluation activities in AMDU and DCN

12:30 - 14:00: Lunch

Session 3: Programme implementation (Cont'd)

14:00 - 15:30: Continuation of analysis on:
4. Data generation and evaluation activities within CRPs and research contracts
5. Bibliographic database. CIAMDA III
6. Data publication. (Data handbooks, compendia, Nucl. Fus. Supplement Series)

15:30 - 16:00: Coffee break

Session 4: Future programmes

16:00 - 18:00:
1. Near-term programmes (1991/92): programmes, priorities
2. Mid-term programmes (1993-1998): scope, directions, activities, policies
3. Meetings for 1991/92

Friday, September 28

Session 5: Relation to ITER

09:00 - 10:30: Involvement in ITER EDA R&D programmes
1. Formal aspects
2. Ways and areas of support to ITER EDA
3. Funding of ITER-related A+M data activities

10:30 - 11:00: Coffee break

Session 6: AMDU and DCN manpower situation and required improvements

11:00 - 12:30: Analysis of present and required AMDU and DCN capabilities for implementation of future A+M data programmes

1. Present manpower and funding situation
2. Assessment of required increase in AMDU and DCN potentials for impolementation of future programmes

12:30 - 14:00: Lunch

Session 7: Concluding discussions and administrative items

14:00 - 16:00: Summary of Meeting conclusions and recommendations

Administrative items: Subcommittee membership changes, next meeting

Appendix 3

Report of the IFRC A+M Subcommittee Chairman at the
27th IFRC Meeting (January 1990)

REPORT TO THE IFRC/IAEA MEETING FROM THE IFRC SUBCOMMITTEE ON ATOMIC AND MOLECULAR DATA FOR FUSION VIENNA, AUSTRIA JANUARY 25-26, 1990

Ronald H. McKnight, Chairman

INTRODUCTION

The IFRC Subcommittee on Atomic and Molecular (A+M) Data for Fusion met in Vienna at the IAEA facility in October 1988. At that meeting, a number of recommendations were made to the IAEA regarding ongoing and proposed activities of the Atomic and Molecular Data Unit (AMDU) during the ensuing 2-year period. The purpose of this report is to briefly discuss selected activities of the AMDU, to address the response of the AMDU to the recommendations, and consider proposed activities during CY 1990. The Subcommittee has met on a bi-annual basis, and the next meeting is planned for fall 1990. Attached to this report is a list of the current Subcommittee members and a summary of the 1988 meeting.

ATOMIC AND MOLECULAR DATA UNIT ACTIVITIES

This section will only highlight selected activities of the AMDU as it is anticipated that a more complete report will be made at this meeting by Dr. Janev of the Data Unit. One of the topics of discussion at the Subcommittee meeting was the frequency and scheduling of meetings. The IAEA has responded very positively to the recommendation that possible meetings, which would attract the same participants, should be consolidated or scheduled consecutively to more readily allow participation by active researchers whose travel may be restricted by budgetary or programmatic considerations.

Data Evaluation and Numerical Databases

The long-standing and continuing efforts of the AMDU have established the basis for an international collection of numerical A+M data for fusion. The recommendation that this be the highest priority activity for the Data Unit has now been reflected in a highly productive year in terms of data evaluation and publication, including the distribution of the first ALADDIN (A Labelled Atomic Data Interface) system manual. The emphasis on data requirements for existing large tokamak devices and those planned as the next generation, particularly ITER, has been recognized as indicated in the ITER related activities described later. Efforts to include fundamental plasma-wall interaction processes will be discussed below. There were several additions to the evaluated databases during the last year, and others are in preparation. Data compilation is continuing at the various data centers as is comprehensive evaluation of selected sets of data. While there is confidence in the quality of these evaluations, there is a continuing need for validation of the data before dissemination.

ALLADIN System Implementation

The ALADDIN System, which was originally developed by R. Hulse of Princeton Plasma Physics Laboratory, has been adapted as the basis for management and exchange of atomic data between data centers and as a vehicle for

incorporating atomic data into fusion-related codes. The decision to use this System represents an important initial step in realizing the goal of easy exchange and utilization of a wide variety of A+M data for fusion. This System uses a standard computer language (Fortran 77) that can be implemented on the full spectrum of computers. The System is interactive, and accesses data contained in portable dictionary files. At present, all data center members are using or introducing ALADDIN. The ALADDIN System has been independently described and discussed in several atomic physics and data center meetings held in the United States, and is being evaluated in a number of laboratories. The System is also being extended to provide the possibility of including in the data; dictionaries, atomic structure and particle surface interaction information. ALADDIN data files are represented in ASCII code that allows straightforward conversion of existing data. During 1989, an ALADDIN source disk and manual were distributed to about 60 interested users. Based on early use of the System, suggestions were made for extensions and improvements at the meeting of the Atomic and Molecular Data Center Network in September. The maintenance, updating and distribution of the ALADDIN System will be the responsibility of the AMDU, with the continued cooperation and assistance of the various data centers and ALADDIN users.

ITER Related Activities

An important meeting addressing the charge of the Subcommittee to emphasize data activities related to major fusion devices and next stage experiments was the specialists meeting on the required atomic database for neutral beam penetration in large tokamaks. From this meeting, the best available database was compiled and made available to the ITER design team for use in specifying the neutral beam system to be used on ITER. Specific questions of the role of excitation and multi-step ionization in the beam penetration were addressed. This detailed analysis is of critical concern because of implications for the energy required for the beam system and its attendant costs. The AMDU has established excellent liaison with the ITER team and is able to integrate into the existing program those needs identified in the ITER program as they develop. This liaison should be continued and strengthened where reasonable.

Coordinated Research Program on Data for Fusion Plasma Edge Studies

It is worthwhile to highlight this Coordinated Research Program (CRP) activity as an example in which planning coordination and initiation of activity that involves the various aspects of AMDU responsibilities. The edge plasma is an extremely complicated system both in terms of its constituents and the multitude of processes that can take place within it. The importance of understanding the role of the edge plasma in the enhanced confinement modes presently under investigation, and for controlling impurities and particle exhaust in ITER is increasingly clear. In order to be able to model the processes occurring in the edge plasma, a more complete and accurate database on collision processes involving those atomic and molecular species is required. The ongoing coordinated research program is in it's second year and the specialists meeting held in September concentrated on identifying specific requirements for data to be used in edge plasma modeling codes and the status of available database. The necessity of being prepared to update data

requirements is typified by the recent JET results using Beryllium in the device, and a resultant call for more extensive information on low-z impurity processes in the edge plasma.

Particle Surface Interaction Data for Fusion

The Subcommittee recommended that the AMDU proceed to include particle surface interaction (PSI) data evaluation as one of its activities. It should be noted that this was done only after extensive discussion and that it was to be done in an exploratory manner. The main concerns of the Subcommittee were the dilution of the available manpower in the Data Unit and possible replication of existing efforts elsewhere. In response to this recommendation, an advisory group was nominated by the Subcommittee to coordinate the Data Unit activities with the appropriate plasma and particle surface interaction communities. In the spirit of this recommendation, the AMDU convened an advisory group meeting to consider the needs in the area, define a scope for the activity and identify existing sets of data. Those attending the meeting represented the most active groups throughout the world fusion effort in this area. The scope of PSI data addressed during this meeting was very broad and the status of ongoing research was described in several talks. The emphasis was on ITER class devices. The main thrust of the meeting was to define a role for the IAEA data units in this area and this emphasis was carried throughout the meeting. The role of ALADDIN in consolidating and providing data exchange was discussed extensively, particularly, in an attempt to define an immediate use of existing data for the simpler particle surface interactions. The advisory group meeting closed with a number of recommendations of actions to be implemented by the IAEA. These included establishing a numerical database of recommended PSI data using the ALADDIN format, initiation of a CRP on selected PSI processes, convening a specialists meeting on thermal responses of materials, and publishing of review articles summarizing status and indicating needs in the PSI area. The response of the AMDU to the recommendation has been consistent with the intent of the Subcommittee, but there are concerns about the future role of the AMDU in this area (see below).

CONCLUSIONS

The response of the IAEA Atomic and Molecular Data Unit to the recommendations of the IFRC Subcommittee on Atomic and Molecular Data have been excellent during the past 12 months. The importance of proceeding with the international data bank of recommended numerical A+M data for fusion is recognized and productivity in this area has been increased. The concerted efforts to maintain close liaison with the international plasma community, particularly the ITER design team, have resulted in identification of important ITER requirements, and where required, specification of immediate needs for data. The organization and conduct of the specialists meeting on beam penetration is an excellent example of the application of database information to the fusion effort.

The production and distribution of the ALADDIN program and its attendant operating manual were primarily the result of Data Unit efforts to bring together various participants in the development of ALADDIN. This promises to

be an extremely important effort and one for which the Data Unit is responsible. However, it will take the continued effort, cooperation and collaboration of many other groups if ALADDIN is to reach its full potential as a data exchange medium.

Plasma surface interaction research is a critical part of the overall fusion program and the advisory group meeting held in April will provide a meaningful guide for future effort by the Data Unit in this area.

RECOMMENDATIONS

Despite the very positive response of the A+M Data Unit to the recommendations of the IFRC Subcommittee, some uncertainties remain to be addressed. The following recommendations and observations are based on information contained in the excellent reports produced by the data center and concerns voiced to Subcommittee members by those attending the various meetings.

1. The continuing effort of the data center to expand the international aspects of data center activity is typified by the cooperative effort between the IAEA and the Chinese data center, including the presence of Chinese colleagues at IAEA.

2. The extension of A+M and PSI recommended databases during 1989 is indicative of a high level of productivity on the part of the individuals in the A+M Data Unit. However, the lack of validation of the new databases is worrisome.

3. The list of meetings planned for CY 1990 appears responsive to community needs.

4. ALADDIN formatting of a substantial number of the recommended databases and the distribution of the ALADDIN System represents a significant step toward the creation of an international bank of recommended numerical data.

5. The advisory group meeting on Particle-Surface Interaction Data for Fusion represents the right level of effort for a proposed expansion of the Data Unit into this area. There is real concern about the ability of the data center to adequately deal with existing tasks and expand the scope of the mission with the existing resources.

6. The importance of this Unit to the international fusion effort has been and continues to be clearly demonstrated. The extension of database activities to the plasma surface interactions is of critical importance, but the Subcommittee feels it cannot support this action unless additional resources in the form of manpower can be provided to the Data Unit. Therefore, in light of the concerns expressed above about the adequacy of the Atomic and Molecular Data Unit to provide the required efforts in A+M data for fusion and expand into the plasma-surface interaction area, the IFRC Subcommittee on Atomic and Molecular Data for Fusion strongly recommends that the IAEA provide an increase in manpower to the Atomic and Molecular Data Unit.

ACKNOWLEDGEMENT

Thanks are extended to Dr. R. Janev and J. Smith for providing data center activity and other information in a timely manner. It should be noted that although a draft of this report was distributed to Subcommittee members, any errors contained in the report are the responsibility of the Subcommittee Chairman.

Attachments

List of IFRC Subcommittee Members
Summary Report of 1988 Subcommittee Meeting

Report on the IAEA A+M Data Unit and Data Centre Network Activities for the Period September 1988 - September 1990

Prepared by R.K. Janev

Appendix 4

REPORT ON THE IAEA

A+M DATA UNIT AND DATA CENTRE NETWORK

ACTIVITIES

PERIOD: SEPT. 1988 - SEPT. 1990

- - - - - - - - - - - - - - - - - -

CONTENT:

(ATTACHMENTS)

1. GENERAL CHARACTERISTICS

* PROGRAM CONSOLIDATION
* EXTENSION OF SCOPE (A+M , PSI , PMI)
* ESTABLISHMENT OF ALADDIN
* STRONG CO-ORDINATION
* STRONG INTERACTION WITH FUSION PROGRAM
* EXPANSION OF DCN
* BROAD SUPPORT FROM A+M / PSI COMMUNITIES

SIZE OF ACTIVITIES

- DCN : 15 MEMBERS
- ALADDIN NETWORK : $\gtrsim$ 20 MEMBERS
- 40 LABS ; GROUPS INVOLVED IN DATA PRODUCTION / EVAULATIONS
- $\simeq$ 60 PARTICIPANTS / YEAR IN IAEA WORKSHOPS

2. STATUS OF NUMERICAL DATABASES

1) SPECTROSCOPIC DATABASE

- ALL NEUTRAL AND SINGLY CHARGED IONS (NIST)
- ALL IONIZATION STAGES FOR $Z \lesssim 10$ (NIST)
- ALL ONE- AND TWO-ELECTRON SYSTEMS (VNIITRI)
- Fe, Ni, Ti, Cr (NIST)
- OTHER IONS (NOT ALL CHARGE STATES)

2) COLLISIONAL A+M DATABASES

(ATTACHMENT # 1)

- σ_{ion}^{el}: ALL ELEMENTS, $q \leqq Z$, $Z \simeq 30$
  $\lesssim$ 5-10, $Z > 30$
- H, H_2, H_2^+, He, He^+ : NEARLY COMPLETE
- C^{q+}, O^{q+}, Fe^{q+}, $e\text{-}Ti^{q+}$: NEARLY COMPLETE
- H-beam penetration: VIRTUALLY COMPLETE
- LARGE VOLUME OF DATA FOR OTHER IMPURITIES

3) PSI DATABASES

(ATTACHMENT # 1)

- PHYSICAL SPUTTERING: ALL RELEVANT ELEMENTAL MATERIALS, SOME COMPOUND MATS.

- REFLECTION: LIGHT IONS, SELF-IONS (ON ELEMENTAL MATERIALS)

- SECONDARY ELECTRON EMISSION (ORNL)

4) PMI DATABASES

- NONE (WITHIN IAEA + DCN)

3. STATUS OF ALADDIN SYSTEM AND DATABASE

* SYSTEM ESSENTIALLY ESTABLISHED

  - ADOPTED BY ALL DCN + ALADDIN NETWORK MEMBERS AS WORKING TOOL

* SYSTEM INCLUDES:

  - A + M COLLISION PART

  - A + M SPECTROSCOPIC PART

  - PSI PART

* ALADDIN SYSTEM MANUAL:

  - VERSION 1.0 DISTRIBUTED TO OVER 70 INSTITUTIONS

  - VERSION 1.1 IN PREPARATION
    (TO BE DISTRIBUTED BY END OF YEAR)

* ALADDIN DATABASE:

  - ALL RECOMMENDED / EVALUATED A + M AND PSI DATA ARE ALADDIN FORMATTED (ALADDIN DATABASE)

    (ATTACHMENT # 2)

* ALADDIN DATABASE DISSEMINATION:

  AS OF TODAY : ≃ 50 INSTITUTIONS

  ORNL Red book vol. 1 : ≃ 150 INSTITIONS / INDIVIDUALS

4. DATA COMPILATION AND EVALUATION

WITHIN:

1) DATA CENTRE NETWORK

(ATTACHMENT # 3a)

2) IAEA AMDU

(ATTACHMENT # 3b)

3) Co-ordinated Research Programmes
Research Contracts

WORK IN IAEA AMDU DONE

- AUTONOMOUSLY (DATA UPDATING + RE-EVALUATION)
- WITH ASSISTANCE OF VISITING EXPERTS (2 in '90)
- WITH ASSISTANCE OF ON-JOB-TRAINEES (2 in '90)

5. DATA GENERATION / EVALUATION ACTIVITIES

FOR SPECIFIC, PURPOSE-ORIENTED DATABASES

DATA GENERATION / EVALUATION IS DONE THROUGH:

1) ORGANIZING CRPs (FOR LONG-TERM PRIORITIES)

(ATTACHMENT # 4a)

2) INDIVIDUAL RESEARCH CONTRACTS

(FOR BOTH SHORT-TERM PRIORITIES AND SUPPORT TO CRPs)

(ATTACHMENT # 4a)

3) EXPERTS' MEETING*

(FOR URGENT TASKS, CRP RESULTS ASSESSMENT)

(ATTACHEMENT # 4b)

* USED ALSO FOR FUSION A+M/PSI/PMI NEEDS ASSESSMENTS

6. BIBLIOGRAPHIC DATABASE

* TWO ISSUES OF INTERNATIONAL BULLETIN

* INPUT TO BULLETIN MAINLY FROM ORNL CFADC

7. PREPARATION OF DATA COMPENDIA

1) Database for H-beam penetration (IAEA)

2) Nucl. Fusion Suppl. Vol. 1 : PSI PROCESSES AND DATA
(TO APPEAR BY END 1990)

3) Nucl. Fusion Suppl. Vol. 2 : A+M PROCESSES AND DATA FOR FUSION EDGE PLASMAS (SCHEDULED FOR 1991)

4) COMPENDIA FOR C^{q+}, O^{q+} and Fe^{q+} COLLISIONAL DATA (IAEA)

8. OTHER ACTIVITIES

1) VISITING CONSULTANTS, EXPERTS, ON-JOB-TRAINEES

a) CONSULTANTS (ON INDIVIDUAL BASIS)

1. Prof. E.W. Thomas	2 weeks (PSI data evaluation)
2. Dr. R.A. Hulse	1 week (ALADDIN development)
3. Dr. A. Faenov	1 week (ALADDIN development)

b) COST-FREE EXPERTS

1. Prof. E.W. Thomas	2 weeks (PSI data evaluation)
2. Dr. W. Eckstein	1 week (PSI data evaluation)

c) ON-JOB-TRAINEES

1. Yu-Bo Qiu ,	CRAAMD/IAPCM	3 months
2. Yanghui Qiu ,	CRAAMD/IAPCM	6 months

2) INTERACTION WITH FUSION PROGRAM

- ITER (WORKSHOP ON NB H/CD)

3) INTERACTION WITH ATOMIC PHYSICS COMMUNITY

- INVITED LECTURES AT INT. CONFERENCES
- REVIEWS ON A+M DATA/PHYSICS FOR FUSION

Attachment # 1

Standard A+M and PSI Recommended and/or Evaluated Databases

A. A+M Collisional Databases

1. "Atomic and Molecular Data for Fusion, Part I - Recommended Cross Sections and Rates for Electron Ionisation of Light Atoms and Ions," K.L. Bell, H.B. Gilbody, J.G. Hughes, A.E. Kingston and F.J. Smith, Culham Laboratory Report CLM-R216, Abingdon, Oxfordshire, United Kingdom (1982); J. Phys. Chem. Ref. Data 12, 891 (1983).

2. "Recommended Data on Excitation of Carbon and Oxygen Ions by Electron Collisions," Y. Itikawa, S. Hara, T. Kato, S. Nakazaki, M.S. Pindzola, D.H. Crandall, IPPJ-AM-27 report series of the Institute of Plasma Physics, Nagoya, Japan (1983); At. Data Nucl. Data Tables (ADNDT) 33, 149 (1985).

3. "Report on Recommended Data (for Electron-Impact Excitation)," K.M. Aggarwal, K.A. Berrington, W.B. Eissner and A.E. Kingston, Atomic Data Workshop, Daresbury Laboratory, United Kingdom (March 1986).

4. "Collisions of Carbon and Oxygen Ions with Electrons, H. H_2, and He, Atomic Data for Controlled Fusion Research, Vol. V," R.A. Phaneuf, R.K. Janev, M.S. Pindzola (Editors), Report ORNL-6090/V5, Oak Ridge National Laboratory, Oak Ridge, Tennessee 37830, USA (1987).

5. "Recommended Data on Atomic Collision Processes Involving Iron and its Ions," C. Bottcher, D.C. Griffin, H.T. Hunter, R.K. Janev, A.E. Kingston, M.A. Lennon, R.A. Phaneuf, M.S. Pindzola, S.M. Younger, Nucl. Fusion, Special Supplement, (1987).

6. "Atomic and Molecular Data for Fusion, Part II - Recommended Cross Sections and Rates for Electron Ionisation of Light Atoms and Ions: Fluorine to Nickel," M.A. Lennon, K.L. Bell, H.B. Gilbody, J.G. Hughes, A.E. Kingston, M.J. Murray, F.J. Smith, Report UKEA, Culham Laboratory, Abingdon, OX14 3DB, Oxfordshire, UK (1986); J. Phys. Chem. Ref. Data 17, 1285 (1988).

7. "Recommended Atomic Data for Hydrogen and Helium Plasmas", V.A. Abramov, L.A. Vainshtein, G.T. Krotova, A.Yu. Pigarov, Kurchatov Institute, Moscow, 1988. (Translated into English in IAEA report INDC(CCP)-286/GA, IAEA, 1988).

8. "Recommended Data for Excitation Rate Coefficients of Helim Atoms and Helim-like Ions by Electron Impact," T. Kato and S. Nakazaki, IPPJ-AM-58 report series of the Institute of Plasma Physics, Nagoya, Japan (1988). At. Data. Nucl. Data Tables (ADNDT), 42, 313 (1989).

9. "Atomic and Molecular Data for Fusion, Part III. Recommended Cross Sections and Rates for Electron Ionization of Atoms and Ions: Copper to Uranium", K.L. Bell et al, Culham Report, CLM-R294, Abingdon, Oxfordshire, U.K., (1989).

10. "Recommended Atomic Database for Neutral Hydrogen Beam Penetration into Fusion Plasmas" (R.K. Janev, IAEA Report), (1989).

11. "Collisions of H. H_2, He and Li Atoms and Ions with Atoms and Molecules, Atomic Data for Controlled Fusion Research, Vol. I," C.F. Barnett (Editor), Report ORNL-6086/VI, Oak Ridge National Laboratory, Oak Ridge, Tennessee 37830, USA.

12. "Cross Sections and Related Data for Electron Collisions with Hydrogen Molecules and their Ions", H. Tawara, Y. Itikawa, H. Nishimura, M. Yoshino, to be published in J. Phys. Chem. Ref. Data (1989).

B. Particile Surface Interactions Databases

1. "Data on Backscattering Coefficients of Light Ions from Solids," R. Ito, T. Tabata, N. Itoh, IPPJ-AM-41 report series of the Institute of Plasma Physics, Nagoya, Japan (1985).

2. "Energy Dependence of the Yields of Ion-Induced Sputtering of Monatomic Solids," N. Matsunami, Y. Yamamura, Y. Itikawa, N. Itoh, Y. Kazumata, S. Miyagawa, K. Morita, R. Shimizu, H. Tawara, IPPJ-AM-32 report series of the Institute of Plasma Physics, Nagoya, Japan (1983).

3. "Data Compendium for Plasma-Surface Interactions," R.A. Langley, J. Bohdansky, W. Eckstein, P. Mioduszewski, J. Roth, E. Taglauer, E.W. Thomas, H. Verbeck, K.L. Wilson, Nucl. Fusion, Special Issue (1984).

Attachment # 2

ALADDIN Formatted Recommended and/or Evaluated Data

A. A+M Collisional Databases

1. "Atomic and Molecular Data for Fusion, Part I - Recommended Cross Sections and Rates for Electron Ionisation of Light Atoms and Ions," K.L. Bell, H.B. Gilbody, J.G. Hughes, A.E. Kingston and F.J. Smith. J. Phys. Chem. Ref. Data 12, 891 (1983).

2. "Recommended Data on Excitation of Carbon and Oxygen Ions by Electron Collisions," Y. Itikawa, S. Hara, T. Kato, S. Nakazaki, M.S. Pindzola, D.H. Crandall.
At. Data Nucl. Data Tables (ADNDT) 33, 149 (1985).

3. "Recommended Data on Atomic Collision Processes Involving Iron and its Ions," C. Bottcher, D.C. Griffin, H.T. Hunter, R.K. Janev, A.E. Kingston, M.A. Lennon, R.A. Phaneuf, M.S. Pindzola, S.M. Younger. Nucl. Fusion, Special Supplement, (1987).

4. "Collisions of Carbon and Oxygen Ions with Electrons, H, H_2, and He". Atomic Data for Controlled Fusion Research, Vol. V. R.A. Phaneuf, R.K. Janev, M.S. Pindzola (Editors).
Report ORNL-6090/V5, Oak Ridge National Laboratory, Oak Ridge, Tennessee 37830, USA (1987).

5. "Atomic and Molecular Data for Fusion, Part II - Recommended Cross Sections and Rates for Electron Ionisation of Light Atoms and Ions: Fluorine to Nickel," M.A. Lennon, K.L. Bell, H.B. Gilbody, J.G. Hughes, A.E. Kingston, M.J. Murray, F.J. Smith.
J. Phys. Chem. Ref. Data 17, 1285 (1988).

6. "Recommended Data for Excitation Rate Coefficients of Helim Atoms and Helim-like Ions by Electron Impact," T. Kato and S. Nakazaki.
At. Data. Nucl. Data Tables (ADNDT), 42, 313 (1989).

7. "Elementary Processes in Hydrogen-Helium Plasmas", R.K. Janev, W.D. Langer, K. Evans Jr., D.G. Post Jr., Springer-Verlag, (1987).

10. "Collisions of H. H_2, He and Li Atoms and Ions with Atoms and Molecules, Vol. 1. C.F. Barnett, (Editor).
Report ORNL-6086/VI, Oak Ridge National Laboratory, Oak Ridge, Tennessee 37830, USA (in preparation).

B. Particle-Surface Interaction Databases

1. "Energy dependence of Ion-Induced Sputtering Yields of Monatomic Solids in the Low Energy Region", N. Matsunami, Y. Yamamura, N. Itoh, H. Tawara, T. Kawamura.
Report IPPJ-AM-52, Institute of Plasma Physics, Nagoya, Japan (1987).

2. "Energy Dependence of the Yields of Ion-Induced Sputtering of Montatomic Solids", N. Maksunami, Y. Yamaura, Y. Itikawa, N. Itoh, Y. Kazumata, S. Miyagawer, K. Morita, R. Strimizu, H. Tawara.
Report IPPJ-AM-32, Institute of Plasma Physics, Nagoya, Japan (1988).

Attachment # 3a

DATA COMPILATION AND EVALUATION (by DCN)

The data evaluation efforts during the reporting period have been concentrated on:

A. Spectroscopic data

1) Atomic transition probabilities: Scandium through Manganese (NIST),
2) Atomic transition probabilities: Iron through Nickel (NIST),
3) Spectroscopic data tables for Ti, Cr and Ni (NIST, in ORNL Redbook series, ORNL-6551/VI-3),
4) Spectral tables for the ions Fe VIII through Fe XXVI (NIST - JAERI colaboration),
5) Characteristics of X-ray transitions in multicharged ions of Ar, Cl and K (Kurchatov Institute, Moscow).

B. A+M Collision data

1) Collisions of H, H_2, He and Li atoms and ions with atoms and molecules (prepared by C.F. Barnett, ORNL Redbook vol. 1),
2) Excitation rate coefficients of He and He-like ions (NIFS (ex IPPJ), Nagoya),
3) Electron-impact collision processes of hydrogen molecules (NIFS, Nagoya),
4) Database for H-beam penetration into fusion plasmas (IAEA A+M Data Unit),
5) Evaluated data for electron-impact processes in hydrogen-helium plasmas (Kurchatov Institute, Moscow),
6) Electron excitation collision strengths for Iron ions: FeI through FeXXVI (ENEA, Bologna),
7) Collision strengths for electron excitation of some Ti and V ions (Kurchatov Institute, Moscow),
8) Recommended cross sections and rates for electron impact ionization of atoms and ions: Copper to Uranium (Belfast Data Centre)

C) Particle-surface interaction data

1) Sputtering of materials for the first wall and divertor plates of tokamak reactors (Kurchatov Institute, Moscow),
2) Total sputtering yields for monoatomic solids under ion impact (NIFS, Nagoya),
3) Angular distributions of sputtered atoms from monoatomic solids under ion impact (NIFS, Nagoya),
4) Light ion backscattering data on elemental and composite targets (W. Eckstein, IPP Garching).

Attachment # 3b

Data Evaluation and Parametrization (by IAEA AMDU)

1. Updating of Carbon and Oxygen databases and new parametrization

   - Inclusion of new data information (since 1987) and data re-evaluation (particularly at low energies);
   - Data fitting to new analytic fit expressions for σ_{CX} and σ_{ION} with appropriate asymptotics.

2. Completion of the database for neutral H-beam penetration into fusion plasmas

   - Existing database updated with recent (since 1988) information and extended to lower energies (particularly for heavy-particle excitation);
   - Collision processes with He^{2+} ions singled out from other impurities;
   - Ionization and charge exchange cross sections treated independently in the electron removal to allow for possible CXRS diagnostics;
   - New scalings for n-n' and n → continuum transitions by electron impact adopted.

3. Database for particle interchange processes in edge plasmas

   - Data compilation and evaluation work has been continued

4. Database for physical sputtering (normal incidence)

   - Re-evaluation of existing data on physical sputtering by light (H, D, He, Li, Be)- and self-ions has been performed (jointly with Dr. E.W. Thomas) for materials of fusion interest;
   - A uniform, three-parameter analytic fit to evaluated data has been established and fit parameter determined;
   - Semi-empirical dependences of fitting parameters on masses and nuclear charges of colliding species have been established (≡ semi-empirical formula with predictive power);
   - Shifted-Maxwellian averaging of sputtering yields underway.

5. Database for backscattering (normal incidence)
   (work performed jointly with Drs. E.W. Thomas and W. Eckstein)

   - Re-evaluation of existing (including very recent) backscattering data for light ions and self-ions from surfaces of fusion interest has been performed (normal incidence case).
   - Analytic fit representation of evaluated data to one general expression, alowing for different projectile-target mass ratios.

6. Database for Li-beam penetration into plasmas
   (joint work with H.P. Winter's group, TUW)

   - Data compilation, evaluation and generation for all Li/Li^{*} - e, H^{+}, A^{q+} processes involved in Li-beam attenuation.

Attachment # 4a

DATA GENERATION/EVALUATION ACTIVITIES

A. Co-ordinated Research Programmes (CRPs)

1. CRP on "A+M data for fusion edge plasmas" (1988-1991)

   - Work on data generation and evaluation continues.
   - Preparation of Nucl. Fusion Supplement Vol. 2, devoted to A+M plasma edge processes and data.

2. CRP on "Plasma-interaction induced erosion of fusion reactor materials" (1990-1993)

   - Programme has just started with 10 participating laboratories.
   - Programme objective: to generate evaluated net erosion rates for prime candidate PFC materials.
   - Programme closely related to ITER needs.

3. CRP on "Atomic data for medium- and high-Z impurities in fusion plasmas" (1991-1994)

   - Programme recommended by the IAEA AGM on metallic impurities (May, 1990).
   - Programme has just been initiated (proposed 15 participating laboratories).
   - Programme has to be approved by the IAEA by the end of 1990.

B. Individual Research Contracts in Support to Data Activities

(granted only to developing countries)

1) "Molecular spectroscopy relevant to fusion edge plasma" (Dr. N. Konjevic).
2) "Cross section calculations for ionization of excited hydrogen and helium" (Dr. R. Rivarola).
3) "Studies of ion-impact ionization processes pertinent to fusion plasmas" (Dr. S. Mukherjee).
4) "Measurements of electron impact ionization cross sections" (Dr. N. Djuric).
5) "Application of improved bipartition model of ion transport to calculate ion reflection and radiation damage for fusion technology" (Dr. Luo Zhengming).
6) "Radiation effects on the first wall material of fusion reactors" (Dr. Yu Jinnan).
7) "Evaluation of A+M data for metallic impurities in plasmas" (Dr. Jia Baolin).

Attachment # 4b

IAEA ORGANIZED MEETINGS

1. IAEA Meetings Convened in 1989

The following four Meetings have been convened in the IAEA Headquarters during 1989 in organization of the IAEA A+M Data Unit.

1) Specialists' Meeting on the "Required atomic database for neutral beam penetration in large tokamaks" (April 10-12, 1989)

Objectives: To set the best available database for neutral beam penetration in ITER-like plasmas.

Participation: Ten experts participated in the Meeting with already prepared results (evaluations or new data), and two theoretical groups have sent their new data to the Meeting.

2) Advisory Group Meeting on "Particle-Surface Interaction Data for Fusion" (April 19-21, 1989)

Objectives: 1) To review the data status and needs in the area of plasma-surface interaction (PSI) processes in view of the ongoing fusion research on the largest operating tokamaks, as well as with regard to the ITER conceptual design needs for PSI data,
2) To define the scope and prepare recommendations regarding the IAEA A+M Data Unit immediate and long-term activities in the fields of compilation, evaluation and generation of PSI data for the present and next-generation fusion devices, and,
3) To identify sets of existing data for certain classes of PSI processes which have a sufficient level of completness and accuracy for storage in the IAEA PSI database, and their dissemination to fusion laboratories.

Participation: Thirty experts participated in the work of this Advisory Group.

3) Specialists' Meeting on "Review of the Status of A+M Data for Fusion Edge Plasma Studies" (September 11-13, 1989)

Objectives: 1) To review the status of database and data needs on A+M processes in the edge plasmas of current large tokamak experiments and for the design of fusion reactors (ITER, NET, etc).
2) Review of the first year results of the ongoing IAEA CRP on A+M data for fusion edge plasmas and updating of priorities within the CRP.

Participation: Twenty five experts participated in the work of the Meeting, including eleven CRP participants.

4) Consultants' Meeting: "8th Atomic and Molecular Data Centre Network Meeting" (September 14-15, 1989)

Objectives: 1) To review the ongoing work and the near-future activity programmes of the national A+M data centres and the IAEA A+M Data Unit,
2) To analyze the experiences with the introduction of ALADDIN into data centre network practices,
3) To consider proposals for further developments of ALADDIN System, and,
4) To consider the possibilities for implementation of the IFRC Subcommittee recommendations regarding the A+M data evaluation priorities.

Participation: Representatives from all national data centres were present (except those from the JAERI and Belfast University data centres), including CRAAMD and Obninsk. Two representatives from the ALADDIN Users Network (outside the A+M DCN) also participated in the Meeting.

2. Meetings Organized During 1990

1) Advisory Group Meeting (AGM) on "A+M Data for Metallic Impurities in fusion Plasmas" (May 16-18; Vienna), to determine the status of spectroscopic and collisional data for Ti, Cr, Fe, Ni and Cu impurities, perform quality assessment of existing database and propose actions for future data production and evaluation activities.

2) Consultants' Meeting (CM) on "Thermal Response of Plasma Facing Materials and Components" (June 11-13, Vienna), to identify the status of the database on thermo-mechanical and irradiation properties of currently considered fusion reactor materials under high-heat normal and off-normal operation conditions and recommend future data related activities in this area.

3) Consultants' Meeting: "9th Meeting of A+M Data Centres and ALADDIN Network" (September 20 and 21, Vienna), to review the data compilation and evaluation work done in the preceeding year, update and co-ordinate the next-year programmes and consider the further ALADDIN system developments.

4) First Research Co-ordination Meeting (RCM) on "A+M Data for Fusion Plasma Edge Studies" (September 24-26, Vienna), to summarize and critically analyze the results of the first two years of data generation, compilation and evaluation for A+M processes in fusion edge plasmas and re-adjust the programme priorities in view of the needs of current fusion research.

Attachment 5

Data publicating of DCN for the period 1989 and 1990

Nagoya Data and Planning Centre

1. T. Kato and S. Nakazaki, At. Data & Nucl. Data Tables 42, 313 (1989)
2. Conference Proc. No. 188, Particles and Fields Series 38 (AIP, ed. by A. Hershcovitch, 1989) p. 427
3. T. Kaneko, IPPJ-AM-63 (1989)
4. N. Itoh and T. Kawamura (ed.), IPPJ-AM-64 (1989)

Internal Reports

5. Y. Yamamura, T. Takiguchi and H. Tawara, Data Compilation of angular distributions of sputtered atoms, NIFS-DATA-1 (January 1990)
6. T. Kato, J. Lang and K.E. Berrington, Intensity ratios of emission lines from O V ion for temperature and density diagnostics, NIFS-DATA-2 (March 1990)
7. T. Kaneko, Partial electronic straggling cross sections of atoms for protons, NIFS-DATA-3 (March 1990)
8. T. Fujimoto, K. Sawada and K. Takahata, Cross sections for production of excited hydrogen atoms following dissociative excitation of molecular hydrogen by electron impact, NIFS-DATA-4 (March 1990)
9. H. Tawar, Some electron detachment data for H^- ions in collisions with electrons, ions, atoms and molecules - an alternative approach to high energy neutral beam production for plasma heating, NISF-DATA-5 (April 1990)
10. H. Tawara, Y. Itikawa, H. Nishimura, H. Tanaka and Y. Nakamura, Collision data involving hydrocarbon molecules, NIFS-DATA-6 (July 1990)
11. H. Tawara, Bibliography on electron transfer processes in ion-ion/atom/molecule collisions, NIFS-DATA-7 (August 1990)

Published Papers

12. H. Tawara, Atomic and molecular data needed in space, fusion and related researches; Molecular Processes in Space (ed. T. Watanabe et al., Plenum Press, 1990)
13. T. Kato, J. Lang and K.E. Berrington, Intensity ratios of emission lines from O V ions for temperature and density diagnostics and recommended excitation rate coefficients; At. Data & Nucl. Data Tables 44, 133 (1990)
14. H. Tawara, Y. Itikawa, H. Nishimura and M. Yoshino, Cross sections and related data for electron collisions with hydrogen molecules and molecular ions; J. Phys. Chem. Ref. Data 19, 617 (1990)
15. T. Kusakabe, Y. Mizumoto, K. Katsurayama and H. Tawar, Electron capture by C^+, N^+ and O^+ ions in collisions with H_2 molecules and He atoms at low keV energies; J. Phys. Soc. Japan 59, 1987 (1990).

NIST Data Centre

1. J. Sugar and A. Musgrove, " Energy Levels of Copper Cu I through XXIX", J. Phys. Chem. Ref. Data 19, 527-616 (1990). (AEL)
2. T. Shirai, Y. Funataka, K. Mori, J. Sugar, W.L. Wiese and Y. Nakai, "Spectral Data and Grotrian Diagams for Highly Ionized Iron, Fe VIII - Fe XXVI", J. Phys. Chem. Ref. Data 19, 127-275 (1990). (ACS)
3. J. Sugar and A. Musgrove, "Energy Levels of Krypton, Kr I through Kr XXXVI", J. Phys. Chem. Ref. Data, in preparation (1990). (ACS)
4. W.C. Martin, R. Zalubas, and A. Musgrove, "Energy Levels of Chlorine, Cl I through Cl XVII", J. Phys. Chem. Ref. Data, in preparation (1990). (ACS)
5. C.E. Moore, "Selected Tables of Atomic Spectra" (O II), Natl. Stand. Ref. Data Ser., Natl. Inst. Stand. Tech. 3, Sect. 12, in preparation (1990). (GPO)
6. T. Shirai, T. Nakagaki, Y. Nakai, J. Sugar, K. Ishii and K. Mori, "Spectral Data and Grotrian Diagrams for Highly Ionized Copper, Cu X-Cu XXIX", J. Phys. Chem. Ref. Data, in press (1990). (ACS)
7. V. Kaufman, and W.C. Martin, "Wavelengths and Energy Level Classifications of Magnesium Spectra for All Stages of Ionization (Mg I through Mg XII)", J. Phys. Chem. Ref. Data, in preparation (1990). (ACS)
8. J.R. Fuhr and W.L. Wiese, "Atomic Transition Probabilities", CRC Handbook of Chemistry and Physics, 71st Edition (also see earlier editions), (CRC Press, Inc., Boca Raton, Fl, 1990). (CRC)

Kurchatov A+M Data Centre

1. V.A. Abramov: Report to the IAEA Specialists' meeting on "Review of the Status of Atomic and Molecular Data for Fusion Edge Plasma Studies", 11-13 September, 1989, Vienna.
2. V.A. Abramov: Report at the IAEA Advisory Group Meeting "Atomic and Molecular Data for Metallic Impurity in Hot Plasmas", 16-18 May, 1990, Vienna.
3. V.A. Abramov et al: "Impurity Control in Toroidal Devices", Proc. of TCM, Japan (1989), IAEA-TEC-DOC-536, p.55.
4. V.A. Abramov et al: Journal of Nuclear Materials, 162-164, 462 (1989).

Belfast A+M Data Centre

1. M.J. Higgins, M.A. Lennon, J.G. Hughes, K.L. Bell, H.B. Gilbody, A.E. Kingston and F.J. Smith, "Recommended Cross Sections and Rates for Electron Impact Ionization of Atoms and Ions: Copper to Uranium", Culham Report CLM-R294 (1989)

Oak Ridge A+M Data Centre

1. W.L. Wiese and A. Musgrove, Atomic Data for Fusion, Volume 6: "Spectroscopic Data for Titanium, Chromium and Nickel", ORNL-6551 (September, 1989)
2. C.F. Barnett, Atomic Data for Fusion, Volum 1: "Collisions of H, H_2, He and Li Atoms and Ions with Atoms and Molecules", ORNL-6086/VI, 1990)

ENEA A+M Data Centre (Bologna)

1. M. Frisoni, P.L. Ottaviani, G.C. Panini: A collection of electron excitation collision strengths for iron ions. I. Fe XXVI-Fe XVIII. RT/TIB/89/3
2. M. Frisoni, P.L. Ottaviani, G.C. Panini: A collection of electron excitation collision strengths for iron ions. II. Fe XVII-Fe I. RT/TIB/89/12

CRAAMD Data Centre (1989-1990 reports)

1. Compiled and evaluated electron impact excitation rate coefficients of Iron ions Fe^{+1}, Fe^{+9}, Fe^{+14} to Fe^{+25} etc. CRAAMD-AM-2
2. Collected experimental cross sections K-shell ionization of C to U atoms by electron impact, and these cross sections are tabulated according to target atomic number and incident electron energy. CRAAMD-AM-4
3. Calculated atomic structure data and spectroscopic data for the Ne-like ions (Fe, Ni, Cu, Ge, Se), using the non-relativistic Hartree-Fork method including the relativistic mass-velocity and Drawin terms in the Hamiltonian (HFR) proposed by Dr. R. Cowan. CRAAMD-AM-5
4. Collected experimental data of emission cross section for the collisions between ions and atoms. These data were measured by Institute of Physics, Academia Sinica during the last two years. CRAAMD-AM-6

Chinese Nuclear Data Centre

1. Xiangquan Long, Mentian Liu et al: Cross section for K-shell ionization by electron impact (Atomic and Nuclear Data Tables 45, 353 (1990))

IAEA AMDU

1. ALADDIN Manual, Version 1.0

Appendix 5

Prepared by R.K. Janev

ITER PHYSICS R+D PROGRAMME 1991/92 AND BEYOND (UP TO 1995)

TASKS REQUIRING A+M AND PSI DATA INFORMATION

1. R+D AREA: POWER AND PARTICLE EXHAUST PHYSICS*

T A S K S

1) PH 1.1. Experimental exploration in hydrogenic background plasmas, characteristics of the scrape-off-layer (SOL), divertor plasma and divertor target loads, validation and development of models

(1) Investigations involving A+M and/or PSI data information:

- Plasma power flow into SOL and in edge/divertor regions
- Detailed power balance
- Impurity and neutral particle transport (and sources)
- Hydrogen and impurity recycling
- Plasma edge diagnostics (H_α and others)
- Development/validation of SOL/plasma edge modelling codes

(2) Required A+M/PSI data on:

- All elastic and inelastic A+M processes between edge plasma constituents
- All impurity generation PSI processes (including secondary electron emission)

(3) A+M/PSI data needs for PH 1.1 covered by existing IAEA programmes:

- CRP on A+M data for fusion edge plasmas (1988-1990; continuation to 1991/92 required)
- CRP on plasma induced erosion rates of PFC (1990-1993)
- Several individual research contracts
- (Data evaluation within DCN)

(4) A+M/PSI data needs not covered (sufficiently or at all) by current IAEA programmes:

- Energy/angular distribution of reaction products (both for A+M and PSI data; partial coverage)
- Elastic and momentum transfer data (not covered)
- Hydrogen retention: trapping/detrapping data (partially covered)
- Secondary election emission (not covered)

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* High Priority

(5) Fusion Labs contributing to PH 1.1 (modelling and diagnostic aspects only):

EC (+Canada):	ASDEX-UP (J. Neuhauser), TEXTOR (U. Samm) CCFM/TdeV (B. Stanfield), AEA Fusion/COMPASS (P. Johnson)
Japan:	JAERI (M. Azumi), JAERI/JT-60U (M. Nagami), JAERI/JFT-2M (M. Mori), NISF/JIPP-T-IIU (K. Toi), NIFS Okayama Univ. (S.-I. Itoh), Kyoto Univ. (T. Ohbiki), Nagoya Univ./NAGDIS, HYBTOK-II (S. Takamura), Univ. Tsukuba/GAMMA 10 (K. Yatsu)
USSR:	KURCHATOV/T-10 (V. Vershkov), KURCHATOV/SPRUT-4 (V. Pistunovich), IOFFE/FT-1 (V. D'yachenko), IOFFE/TUMAN-3 (M. Gryaznevich)
USA:	GA, LLNL/DIII-D (M. Mahdavi/D. Hill), LANL (K. Werley), MIT/Alc. C-MOD (B. Lipschultz), GA, LLNL/DIII-D (G. Porter), PPL, UCLA/PBX (M. Okabayashi), PPPL/TFTR (D. Manos), Univ. Texas/TEXT-U (C. Ritz)

2) PH 1.2. Impurity radiation and transport in the bulk, SOL and divertor plasma (including: viability of powerfully radiating plasma edge)

(1) Investigations involving A+M/PSI data information:

- Impurity transport in core, SOL and divertor plasmas
- Impurity radiation losses (radial and poloidal distributions, edge plasma radiation)
- Wall impurity influxes
- Search for methods for impurity radiation enhancement in the edge only (with no fuel dilution effects and violation of density limit): Z-optimization of injected impurities
- Validation/development of 1.5-D and 2-D modelling codes

(2) Required A+M/PSI data on:

- All processes involved in ionization balance and impurity transport (including multistep processes in the edge region)
- All radiative processes (with required energy level information)
- Impurity generating PSI processes

(3) A+M/PSI data needs for PH 1.2 covered by existing IAEA programmes:

- CRP on A+M data for plasma edge (1988-90; need for continuation)
- CRP on erosion rates (only partly) (1990-1993)
- CRP on metallic impurities (1990-1993) (proposed for approval)
- (DCN data compilation and evaluation activities)

(4) A+M/PSI data needs not covered by current IAEA programmes

- A+M data for Be and B
- Collisional data for Z ~ 10 elements
- Data on radiative power losses
- Particle-impact (impurity) desorption data

(5) Fusion labs contributing to PH 1.2. (A+M/PSI aspects):

EC (+Canada):	IPP/ASDEX-UP (G. Fussmann), NFR/(JET+TEXTOR) (B. Emmoth), KFA Jülich/TEXTOR (U. Samm), CCFM/TdeV (B. Gregory), AEA Fusion/JET, COMPASS (N. Peacock)
Japan:	JAERI (M. Azumi), JAERI/JFT-2M (M. Mori), NIFS, Okayama Univ. (S.-I. Itoh), Kyoto Univ./HELIOTRON (T. Ohbiki), Kyushyu Univ./TRIAM-1M (S. Itoh)
USSR:	KURCHATOV/SPRUT-4, LENTA-M (V. Pistunovich), KURCHATOV/T-10 (V. Vershkov)
USA:	GA, LLNL/DIII-D (S. Lippman), (PH 1.2a: T. Petrie), MIT/Alc. C-MOD (E. Marmar), ORNL/ATF (R. Isler), PPPL/PBX (R. Kaita), PPPL/TFTR (B. Stratton), Univ. Texas/TEXT-U (W. Rowan)

3) PH 1.3. Exhaust of helium and hydrogenic species

(1) Investigations involving A+M data information:

- Transport of He^{2+} and He^{+} in the core and SOL regions
- Transport of He^{2+}, He^{+} and He^{o} in divertor region
- Determination of He^{o}/H^{o} in divertor region
- He recycling

(2) Required A+M/PSI data on:

- All collision processes of He^{2+}, He^{+} and He^{o} with other plasma constituents in the core, scrape-off and divertor regions
- Helium retention/release in/from wall and plate materials

(3) A+M/PSI data needs for PH 1.3 covered by current IAEA programmes:

- CRP on A+M data for edge plasmas (mainly He^{o})
- (ORNL Redbook vol. 1, 1990)

(4) A+M/PSI data needs still not covered by IAEA programmes:

- Collision data of He^{2+}, He^{+} with impurities (high energies)
- Electron and proton collisions with excited He (low energies)
- $He^{q+}(q=0-2)$ collisions with surfaces and trapping/detrapping processes

(5) Fusion Labs contributing to PH 1.3. (A+M/PSI aspects only)

EC (+Canada):	IPP/ASDEX-UP (H. Vernickel), KFA Jülich, ORNL, UCLA, NIFS/TEXTOR (D. Hillis, K. Finken), CCFM/TdeV (B. Gregory)
Japan:	JAERI/JFT-2M (M. Mori), NIFS, Okayama Univ. (S.-I. Itoh)
USSR:	IOFFE, KURCHATOV/T-10, T-15, TUMAN-3 (V. Sergeev), IOFFE/TUMAN-3 (A. Korotkov), KURCHATOV/T-10, T-15 (E. Berezovskii, V. Pistunovich)
USA:	MIT/Alc. C-MOD (B. Lipschultz), PPPL/PBX (R. Kaita), PPPL/TFTR (E. Synakowski), Univ. Texas/TEXT-U (W. Rowan)

4) PH 1.4. Active control and optimization of divertor and startup limiter conditions

(1) Investigations involving A+M/PSI data:

- Control of impurity influxes from plates/limiter
- Optimization of divertor plasma parameters (density, temperature) and hydrogen recycling
- Control of volume power exhaust in divertor region (gas and impurity injection)
- Wall pumping ad divertor neutral density enhancement
- Fuelling near flow reversal point and effects on impurity and helium transport
- Divertor performance modelling

(2) A+M/PSI data required:

- All inelastic A+M processes in a divertor plasma (required in impurity and neutral transport codes)
- Data for specific (injected) impurities, (radiation power losses)
- PSI processes involved in H, He wall pumping (retention/release times)
- Temperature dependence of impurity generation PSI processes

(3) A+M/PSI data needs covered by current IAEA programmes:

- CRP on A+M data for plasma edge (1988-1990; continuation for 1991/92 required)
- CRP on erosion rates of PFC (partly only)

(4) A+M/PSI data needs not adequately covered by IAEA programmes:

- Trapping/detrapping PSI processes (for H and He)
- Ion-atom momentum transfer (for impurity transport codes)
- Data for specific impurities (as yet unspecified)

(5) Fusion Labs contributing to PH 1.4.

EC (+Canada): IPP/ASDEX-UP (J. Neuhauser), IPP/W7-AS (A. Weller), KFA Jülich, UCLA, NIFS/TEXTOR (R. Conn, K. Dippel, A. Miyahara, CCFM/TdeV (P. Conture)

Japan: JAERI (M. Azumi), JAERI/JFT-2M (M. Mori), Nagoya Univ/NAGDIS, CSTN-III, HYBTOK-II (S. Takamura)

USA: GA, JAERI, LLNL, ORNL, SNL, UCLA, JET/DIII-D (M. Schafter), LANL (K. Schoenberg), LLNL/DIII-D (G. Porter), MIT/AlcD-MOD (B. Lipschultz), PPPL/PBX (H. Kugel)

5) PH 1.5. Characterization and test of plasma-facing components (PFC)

(1) Investigations involving PSI and PMI data:

- Characterization of net erosion rates of candidate PFC materials (in particular: carbon-fiber-composites (CFC), B-, Si-, Ti- doped CFC, Be and its compounds, high-Z materials (Nb, Mo, W)), including temperature dependence, ion dose dependence, neutron irradiation dose dependence
- Hydrogen isotope retention in PFC materials, including location and mode of bonding
- Thermo-mechanical properties of PFC materials under normal and off-normal operation conditions (elastic and stress moduli, thermal conductivities, fatigue lifetimes, etc)
- Temperature and radiation dose dependence of thermo-mechanical properties of PFC materials

(2) PSI/PMI data needs covered by present IAEA programmes:

- CRP on erosion rates of PFC materials (1990-1993)
- Compilation and evaluation of thermo-mechanical data for CFC, C-C and doped C-C (starting 1991)
- Two individual research contracts on radiation damage of structural materials

(3) PSI/PMI data needs not covered by present IAEA programmes:

- Hydrogen isotope retention (in particular: tritium inventory)
- Systematic radiation damage data for PFC materials
- Thermo-mechanical data for non-C-C candidate materials

(4) Fusion Labs contributing to PH 1.5.

EC (+Canada):	IPP/ASDEX-UP+W7-AS (J. Roth), KFA Jülich, ORNL, NIFS, UCLA/TEXTOR (J. Winter), CCFM/TdeV (B. Terreault)
Japan:	NISF/CHS (K. Matsuoka), Kyushyu Univ./TRIAM-1M (S. Itoh), Nagoya Univ./NAGDIS, CSTN-III, HYBTOK-II (S. Takamura), Univ. Tsukuba/GAMMA 10 (K. Yatsu), ELT/TPE-1RM15 (K. Sugisaki)
USSR:	KURCHATOV/SPRVT-4, LENTA-M (V. Pistunovich), IOFFE/TUMAN-3 (S. Lebedev), KURCHATOV/T-15 (V. Khrabov, A. Vertiporokh), FIAE (Troitsk) SIA "ENERGY"/T-14, T-3M-2 (S. Mirnov)
USA:	GA, SNLL, UCLA, LLNL, ANL/DIII-D (C. Wong), GA/DIII-D (G. Jackson), MIT/Alc. C-MOD (E. Marmar/B. Lipschultz), PPPL/PBX (H. Kugel), PPPL/TFTR (M. Ulrickson)

2. R+D AREA: 4: OPTIMIZATION OF OPERATION SCENARIO AND LONG-PULSE OPERATION

1) Task PH 4.1. Long-pulse operation experience

Sub-task: PH 4.1e: Neutral beam current drive (NBCD)

(1) Investigations involving A+M data:

- Investigation of neoclassical effects on NBCD
- Investigation of current drive efficiency in the region of critical beam velocities (onset of Alfvén instabilities)
- Dependence of beam stopping cross section on the impurity mix, electron temperature and density

(2) A+M physics involved

- All electron, proton and impurity ion collision processes with hydrogen in the region from ~ 1 keV/u (*) to 2 MeV/u and involving hydrogenic excited states up to n=7

(3) Available data

- Database available for energies above 20 keV/u, with:
  * scaled proton excitation data (for $n \geqq 7$)
  * scaled proton electron removal data (for $n \geqq 2$)
  * scaled impurity-ion electron removal data (for $n \geqq 2$, $q \geqq 3$)
  * empirical formulae for n-n' transitions

(4) Data needed down to E/q ~ 1 keV/u for:

- proton and impurity-ion excitation of H (for $n \leqq 7$)
- proton and impurity ionization of $H^*(n)$
- proton and impurity charge exchange on $H^*(n)$
- more reliable formulae for n-n' transitions (in heavy particle collisions)

(*) Such low energies are required to accurately take into account the stopping due to beam-self ion collisions

2) PH 4.5.
======= Fuelling physics: Pellet ablation model

(1) Investigations involving A+M/PSI data:

- pellet ablation processes
- effects of thermal and suprathermal electrons and fast ions on pellet ablation
- velocity dependence of pellet penetration depth
- pellet ablation modelling
- pellet ablation diagnostics

(2) A+M/PSI data required:

- PSI processes due to plasma particle and impurity bombardment (energy deposition, erosion)
- A+M processes involving plasma particle-eroded pellet material interaction
- A+M processes involved in pellet ablation soft X-ray diagnostics

(3) A+M/PSI data produced by current IAEA programmes:

(4) A+M/PSI data needs not covered by current IAEA programmes

- PSI processes with solid hydrogen (under electron, proton and impurity impact) leading to erosion and evaporation
- plasma particle and impurity impact processes with H and H_2 at energies corresponding to $T \propto 10$–20 keV

3. R+D AREA: DIAGNOSTICS

(1) Diagnostics for physics phase involving A+M data

Plasma Parameter	Diagnostic Method	Comment
- Ion/electron temperature	Neutral particle analysis	For edge plasma
	CXRS	Needs diagnostic NB
- D/T density	Neutral particle analysis	For edge plasma
	Visible spectroscopy	For edge plasma
- Impurity content	VUV, visible spectroscopy	Edge plasma, SOL
	X-ray spectroscopy	Core plasma
	CXRS (?)	Heating beam (?)
- Confined α-particles	CXRS	Needs diagnostic beam (He^0)
	Neutral particle analysis	Needs diagnostic beam (He^0)
- He concentration	CXRS	Needs diagnostic beam
	Neutral particle analysis	Needs diagnostic beam
- Divertor plasma parameters	Visible spectroscopy	Needs radiation resistent optics
- Erosion rates	Visible spectroscopy	
- q(r) (current density)	Motional stark effect	Needs diagnostic beams

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(2) A+M physics required

- H-beam attenuation processes for beams of E ~ 100-200 keV/u
- He^0-beam attenuation processes for beams of E ~ 0.5-2 MeV/u and E ~ 30-100 keV/u

(3) Data availability

- Database not complete, particularly with respect to processes involving excited states

(4) Particularly important data needs

- Radiation damage of diagnostic components

  * neutron, γ, X-ray radiation damage
  * charged particle radiation damage

  } → A+M/PSI involved

  * He-acummulation problem

Appendix 6

MEETINGS PLANNED FOR 1991/92

1991

1) RCM on "Plasma-Interaction Induced Erosion Rates of Fusion Reactor Materials" (May 15-17, Vienna), to analyze the first year results produced within the ongoing CRP, assess the overall database status and identify further urgent tasks.

2) CM on "A+M databases for Be and B Impurities" (June 10-12, Vienna), tolperform critical analysis of the existing data and generate new data required for completion of the spectroscopic and collisional databases for these two impurities.

3) AGM: "10th A+M Data Centre Network Meeting" (September 23 and 24, Vienna), to analyze the results of A+M data evaluations carried out in previous year and coordinate the data compilation/evaluation activity for the next year.

4) AGM on "A+M Data for Medium and High-Z Impurities", to assess the status in this A+M data area, identify further data needs and adopt actions for establishing the required database.

5) CM on "He database for Alpha Particle Diagnostics" (June, Vienna), to determine a recommended database for neutral He-beam penetration and fusion alpha neutralization.

1992

1) RCM on "Plasma-Interaction Induced Erosion Rates of Fusion Reactor Materials" (May/June, Vienna) (2nd RCM of the CRP on the subject), to review the progress in the data production/evaluation work and prepare the final document on erosion rates, with appropriate recommendations to reactor designers.

* 2) RCM on "A+M Data for Fusion Edge Plasmas" (September, Vienna) (2nd RCM of the CRP on the subject), to summarize the final results of the CRP and prepare a document with recommended A+M data for plasma edge studies.

* 3) AGM: "11th A+M Data Centre Network Meeting" (September, Vienna), to review the A+M data compilation/evaluation results from the previous year and coordinate the activity plans for the next year.

* 4) TCM: "7th IFRC A+M Subcommittee Meeting" (September, Vienna), to review the IAEA and Data Centre Network activity for the previous two years and set priorities for the A+M and PWI data programmes for the next period.

5) TCM on "A+M and PWI Data for Fusion Reactor Technology", (October/November, to be held at a major fusion laboratory), a large meeting of experts from atomic and fusion research communities to evaluate the results of the past support of atomic and surface physics and material sciences to fusion research development, and establish directions for data generation and evaluation work in the A+M, PWI and material properties areas in support to fusion reactor design and reactor technology development in a longer time scale.

6) CM on a subject related to the ITER R&D short-term needs (dates to be determined by IAEA A+M Data Unit).

* Meetings to be held consecutively

Appendix 7

Status of the Fusion A+M DCN Manpower (in P-Y)

Data Centre	Professional Staff		Technical Staff			Data Production Capabilities	
	Scientific Permanent	Consultants	Computer Support	Technical Assistance	Clerical Staff	Theory	Experiment
1. NIST (a) At. Energy Levels	1.0	0.3	0.4	0.8	0.1	-	2.0
2. NIST (b) At. Trans. Probabilities	1.0	-	0.2	0.2	0.2	1.5	0.5
3. ORNL CFADC	0.4	0.2	0.5	-	0.5	0.8	2.5
4. QUB Belfast	1.0	0.6	0.5	0.3	-	2.0	-
5. NIFS Nagoya	2.0	0.5	0.5	0.5	0.2	-	-
6. JAERI AMDU	0.6	0.1	0.1	0.2	-	0.5	0.5
7. GAPHYOR Orsay	2.0	0.5	1.5	-	-	2.0	-
8. KURCHATOV INST. AMDU Moscow	1.5	0.8	0.5	-	-	3.0	7.0

(Contd.)

9. CRAAMD IAPC Beijing	4.0	3.0	3.0	2.0	1.0	3.0	8.0
10. CNDC-AMDU Beijing	2.0	-	-	-	-	-	-
11. NDC-AMDU Obninsk	1.0	1.0	1.0	1.0	0.5	2.0	2.0
12. ENEA NDC-AMDU Bologna	0.6	-	0.2	-	-	-	-
13. JILA Boulder	1.5	0.5	-	-	-	-	-
14. VNIIFTRI Mendeleevo	2.6	-	2.0	1.0	1.0	1.5	1.0
15. IAEA AMDU	1.5	0.2	0.5	-	1.0	-	-
TOTAL DCN	22.7	7.7	10.9	6.0	4.5	16.3	23.5

Appendix 8

A+M Data Centre Network Members

1. A+M Data Centre Network

1) IAEA Atomic and Molecular Data Unit
Nuclear Data Section
Wagramer Strasse 5
P.O. Box 100
A-1400 Vienna
Austria
Tel.: 0222/2360-1731 Telex: 1-12645 Fax: 431234564
Key Person: Dr. R.K. Janev

2) Atomic Data Group
Chinese Nuclear Data Centre
Institute of Atomic Energy
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Peoples Republic of China
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Key Person: Dr. Yao Jinzhang

3) CRAAMD
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Computational Mathematics
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Telex: 222499+IAP
Key Person: Dr. Sun Yongsheng

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Tel.: 33(1)69417251 Fax: 33169417844 (Katsonis)
Key Persons: Dr. J.L. Delcroix, Dr. K. Katsonis

5) ENEA A+M Data Center
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Italy
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Key Persons: Dr. E. Menapace, Dr. G.-C. Panini

6) JAERI A+M Data Centre
Nuclear Data Center
Japan Atomic Energy Research Institute
Tokai-mura, Naka-gun,
Ibaraki-ken 319-11
Japan
Telex: J/24596 Fax: 8135806107 (Nakai)
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Key Persons: Dr. Y. Nakai, Dr. T. Shirai

7) Data and Planning Centre
National Institute for Fusion Science
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Key Person: Dr. H. Tawara

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Key Person: Dr. R.A. Phaneuf

12) Data Center on Atomic Energy Levels
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Key Person: Dr. W.C. Martin

13) Data Center on Atomic Transition Probabilities
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Key Person: Dr. W.L. Wiese

14) Scientific Data Center
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Key Person: Dr. J. Broad

15) Multicharged Ions Spectra Data Centre
National Scientific and Research Institute
for Physical-Technical and Radio-Technical
Measurements
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141570 Mendeleevo, Moscow region
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Tel.: 539-24-01 Fax: 5357386
Key Person: Dr. A. Faenov

Appendix 9

IFRC A+M Subcommittee Membership

Dr. R. McKnight (Chairman)	U.S. Department of Energy Division of Applied Plasma Physics Washington, D.C. 20545 Fax: 3013532791
Dr. R.K. Janev (Secretary)	IAEA, Atomic and Molecular Data Unit Wagramerstrasse-5, P.O. Box 100 1400 Vienna, Austria Tel.: 0222-2360-1731 Telex: 1-12645 Fax: 431234564
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Dr. H.-W. Drawin	Dept. de Recherches sur la Fusion Controlee Association Euratom-CEA Centre d'Etudes Nucleaires de Cadarache B.P. No. 1 F-13108 Saint-Paul-Lez-Durance Tel.: 42-25-7000 Telex: 440678+CEA Fax: 3342256233
Dr. M.F.A. Harrison	AEA Technology Reactor and Strategic Studies Division Culham Laboratory Abingdon, Oxfordshire OX14 3DB Tel.: 0235-464277 Fax: 0235463435
Dr. Y. Kikuchi	Japan Atomic Energy Research Institute (JAERI) Tokai-mura, Naka-gun Ibaraki-ken 319-11 Fax: 0292825927
Dr. A. Miyahara	National Institute for Fusion Science Nagoya 464-01 Tel.: 052-782-1783 Telex: 4473691+NIF Fax: 0527819564