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**COVER SHEET
FOR TRIP REPORTS SUBMITTED TO THE
OFFICE OF ENERGY RESEARCH**

**Destination(s) and Dates for
Which Trip Report Being Submitted: West Germany, 9/10-18/90; Austria, 9/20-26/90**

Name of Traveler: R. A. Phaneuf

Joint Trip Report ☐ Yes
 ☒ No

If so, Name of Other Traveler(s): _____

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ORNL
FOREIGN TRIP REPORT

ORNL/FTR-3775

DATE: October 12, 1990

SUBJECT: Report of Foreign Travel of Ronald A. Phaneuf, Senior Research Staff
Member, Physics Division

TO: Alvin W. Trivelpiece

FROM: Ronald A. Phaneuf

PURPOSE: To participate in the Fifth International Conference on the Physics of Highly Charged Ions; to discuss collaborative research plans and perform experiments at Justus Liebig University; to participate in IAEA Consultants' Meetings of the Atomic and Molecular Data Center and ALADDIN Network, and of the Coordinated Research Program on Atomic and Molecular Processes for Fusion Edge Plasmas.

SITES

VISITED: 9/10 - 9/18/90 Justus Liebig University, Giessen, West Germany
9/20 - 9/26/90 International Atomic Energy Agency, Vienna, Austria

ABSTRACT: The Fifth International Conference on the Physics of Highly Charged Ions drew more than 200 participants, providing an excellent overview of this growing field. Important technical developments and experimental results in electron-ion collisions were reported. The merging of fast ion beams from accelerators or storage rings with advanced high-intensity electron-beam targets has yielded data of unprecedented quality on radiative and dielectronic recombination, providing stringent tests of theory. Long-awaited technical innovations in electron-impact excitation measurements were also reported. The level of activity in multicharged ion-surface interactions has increased. More sophisticated experimental studies of the neutralization process have shown the inadequacy of previously accepted mechanisms, and theoretical activity in this area is just being initiated. The IAEA meetings addressed atomic and molecular data needs for fusion research, with ITER providing a key focus. Such data are especially critical to modelling and diagnostics of the edge plasma. The ALADDIN data base system has been universally accepted and has streamlined the exchange of numerical data among data centers and the fusion community. The IAEA continues to play a pivotal role in the identification of data needs, and in the coordination of data compilation and research activities for fusion applications.

Fifth International Conference on the Physics of Highly Charged Ions, Giessen

The HCI V Conference was hosted by the atomic collisions group in the Strahlenzentrum of the Justus Liebig University. This biennial conference drew more than 200 participants, the majority from Europe and the British Isles. The level of participation by Soviet and Eastern European scientists was noticeably increased, whereas U.S. representation was reduced from that of previous conferences in the series. The program consisted of 27 invited lectures and 125 contributed poster presentations, covering spectroscopy and structure of highly charged ions, and their interaction with electrons, atoms, molecules, ions, and solid surfaces. The conference program is included as Appendix C. An increasing emphasis on ion-surface interactions was evidenced by the 4 invited and 12 contributed papers on the subject. Our contributed post-deadline paper on very recent JILA-ORNL results on electron-impact excitation of Si^{3+} by merged-beams electron energy loss was initially selected as one of two hot-topics presentations, and then later as a last-minute replacement for a scheduled invited paper on EBIT, for which the speaker was denied permission by LLNL to attend the conference. This caused much consternation among the conference organizers, who would have been willing to fully support travel expenses in this case, had they known about the situation in advance. Several contributed papers by LLNL staff were also not presented for the same reason.

A number of papers were of direct interest to current ORNL research programs. B. A. Huber of Grenoble reported differential cross-section measurements for electron-impact excitation of Ar^{7+} (3s-3p) at an energy of 100 eV using a new crossed-beams apparatus. The approach is similar to that employed by Chutjian and co-workers a few years ago. A high-resolution electron spectrometer is used to determine the ratio of cross sections for inelastic and elastic scattering over an angular range of 8-22 degrees. The background is too large to permit measurements at lower energies or smaller angles. The technique is complementary to the JILA approach, which determines the total cross section near threshold. I. D. Williams of Belfast also reported on a new electron-impact excitation experiment under development, which is similar to the JILA approach. Electron and ion beams are merged in an axial magnetic field, and, to reduce shear effects, cylindrical ExB analyzers will be used to merge and demerge the beams. An electrostatic mirror will redirect backwardly scattered electrons to the detector. This experiment should provide competition for the JILA-ORNL experiments within a year or two. An overview of impressive high-resolution measurements of electron-impact ionization of Li-like and other heavy ions at Giessen was presented by A. Müller, in which clear evidence was presented for the role of dielectronic resonances in a large number of collision systems. To contribute to the ionization channel, such resonances must decay by multiple autoionization.

New experimental results for electron-ion recombination were presented by several groups. A. Wolf reported impressive dielectronic and radiative recombination measurements at the TSR storage ring in Heidelberg for H, He, and Li-like C and O ions, as well as Li-like Cu^{26+} . The absolute precision of 30% is limited mainly by calibration of the detector efficiency. Improvements to the energy calibration and resolution are planned which will make the technique valuable for spectroscopy of doubly excited states. Single-pass measurements were reported by L. Anderson of Aarhus for radiative recombination of electrons with He^{2+} , C^{5+} , O^{5+} , C^{6+} , and F^{9+} , which are in good agreement with the Bether-Salpeter formula. Dielectronic recombination data were also presented for He-like C, O, and

F, which compare remarkably well with the theory of Badnell et al., except for the $n=10$ and $n=11$ resonances.

A common theme among several papers presented on multicharged ion-surface interactions was the growing body of evidence that neutralization of the ion clearly occurs on a time scale which is short compared to that predicted for an Auger/radiative cascade from high- n states, which are thought to be populated by resonant neutralization from the valence band of the solid. The relaxation of the so-created "hollow" or "super-excited" atom provides information about the time scale of neutralization process via the emission of k-shell Auger electrons or X rays. Proposed explanations ranged from theoretical predictions of autoionization and radiative decay rates for triply excited levels of N^{2+} , which were found by a group in Amsterdam to be 200 times larger than those for doubly excited levels, to postulates of neutralization mechanisms involving direct "side feeding" of inner shells of the ion from inner levels of the solid, by groups at Groningen and Grenoble. The first direct evidence for latter mechanism was found several years ago by our group at ORNL led by F. W. Meyer, and the question of neutralization mechanisms and time scales is the subject of current investigation.

Other papers of particular relevance to ORNL research included a presentation by R. Hoekstra of FOM-Groningen of state-selective electron capture cross section measurements for $C^{4+} + H$ collisions down to 50 eV/amu using a newly developed retardation lens system. New low-energy data for $O^{3+} + H$ substantiate our own conclusions of a smaller 3p contribution than predicted theoretically. Status reports were presented on ECR and EBIS ion source development by R. Geller and M. Stockli, respectively.

The conference program also included a tour of the impressive Gesellschaft für Schwerionenforschung (GSI) accelerator laboratory in Darmstadt, where two major heavy-ion synchrotron storage rings, the ESR and the larger SIS, are currently in the final stages of development. The project was initiated in 1986. Still in the commissioning phase, the ESR had recently stored an electron-cooled beam of 10^7 bare Ar^{18+} ions for more than one hour. The low-stored ion beam intensity is a temporary consequence of a non-optimized injection beam line. The SIS is in the final stage of construction. The tour also provided me an opportunity to examine the recently-implemented GSI dielectronic recombination experiment, a single-pass merged-beams apparatus on the UNILAC accelerator, which employs an advanced electron-beam target. This collaboration by researchers from Giessen, Frankfurt, and GSI has yielded preliminary radiative and dielectronic recombination data for S^{15+} , Au^{25+} , and U^{28+} , which were reported at the conference. Preliminary data on radiative recombination for these highly charged ions are 3 to 4 times larger than expected, suggesting the possibility of dielectronic resonances near 0 eV, or of spurious effects. Extremely limited beam time thus far has prevented the usual diagnostic tests from being made. Another run is scheduled for early November. I was invited to participate in this or in subsequent experiments using this facility as part of a continuing NATO collaboration.

As a member of the international scientific committee for the HCI-V Conference, I participated in deliberations leading to a decision to site the next conference in two years. There was a strong consensus that if the conference were to be truly international rather than European, then it should be held in the U.S. the next time. Offers to host the conference from Cornell and Kansas State universities and from ORNL were considered, with a decision

reached to meet next in Kansas in September 1992. V. Kostroun of Cornell and I were asked to serve on the scientific committee for this meeting.

Strahlenzentrum, Justus Liebig University, Giessen

As part of a NATO cooperative research agreement, I spent several days after the conference at the Strahlenzentrum of Justus Liebig University making plans for future collaborative research and working with A. Müller and G. Hoffman on their electron-impact ionization experiment. One data-taking option for this apparatus is a high-resolution electron-energy scanning mode, for which hardware and software was developed to investigate resonance structure in total ionization cross-section measurements. A new 10-GHz ECR multicharged ion source was in final stages of development, but was not yet ready for initial operation at the time of my visit. This source replaces a 5-GHz ion source which has been in operation for more than three years in their laboratory. I was interested to learn that an unused 2-kW, 10-GHz microwave system was obtained for the source at negligible cost from U.S. military surplus in Germany.

Since no ion beam was then available for the electron-impact experiment, it was decided to search for resonances in electron-impact ionization of neutral Kr by elevating the potential of the entire electron gun assembly to -500 V, admitting Kr gas into the vacuum chamber, and accelerating some fraction of the Kr^+ ions produced by electron impact into the magnetic charge analyzer for detection. Although no evidence was found for resonance structure in the relative ionization cross section at the 0.2% level, a distinct contribution was evident due to 3d-nl excitation-autoionization. However, uncertainties in the efficiency of ionized ion extraction as a function of electron beam energy precluded reliable measurements of the relative ionization cross section over a wide energy range.

Especially noteworthy was the level of manpower available for atomic collisions research in the Giessen group. Three permanent faculty, E. Salzborn, A. Müller, and F. Melchert, head a group of 20 graduate students working on electron-ion, ion-ion, and ion-atom collision experiments, as well as ECR ion source development. With up to seven years of research experience, their senior graduate students perform at a level comparable to postdoctoral fellows in the U.S., and supervise the less-experienced students. Their group are the major customers of a well-equipped machine shop with a staff of about seven, for which their only costs are for materials. With a number of imminent faculty retirements in the Strahlenzentrum, and probable shut-down of the electron linac, a significant opportunity exists for expanding the atomic physics program within the next few years.

Meeting of Atomic and Molecular Data Centres and ALADDIN Network, IAEA, Vienna

The 9th meeting of the Atomic and Molecular Data Centres and ALADDIN Network was hosted by the Atomic and Molecular Data Unit of the IAEA Nuclear Data Section. Data centers and related activities in the U.S., U.K., U.S.S.R., Europe, Japan, and China were represented by about 20 scientists. The role of the network is to coordinate data compilation and evaluation on an international scale, and to promote the effective exchange and dissemination of atomic and molecular data relevant to fusion applications.

The program for the Network Meeting is included as Appendix D. On the first day, the past year's activities and near-term plans of each of the participating centers were briefly reviewed, along with discussion about manpower and funding levels. The IAEA Data Unit is compiling statistics on the latter to document a proposal to ITER. Data Center Network activities are now strongly focused on ITER requirements, with particular emphasis on the edge plasma, helium transport, and beam attenuation (H and He). The key atomic physics issues are associated with the physics of power and particle exhaust, and with long-pulse operation. Beryllium has become an important species because of recent success in using it as a plasma-facing material in JET, as has boron because of its promising use in the doping of carbon composites.

The Belfast Data Center has been recently redirected by Culham to emphasize plasma-edge relevant processes involving molecules containing H, C, and O, and the Nagoya Center has recently published a report on processes involving hydrocarbons. The JAERI and IAEA Centers have emphasized analytic parametrization of heavy-particle collision data, but this is still problematic at low energies, where simple scalings with ionic charge, velocity, and binding energy are not possible. A. Faenov of VNIIFTRI in Moscow is assembling a large computer data base, and plans to try to market it internationally on CD-ROM. This data base consists of more than 200 MBytes thus far. It appears that much of the atomic structure and electron collision data is from "production" computer codes, and its accuracy is therefore subject to some question. The Chinese CRAAMD Network has also been concentrating on structure and electron-impact data, but is more involved in calculation of data at present. Manpower appears to be abundant for this purpose.

An overview of a recent evaluation of data for heavy-particle reflection and sputtering coefficients was presented by E. Thomas, who had spent the previous several weeks at the IAEA working on this project as a representative of the ORNL Controlled Fusion Atomic Data Center (CFADC). Analytical formulae with a small number of coefficients are remarkably successful in parametrizing the available data. The IAEA has also assembled a data base for Li beam penetration into plasmas, and will do the same for He beams.

The second morning of the meeting was devoted to the status of the ALADDIN data base system, which has now been universally adopted and extremely successful as a data exchange system. All centers are now producing data files in ALADDIN format, and the IAEA is assembling a large fusion-relevant data base. D. McCune of PPPL has successfully interfaced ALADDIN with the TRANSP neutral-beam transport code. I had, in fact, recently provided him with the ALADDIN data files for the newly published ORNL-6086 "Redbook" volume, which he was able to readily assimilate into the code. R.E.H. Clark of LANL reported on an ALADDIN data base for structure and electron collisional data for all ionization stages of Ti, based on distorted-wave calculations. He has also generated collisional excitation data for transitions between excited levels of B^{2+} and C^{2+} . A number of enhancements to the ALADDIN program which were recommended at the previous year's meeting have been successfully implemented by the IAEA Data Unit, who are nearly ready to distribute an improved version 1.1. It was agreed that an ALADDIN area should be set up on the NERSC system, to make the large and growing data base more accessible to data users in the fusion community. The CFADC will take responsibility for implementing this. The Opacity Project is now turning to production of excitation and ionization cross sections for all ionization stages of H through Ne, as well as Fe, although access to this massive bank of data still remains a problem.

The final afternoon was devoted to more general discussion and planning. It was announced that the IAEA Atomic and Molecular Data Unit will acquire at least one additional full-time staff member as a result of several retirements in the Nuclear Data Section. This should have a significant positive impact on the Unit's productivity, which has been most impressive since R. K. Janev became its director in 1988. On the negative side, it was also announced that J. J. Smith will transfer in March 1991 to another part of the IAEA, due to personnel policies within the Agency. His high levels of energy and enthusiasm will be missed by the Unit. Janev also announced that a Coordinated Research Program on Medium and High-Z Materials had just been approved by the Agency. There was considerable discussion of ITER-related data requirements, with specific data needs identified for collisions involving excited H atoms, for He transport, and for deposition of energetic neutral H and He beams into plasmas.

On the basis of the discussions, topics selected for emphasis by the CFADC during the next year will include the assembly of an ALADDIN data base for dielectronic recombination of C and O ions, and calculation of radiative cooling rates for C and O ions using these and recommended excitation data from the ORNL-6090 "Redbook." These projects were judged to have a higher immediate impact on fusion than completion of the remaining "Redbook" compilation on electron collisions with atoms and molecules, which will be given a lower priority by the CFADC. The meeting also provided an opportunity to meet with T. Shirai of JAERI to finalize a collaborative manuscript on extended scaling relationships for ionization of H, H₂, and He by multiply charged ions.

Research Coordination Meeting on Atomic and Molecular Data for Fusion Edge Plasmas, IAEA, Vienna

A Coordinated Research Program on Atomic and Molecular Data for Fusion Edge Plasmas was formally initiated by the IAEA in 1988. The objective of this first research coordination meeting, attended by about 20 scientists from the U.S., U.S.S.R., Europe, Japan, and China, was to assess progress and to identify new directions for research, since ITER objectives and data needs are now better defined. I was asked to prepare a survey and assessment of the data base for ion-atom collisions relevant to the plasma edge for publication in a forthcoming **Nuclear Fusion Special Supplement**, and for presentation at this meeting.

A number of developments were of direct relevance to current ORNL research. V. Belyaev reported measurements at Kurchatov Institute of total electron-capture cross sections for $C^{3+} + H$ collisions in the energy range 2-1000 eV/amu using a novel merged-beams coincidence technique. A parallel-plate electrostatic analyzer demerges the beams and directs the collision products onto two large-area microchannel-plate detectors. Their measurements are consistent with our earlier ORNL data, although the role of excited states in the fast neutralized H beam is unclear, as is the procedure used to place the measurements on an absolute scale. In any case, this must surely rank as one of the most significant Soviet technical accomplishments in atomic collision physics. F. Brouillard of Louvain-la-Neuve in Belgium reported absolute electron-capture cross section measurements for $H(n=3) + Cs$ collisions. The $H(n=3)$ reactant beam is produced by dye-laser excitation of a neutralized H beam in an electric field. The $H(n=3)$ fraction is determined from measurements of Lyman-alpha radiation using electric-field mixing, and from the variation in Lyman-alpha intensity as the frequency of the dye laser is varied. He also reported merged-beams measurements of

transfer ionization in $\text{He}^{++} + \text{H}^-$ collisions, and associative ionization in $\text{H}(1s) + \text{H}(2s)$ collisions. These innovative experiments all represent the current state of the art in slow heavy-particle collisions. E. Unterreiter reported on electron-capture cross-section measurements in Vienna for C^{9+} and O^{9+} colliding with H_2 and He, in which ion-beam metastable fractions were carefully controlled and measured using attenuation and excitation/de-excitation techniques. Such cross sections are particularly sensitive to the initial ion state at the lower energies, explaining some discrepancies between existing data.

In the area of electron collisions, E. Salzborn reviewed recent high-resolution electron-impact ionization measurements at Giessen, as well as exploratory measurements of dissociative ionization of CO_2^+ , NO^+ , and CaH^+ . The accuracy of such measurements has thus far been limited by large backgrounds due to the Kr gas which must be added to neutralize space charge in the electron beam, by appreciable angular scattering of (particularly light) fragments, and by internal excitation of the reactant ion beams. V. McCoy reported calculations of electron-impact excitation of N_2 , based on the Schwinger multichannel variational method. The calculations show strong resonance structures, but almost no experimental data exist to test such calculations for molecules. Multiple-Instruction Multiple Data (MIMD) machines consisting of hundreds to thousands of microprocessors are ideally suited to such massively-parallel calculations. A home-built hypercube system consisting of 64 microprocessors is being developed which is expected to out-perform the fastest shared-memory (e.g., Cray) computer in this application.

Atomic physics issues relevant to ITER were summarized by R. Janev of the IAEA, and discussions followed along similar lines to those at the data center meeting. Working groups on spectroscopy and electron collisions, chaired by S. Trajmar, and on heavy-particle collisions, chaired by myself, were formed to review progress, to identify areas for study, and to produce a summary report. A general need was expressed for cross sections differential in product energy and scattering angle, especially for neutral products. Data for inelastic processes involving excited H and He are also required. A better definition of reactant quantum states is required for some experiments, since ionic metastable levels are often significantly populated, and cross sections for many low-energy processes are strongly state-dependent. Data for many relevant heavy-particle collision processes (e.g., electron capture) are unavailable at edge-relevant energies below 100 eV/amu. Because of ITER materials considerations, the elements Be, B, Ti, and Si were added to the scope, and, recognizing the expanded ITER focus, it was recommended that the coordinated research program be extended for three additional years.

Summary

Activity in the field of physics of highly charged ions continues to expand, particularly in Europe, where manpower and resources are not constrained as they are in the U.S. at present. A number of technical advances have produced important new results, particularly in electron-ion collisions, where experiment now appears capable of keeping pace with theory. There is relatively less activity in heavy-particle collisions at present, even though low-energy theory remains essentially untested by experiment. The study of ion-surface interactions is a growing sub-field. New insights have developed on the neutralization process as experiments have become more sophisticated. Previously accepted models appear inadequate to explain the observations, and theoretical activity in this area is just being initiated.

9/10

ITER now provides an important focus for the production and compilation of atomic and molecular data for applications in fusion research. The most urgent data needs are for modelling and diagnostics of the edge plasma, and for neutral-beam penetration. The ALADDIN data base system has been universally accepted and has significantly streamlined the exchange of numerical data among data centers and the fusion community. The IAEA continues to play a pivotal role in the identification of atomic data needs, and in the coordination of data compilation and research activities for fusion applications.

APPENDIX A ITINERARY AND PRINCIPAL CONTACTS

1990

- 9/8-9/9 Travel by air from Oak Ridge, Tennessee, to Frankfurt, West Germany, and by train to Giessen
- 9/10-9/14 Fifth International Conference on the Physics of Highly Charged Ions, Justus Liebig University, Giessen
 E. Salzborn, A. Müller, F. Melchert, M. Liehr (Univ. of Giessen)
 G. H. Dunn (JILA, Boulder, CO)
 W. Wiese (NIST, Gaithersburg, MD)
 M. S. Pindzola (Auburn Univ., Auburn, AL)
 R. E. Olson, M. Schulz (Univ. Missouri-Rolla, MO)
 C. L. Cocke, J. P. Giese (Kansas State Univ., Manhattan, KS)
 D. Schneider (LLNL, Livermore, CA)
 H. P. Summers (JET, Culham, U.K.)
 H. B. Gilbody, K. F. Dunn, I. Williams (Queen's Univ., Belfast, U.K.)
 R. W. McCullough, W. G. Graham (Queen's Univ., Belfast, U.K.)
 P. Hvelplund (Aarhus Univ., Denmark)
 H. Andra, B. A. Huber (CEN, Grenoble, France)
 S. Ohtani (Univ. Electro-Communications, Tokyo, Japan)
 N. Elander, A. Barany (Inst. Physics, Stockholm, Sweden)
 F. J. De Heer (FOM Inst., Amsterdam, the Netherlands)
 R. Hoeckstra (KVI, Groningen, the Netherlands)
 V. V. Afrosimov, S. Bobashev (IOFFE Inst., Leningrad, U.S.S.R.)
 L. P. Presnyakov (Lebedev Inst., Moscow, U.S.S.R.)
 M. Gryzinski (Inst. Nucl. Studies, Swierk-Otwock, Poland)
 R. Mann (GSI, Darmstadt, W. Germany)
- 9/15-9/16 Weekend in Giessen
- 9/17-9/18 Strahlenzentrum, Justus Liebig University, Giessen
 A. Müller, G. Hoffman
- 9/19 Travel by train from Giessen to Frankfurt, by air to Vienna, Austria

APPENDIX A (Continued)

- 9/20-9/21 9th Meeting of the Atomic and Molecular Data Center and ALADDIN Network, International Atomic Energy Agency, Vienna (R. K. Janev)
 R. K. Janev, J. J. Smith, J. Schmidt (IAEA, Vienna)
 R. H. McKnight (DOE, Germantown, MD)
 R. A. Hulse (PPPL, Princeton, NJ)
 W. Wiese (NIST, Gaithersburg, MD)
 R.E.H. Clark (LANL, Los Alamos, NM)
 T. Shirai (JAERI, Tokai, Japan)
 H. Tawara (Nat. Inst. Fusion Sci., Nagoya, Japan)
 V. A. Abramov (Kurchatov Inst., Moscow, U.S.S.R.)
 J. L. Delcroix, K. Katsonis (GAPHYOR, Orsay, France)
 E. Menapace (ENEA, Bologna, Italy)
 Sun Yongsheng (CRAAMD, Beijing, China)
 A. Faenov (VNIIFTRI, Moscow, U.S.S.R.)
 V. Piksaikin (Fiziko-En. Inst., Obninsk, U.S.S.R.)
- 9/22-9/23 Weekend in Vienna
- 9/24-9/26 Research Coordination Meeting on Atomic and Molecular Data for Fusion Edge Plasmas, International Atomic Energy Agency, Vienna
 R. K. Janev, J. J. Smith, J. Schmidt (IAEA, Vienna)
 R. H. McKnight (DOE, Germantown, MD)
 R. A. Hulse (PPPL, Princeton, NJ)
 W. Wiese (NIST, Gaithersburg, MD)
 S. Trajmar (JPL, Pasadena, CA)
 V. McCoy (Cal. Tech., Pasadena, CA)
 E. Salzborn (Univ. Giessen, W. Germany)
 F. Brouillard (Univ. Louvain-la-Neuve, Belgium)
 F. Linder (Univ. Kaiserslautern, W. Germany)
 T. Shirai (JAERI, Tokai, Japan)
 H. Tawara (Nat. Inst. Fusion Sci., Nagoya, Japan)
 V. A. Abramov V. Belyaev (Kurchatov Inst., Moscow, U.S.S.R.)
 Sun Yongsheng (CRAAMD, Beijing, China)
 E. Unterreiter (Tech. Univ., Vienna, Austria)
 I. Cadez (Inst. Physics, Belgrade, Yugoslavia)
- 9/27 Travel by air from Vienna to Oak Ridge

**APPENDIX B
LITERATURE RECEIVED**

Vth International Conference on the Physics of Highly Charged Ions, Giessen, Book of Abstracts.

"Atomic Physics Issues in Fusion Reactor Design," R. K. Janev, preprint, to be submitted to Comments on Atomic and Molecular Physics.

Copies of materials used in presentations, International Atomic Energy Agency, Vienna

"Measurements of Electron-Impact Ionization and Dissociative Attachment Cross Sections," N. Djuric, proposal to US-Yugoslav Joint Board.

"Are the existing measurements and theoretical calculations of the charge transfer correct?" M. Gryzinski, Report JET-P(88)23, Abingdon, U.K. (1988).

"Deterministic theory of the atom - real possibility or utopia?" Michael Gryzinski, Proc. Int. Conf. on Classical Dynamics in Atomic and Molecular Physics, Brioni, Yugoslavia, 1988.

APPENDIX C

Vth International Conference on the Physics of Highly Charged Ions
Giessen, FRG, September 10-14, 1990

Conference Program

Monday

- 09:45 - 10:00 *Conference opening*
 10:00 - 10:30 B. Fawcett (Chilton)
 The role of highly-charged ions in astrophysical and laboratory plasmas
 10:30 - 11:00 *coffee*
 11:00 - 11:30 G. Soff (GSI)
 Theory of highly-ionized few-electron systems
 11:30 - 12:00 G. Berry (Argonne)
 Precision spectroscopic measurements in few-electron ions
 12:00 - 12:30 H. P. Summers (Abingdon)
 Atomic spectroscopy in highly-ionized plasmas
 14:30 - 18:00 *Poster Session 1*

Tuesday

- 9:00 - 9:30 M. S. Pindzola (Auburn)
 Electron scattering theory for highly-charged ions
 9:30 - 10:00 L. H. Andersen (Aarhus)
 Dielectronic and radiative recombination with highly-charged ions
 10:00 - 10:30 D. Knapp (Livermore)
 Measurements of electron-ion interactions at EBIT
 10:30 - 11:00 *coffee*
 11:00 - 11:30 A. Müller (Giessen)
 Electron-impact ionization of multiply-charged ions
 11:30 - 12:00 S. Datz (Oak Ridge)
 Electron-ion interactions in crystal channels
 12:00 - 12:30 A. Warczak (Krakow)
 Electron-electron interaction in fast ion-atom collisions
 14:30 - 18:00 *Poster Session 2*
 18:30 - 22:00 Laboratory Visit

Wednesday

- 9:00 - 9:30 R. Dörner (Frankfurt)
 Dynamics of recoil-ion production
 9:30 - 10:00 M. Horbatsch (Toronto)
 Theory of multiple ionization and capture in energetic ion-atom collisions
 10:00 - 10:30 D. Schneider (Livermore)
 Electron spectroscopy in ion-atom collisions
 10:30 - 11:00 *coffee*
 11:00 - 11:30 A. Wolf (Heidelberg)
 Experiments with highly-charged ions at the TSR
 11:30 - 12:00 F. Bosch (GSI)
 The first atomic physics experiments at the Darmstadt heavy-ion storage ring ESR
 13:30 - 19:30 Visit at GSI

APPENDIX C (Continued)

Thursday

- 9:00 - 9:30 K. Taulbjerg (Aarhus)
Status of the theory of electron capture in ion-atom collisions at low and intermediate energies
- 9:30 - 10:00 R. Hoekstra (Groningen)
Photons shedding light on basic charge exchange processes
- 10:00 - 10:30 J. Hansen (Amsterdam)
Calculations for doubly-excited states populated in two-electron processes
- 10:30 - 11:00 *coffee*
- 11:00 - 11:30 P. Roncin (Orsay)
Dynamic processes in two-electron capture reactions
- 11:30 - 12:00 H. Cederquist (Stockholm)
Multi-electron processes in slow ion-atom collisions at very high charge
- 12:00 - 12:30 D. H. Hoffmann (GSI)
Interaction of heavy ions with hot ionized matter
- 14:30 - 18:00 *Poster Session 4*
- 19:30 *Conference Dinner*

Friday

- 9:00 - 9:30 M. P. Stöckli (Manhattan)
The status of the electron beam ion sources
- 9:30 - 10:00 R. Geller (Grenoble)
The status of ECR ion sources
- 10:00 - 10:30 J. P. Briand (Paris)
Collisions of highly-charged ions with surfaces
- 10:30 - 11:00 *coffee*
- 11:00 - 11:30 E. S. Parilis (Tashkent)
New trends in ion-surface interactions
- 11:30 - 12:00 H. Winter (Vienna)
What ions experience on their way into a metal surface
- 12:00 - 12:30 J. Remillieux (Lyon)
Atomic collision processes induced by fast heavy ions channeled in crystals
- 14:30 - 18:00 *Poster Session 5*

APPENDIX D

IAEA Consultants' Meeting:
9th Meeting of Atomic and Molecular Data Centres and ALADDIN Network

September 20 and 21, 1990, Vienna, Austria

PROPOSED AGENDA

Thursday, September 20

09:30 - 09:45: Opening
 Adoption of Meeting Agenda

Session 1: Current activities and near-future plans of A+M Data Centres
Chairman: Delcroix

09:45 - 11:00: Reports from Data Centres:
Wiese (NIST), Abramov (Moscow), Smith (Belfast)

11:00 - 11:15: Coffee break

11:15 - 12:30: Reports from Data Centres:
Phaneuf (ORNL), Tawara (Nagoya), Shirai (JAERI)

12:30 - 14:00: Lunch

Session 1: (Cont'd)
Chairman: Abramov

14:00 - 15:45: Reports from Data Centres:
Delcroix/Katsonis (GAPHYOR), Menapace (Bologna), Piksaikin (Obninsk)

15:45 - 16:00: Coffee break

16:00 - 18:00: Reports from Data Centres:
Sun Yongsheng (CRAAMD), Yao Jin-Zhang (CNDC), Faenov (VNIIFTRI), Mattioli (?) (Cadarache), Janev (IAEA)

19:30 - Joint Dinner

Friday, September 21

Session 2: Status of ALADDIN system, its implementation in data centre practices and further developments
Chairman: Hulse

09:00 - 10:30: Comments of Hulse and Reports from IAEA AMDU, A+M Data Centres and other ALADDIN users

10:30 - 10:45: Coffee break

10:45 - 12:00: Further ALADDIN developments and next version of ALADDIN Manual (Hulse, Clark, Faenov, J.J. Smith, other ALADDIN users)

12:00 - 14:00: Lunch

APPENDIX D (Continued)

Session 3: Priorities in the A+M data compilation and evaluation,
 activities and DCN funding/manpower situation

Chairman: Janev

- 14:00 - 15:30: a) Progress in development of current priority A+M databases:
 status of the activity actions adopted at the last DCN
 meeting;
 b) Analysis of the DCN funding and manpower situation

15:30 - 16:00: Coffee_break_

Session 4: Meeting conclusions and recommendations

Chairman: Janev

- 16:00 - 17:30: - Formulation of Meeting conclusions and recommendations
 - Adoption of Meeting conclusions and recommendations

APPENDIX E

First Research Co-ordination Meeting on
"Atomic and Molecular Data for Fusion Edge Plasmas"

September 24-26, 1990, Vienna, Austria

MEETING AGENDA

Monday, September 24

09:30 - 09:45: Opening

Session 1: Inelastic electron-impact processes in the plasma edge
Chairman: F. Brouillard

09:45 - 10:15: W.L. Wiese: Spectroscopic data for plasma edge constituents
(tentative)

10:15 - 10:45: E. Salzborn: Electron impact ionization of atomic and
molecular ions

10:45 - 11:00: Coffee break

11:00 - 11:30: Jia Baolin: Brief review on dielectronic recombination

11:30 - 12:00: Sun Yongsheng: Calculation of dielectronic recombination cross
sections for Ti, Cr, Fe and Ni ions

12:00 - 14:00: Lunch

Session 1: (Cont'd)
Chairman: F. Linder

14:00 - 14:30: S. Trajmar: Electron collisions with excited atoms and
molecules

14:30 - 15:00: V. McKoy: Theoretical studies of electron-molecule collision
cross sections

15:00 - 15:30: I. Cadez: Some aspects of dynamics of vibrationally excited
hydrogen

15:30 - 16:00: Coffee break

16:00 - 16:30: H. Tawara: Collision data for hydrocarbon molecules: further
compilation and some new data

16:30 - 17:00: V. Abramov: (pending)

19:30 - Joint Dinner

APPENDIX E (Continued)

Tuesday, September 25Session 2: Heavy particle collision processes in the plasma edgeChairman: E. Salzborn

- 09:00 - 09:30: R. Phaneuf: Assessment of ion-atom collision data for plasma edge modelling
- 09:30 - 10:00: F. Brouillard: Low-energy rearrangement collisions of hydrogen atoms and ions
- 10:00 - 10:30: Coffee break
- 10:30 - 11:00: V. Belyaev: (pending)
- 11:00 - 11:30: K. Katsonis: CTMC studies of charge exchange and ionization (tentative)
- 11:30 - 12:00: T. Shirai: Comments on scaled cross section for the ionization of H, H₂ and He by multiply charged ions
- 12:00 - 14:00: Lunch

Session 2: (Cont'd)Chairman: R. Phaneuf

- 14:00 - 14:30: F. Linder: Beam scattering experiments on ion-molecule collision processes relevant to fusion edge plasmas
- 14:30 - 15:00: E. Unterreiter: Electron capture by C⁺ and C²⁺ from H₂ and He: absolute state-selective and total cross sections
- 15:00 - 15:30: Coffee break
- 15:30 - 16:00: P. Krstic: Calculations of vibrationally resolved charge exchange in H⁺, He⁺-H₂ collisions
- 16:00 - 16:30: Yao Jinzhang: Study of atomic and molecular processes on HI-13 Tandem
- 16:30 - 17:00: W. Lindinger: (pending)

Wednesday, September 26Session 3: Preparation of Working Group Reports

09:00 - 12:00: Work in parallel sessions:

A) Working Group on Spectroscopic and electron-impact collisional data (Room:)

B) Working Group on heavy-particle collision data (Room: A-19)

12:00 - 14:00 LunchSession 4: Meeting conclusions and recommendationsChairman: R. Janev

- 14:00 - 15:15: Discussion of Working Group Reports
- 15:15 - 15:45: Coffee break
- 15:45 - 16:30: Adoption of Working Group Reports and of the Meeting conclusions and recommendations

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