US NEUTRON SOURCES

A 1993 report by a sub-panel of the US Department of Energy (DoE) Basic Energy Sciences Advisory Committee (BESAC) recommended priority be given to the Advanced Neutron (reactor) Source (ANS) and to a new spallation source. In view of the cancellation by the US Administration of the ANS last February and the need to develop a coherent programme for neutron scattering within DoE, Martha Krebs, the Director of DOE's Office of Energy, asked BESAC in July (with an unspecified deadline):

- To evaluate possible upgrades to existing reactor sources at:
  - ORNL (Oak Ridge National Laboratory)
  - BNL (Brookhaven National Laboratory).
- For advice on the type of accelerator-based spallation source that could be built at ONRL for about one-third of the cost of the 3000 M$ ANS which was proposed by ONRL. ORNL has been identified by DoE as the preferred site for a spallation source and is due to receive 16 M$ for a two-year conceptual design study of a 1 MW/1000 M$ facility (a similar study is currently underway for a proposed 5 MW European Spallation Source).

Meanwhile, several upgraded or new facilities have been proposed in the US, namely:

- ANL (Argonne National Laboratory), site of the nearly complete 800 M$ Advanced Photon Source, has a detailed design for upgrading its Intense Pulse Neutron Source.
- BNL, site of the new Relativistic Heavy Ion Collider, has designed a spallation source.
- LANL (Los Alamos National Laboratory) is considering a 95 M$ upgrade of its proton linac (LANSCE) to give a 1 MW long-pulse spallation source. LANL will lead a first phase, 300 M$ technical study of a spallation-based tritium production facility that includes the construction of a prototype, although plans for a final facility based elsewhere are meeting opposition.

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provide an independent avenue for future progress in neutron scattering.

It is far too early to say whether a long-pulse source will be built in the US. However, the availability at the Los Alamos National Laboratory of a proton linear accelerator which has produced a megawatt of beam power for the past two decades would make the construction of such a source remarkably cost-effective, a feature which is especially attractive in these times of tight budgets for scientific projects.

ECAMP-5

Spanning a Broad Field

H. Hotop reports that the highlights of the 5th European Conference on Atomic and Molecular Physics (ECAMP-5) demonstrate the breadth and depth of a field which spans topics ranging from basic reasearch to applications.

Precision Spectroscopy

The combination of intense, pulsed UV laser radiation with fast, position-sensitive photon detection methods allows detailed diagnostic studies of turbulent combustion processes (cover illustration). P. Andresen (Bielefeld) demonstrated that the simultaneous measurement of gas composition, temperature, pressure, and flow velocity leads to a better understanding of fundamental processes in turbulent reaction flow fields, thereby allowing the design of efficient, clean motors, jet engines and furnaces. G. Meijer (Nijmegen) presented cavity ring-down (CRD) spectroscopy, a novel method for trace-gas detection based on measuring the rate of absorption rather than the magnitude of absorption of a (laser-) light pulse confined in a high-Q optical cavity. Noise-equivalent absorption coefficients in the 10^{-10} cm^{-1} range have been demonstrated in the visible and near-UV range.

Impressive advances have been recently made at four facilities in Europe — TSR (Heidleberg); ESR (Darmstadt); ASTRID (Aarhus); CRYRING (Stockholm) — which operate ion-storage cooler rings. D. Habs (Heidelberg) gave an overview of the fascinating atomic and molecular physics programme that is being carried out. Electron cooling of atomic ions leads to brilliant monochromatic beams of highly-charged ions which can be used for new kinds of precision experiments, both in spectroscopy and collisions. Many beautiful results have been obtained in the last three years in X-ray spectroscopy (*e.g.*, of hydrogen-like U^{91+} ions) and in radiative, laser-stimulated and dielectronic recombination of ions in collisions with electrons. Advanced electron cooling schemes with a magnetically expanded electron beam now allow studies at energy resolutions of 10 meV and below. Molecular ions have also been successfully studied, taking advantage of the vibrational and rotational cooling associated with storage times of several seconds. M. Larsson (Stockholm) highlighted the progress in dissociative recombination experiments with storage rings and J. Tenyson (London) surveyed recent advances in the theoretical descriptions of processes.

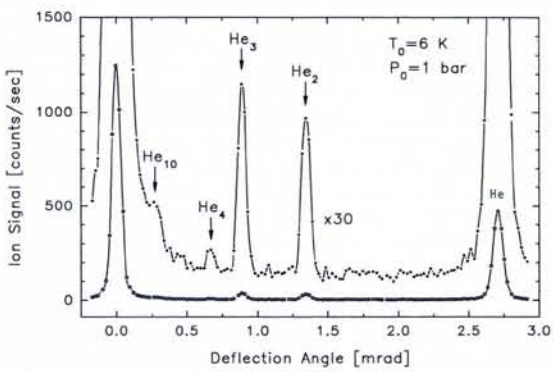
Electron-Ion & Ion-Surface Interactions

Regarding electron collisions with atoms, molecules and surfaces, the dynamics of ionization processes has been studied in great detail using (e, 2e)- and (e, 3e)-coincidence experiments. They reveal electron correlation effects in bound and continuum states, including post-collision interactions affecting near-threshold inner-shell ionization processes (G. Stefani, Rome). Future studies will consider atoms in both excited states and external fields as well as surfaces. Recent progress includes electron-photon (e, eγ) and electron-electron (e, 2e) coincidence studies involving spin-polarized electrons. The results will shed light on exchange effects and spin-orbit interaction, both in bound and continuum states. Some problems, especially for chiral molecules, remain to be clarified. D. Teillet-Billy (Orsay) discussed the physics of the dynamics of energy transfer in electron collisions with molecules absorbed at surfaces. Specific properties of resonant electron-molecules scattering can be explored for adsorbate analysis and exploited to induce reactions on surfaces. Progress in positron and positronium scattering studies were surveyed by G. Laricchia (London). Experimental investigations of positron collisions with simple atomic and molecular systems have advanced to near-threshold and differential measurements of selected scattering channels. Controlled diffusion experiments involving positronium projectiles have recently begun.

New Techniques - New Insights

New techniques are leading to new insights. This is illustrated by the following:

- Recent advances made in investigations of heavy-particle collisions which include the development of ion-recoil spectroscopy allowing, for instance, detailed studies of state-selective, electron capture of highly-charged ions with a high-energy resolution and sensitivity (J. Ullrich, Darmstadt). Ion-recoil spectroscopy also allows the kinematically complete measurement of electron-impact induced single ionization and of photon-induced double ionization.
- The interaction of slow, highly charged ions with metal and insulator surfaces leading to



Diffraction of helium clusters. *This diffraction pattern was taken with a He_2 cluster beam produced by expanding pure ^4He through a 5 μm nozzle (6 K source temperature; 1 bar source pressure). The forward undiffracted peak is at 0 mrad and the first-order diffraction peaks corresponding to the monomer, dimer, trimer, and tetramer are all clearly resolved. It should be noted that the relative intensities depend on the source pressure, with He_2 as the dominant cluster contribution at low pressures, followed by trimers at intermediate pressures. Since the diffraction mechanism is totally non-destructive, this type of experiment provides the first unequivocal evidence not only for the dimer, but also for the existence of the trimer and tetramer. There is great interest in the trimer since it is the best candidate for showing long-range Efimov states. See W. Schöllkopf & J.P. Tonnies,* Science ***266*** *(1994) 1345.*

ECAMP-5 (Edinburgh; 3-7 April 1995)

The fifth European Conference on Atomic and Molecular Physics (ECAMP), the Divisional conference of the EPS Atomic and Molecular Division (AMPD), was organized by our British colleagues, with J.-P. Connerade as the Chairman, N.J. Mason as the Secretary, A.C. Smith as the Treasurer, and R.C. Thompson handling publications. They were supported by many other colleagues, especially from Edinburgh where the conference took place. ECAMP-5 was held jointly with the annual meetings of the Atomic, Molecular and Optical Physics Division of the UK Institute of Physics, of the Atomic and Molecular Physics Division of the German Physical Society, and of the European Group of Atomic Spectroscopy (EGAS). With more than 750 participants from 33 countries, the response to ECAMP-5 was excellent in spite of the distance between Edinburgh and most parts of Europe. Attendance by many young scientists was made possible through grants from the European Union's Human Capital and Mobility Programme and - for German students - from the W.E. Heraeus Foundation; the International Science Foundation are thanked for making possible the participation of 12 east European scientists.

The oral presentations consisted of 54 invited lectures (9 plenary talks, 41 review talks or progress reports, and 4 lectures as part of the Edinburgh Science Festival). In addition, 25 "hot topics" - chosen from the submitted abstracts - were presented, often by young scientists.The oral presentations together with the well-attended poster sessions (representing about 800 contributed papers in all) testified to the atomic and molecular physics community's vitality. Its strong links to (physical) chemistry were emphasized by the Chemical Physics Symposium supported by the Faraday Society, the Bunsen-Gesellschaft and Société Française de Chimie. The programme also included evening lectures by A. Dalgarno (Cambridge, USA) and T.W. Hänsch (Munich) to pay tribute to two eminent British atomic physicists, David Bates and George Series, who died recently.

The AMPD Board met during the conference and elections were held during the Division's General Assembly on 5 April. R. Morgenstern (Groningen) was elected as new the AMPD chair, replacing H. Hotop (Kaiserslautern); V. Aquilanti (Perugia) will serve as Vice-Chair with R.C. Thompson (London) as the Treasurer.The Board accepted a proposal to hold ECAMP-6 in Sienna in mid-July 1998 (L. Moi from Sienna will chair the local organizing committee).

the generation and decay of multiply excited "hollow" atoms as revealed by spectroscopic studies of the decay electrons and photons. In this context, F. Aumayr (Vienna) addressed the measurement of electron yields and the statistics of electron emission.

• The laser preparation of atomic targets, which gives insight into the influence of orbital alignment and orientation on the outcome of a reaction. This was discussed by D. Dowek (Orsay), H. Rudolph (Utrecht) and E. Horsdal-Pedersen (Aahus) who described experiments with target atoms having an oriented, circular Rydberg state. In a "hot topic" presentation, A. Grosser (Hannover) reported on the first study of the angular dependence of atom-atom scattering in a non-resonant laser field.

• The development of techniques involving supersonic expansion, which has recently allowed detailed investigations of chemical reactions at low temperatures (reviewed by B.R. Rowe, Rennes). The resulting data are important for understanding the chemistry leading to the formation of molecules in astro-chemical and atmospheric situations.

• The availability of fullerene clusters (especially C_{60}), whose chemical structure was reviewed by P.W. Fowler (Exeter), allows the detailed investigation of the dynamics of size-selected cluster-cluster collisions. E.E.B. Campbell (Berlin) and R. Schmidt (Dresden) discussed experimental and theoretical advances, respectively. Remarkable capture and fusion processes are observed, resembling in a certain sense nuclear processes. The fragmentation behaviour of multiply-charged fullerene ions upon electron impact as well as paths leading to the production of charged fragment ions has been clarified by mass spectrometry (P. Scheier, Innsbruck). Cold helium cluster beams have been used for impressive diffraction studies, and for high-resolution spectroscopy of embedded molecules (*e.g.*, SF_6), by J.P. Toennies (Göttingen) and his group. Small He clusters were separated by diffraction (see figure) using a transmission grating having a 200 nm period, and the existence of the (very weakly bound) He_2 molecule was established.

Photon Interactions

A major part of the scientific programme was devoted to the interaction of photons with atoms, molecules, clusters, and surfaces. J.A. Beswick (Toulouse) and P. Villareal (Madrid) discussed the photodynamics of molecules and small clusters, especially the theory of photofragmentation following a defined optical excitation (including the time-dependent pump-probe dynamics on a femtosecond time-scale). Progress in the theory of photo-ionization of molecules (V. Carravetta, Pisa) and of positive and negative ions (V.K. Ivanov, St. Petersburg) is paralleled by nearly complete experimental studies of the double photo-ionization of simple atoms (V. Schmidt, Freiburg). Electron correlations and channel interaction in highly-excited alkaline-earth atoms were described in detail by combining R-matrix and multichannel quantum defect theory (M. Aymar, Orsay). R. Karazija (Vilnius) showed how the global characteristics of atomic spectra (moments of the spectral distribution) can be used to analyze photo-induced spectra. Optical-optical double resonance has been exploited recently to reveal the presence of ion-pair states in the spectra of diatomic molecules (R.J. Donovan, Edinburgh). Detailed analysis of photofragmentation of excited H_2 molecules have permitted the detection of non-adiabatic and spin-dependent interactions (W.J. van der Zande, Amsterdam). The preparation of selected, polyatomic molecules of intermediate-size in single vibration-rotation quantum states of the electronic ground state at energies above the threshold for unimolecular decomposition or isomerization allows a better insight into molecular reaction dynamics (F. Temps, Göttingen). This approach reveals – depending on the system – mode-selective dynamics or statistical behaviour. Photoelectron spectra of the negative ion (FH_2^-) complex sheds new light on chemical reaction dynamics in triatomic molecules such as $F\text{-}H_2$ (D.E. Manolopoulos, Nottingham). Delayed pulsed field ionization of long-lived high-lying Rydberg states (corresponding to the detection of zero-energy photoelectrons – ZEKE spectroscopy) offers unprecedented possibilities for high-resolution studies of molecular and cluster ions (as demonstrated by K. Müller-Dethlefs, Munich) who developed the ZEKE method).

Strong Fields

Several speakers dealt with the behaviour of atoms in strong electromagnetic fields. Besides studies of Rydberg states in static electric and magnetic fields (K.T. Taylor, Belfast), the effects associated with strong laser fields (which now reach about 10^{19} W/cm^2) were discussed (P.L. Knight, London). C.G. Wahlstrom (Lund) surveyed the generation and application of high harmonics (number of harmonics n up to 100 and above) in gases and G.G. Paulus (Munich) showed that the plateau in the high-harmonics intensity spectrum around a certain value of n corresponds to a plateau in the mutiphoton ionization process as observed in the electron spectra. F. Faisal (Bielefeld) demonstrated the effects of strong laser fields on electron scattering processes and M. Allegrini (Pisa) discussed the dynamics of laser-induced plasmas after the interaction of an intense XeCl excimer laser (308 nm) with metal, dielectric and ceramic targets.

Precision Spectroscopy

Precision spectroscopy of basic electronic systems is at the heart of atomic physics. T.W. Hänsch (Munich) demonstrated in his tribute to George Series the impressive recent advances in the spectroscopy of the hydrogen atom. They stem from the reduction of laser linewidths, the use of cold hydrogen atoms and the attainment of higher precision in optical frequency measurements (the Rydberg constant is now known to within $3\text{x}10^{-11}$). Highly-charged hydrogen-like ions (such as U^{91+}) also allow detailed tests of QED corrections, and their spectra are being studied theoretically (L.N. Labzowsky, St. Petersburg) and experimentally using ion-storage rings (D. Habs, Heildeberg). In principle, the positronium atom is especially well-suited for QED tests owing to the absence of nuclear effects; today's accuracy in (e^+e^-) spectroscopy (R. Ley, Mainz) is around 1MHz (confirming QED on the 10^{-4} level). R. Blatt (Göttingen) discussed precision spectroscopy and new cooling techniques for a single trapped ion (transitions in a such an ion may offer a future frequency standard).

A. Hemmerich (Munich) led us into the world of "bright and dark optical lattices" formed by ultra-cold atoms which are localized by dipole forces inside optical standing waves. Atoms in nearly "quantum states" are only weakly coupled to the light field, and it should be possible to reach high atomic densities in dark optical lattices. Atom optics interferometry has seen a rapid development since the last ECAMP. J. Baudon (Paris) in a clear, concise survey of recent achievements, associated much of it to progress in microstructure fabrication and in the manipulation of atoms with lasers.