LASERS

Laser Induced Processes in Molecules

Is Laser Chemistry Dying?

This, paradoxically, was the question being asked at the Divisional Conference held in Edinburgh, organized by the EPS Quantum Electronics Division on the "Physics and Chemistry of Laser Induced Processes in Molecules". Judging from the 102 papers offered from 250 participants from many countries and also from the large variety of new effects reported, in research terms the subject is, on the contrary, very much alive. The conference programme covered five different areas, namely:

- Part I: Study of lasers and related techniques suitable for applications in chemistry and spectroscopy
- Part II: Spectroscopic studies with and related to lasers
- Part III: Multiphoton excitation, dissociation, and ionization
- Part IV: Laser control of chemical reactions
- Part V: Molecular relaxation

Laser chemistry used often to be viewed, because of early naiveté, primarily as a new route to synthetic chemistry, providing major chances for a real break-through even in industrial applications. As the field developed, however, this became less and less important, and instead, gave way to new and unexpected laser applications which had nothing to do with synthesis, but rather with analysis of chemical compounds. In addition to these analytical applications, the high radiation powers available with lasers led to the discovery of the new phenomenon of multiple photon excitation of molecules, i.e. the absorption of many photons by a polyatomic molecule under not strictly resonant conditions, resulting in chemical changes. Successful use of this excitation concept in the separation of many isotopes, including uranium, has added to the motivation (and funding) of the study of this process. As in other international conferences of this type, multiple photon excitation was, therefore, one of the themes upon which the meeting focused.

Three types of new experimental information were reported concerning: the time history of the absorption process and the energy distribution in the highly excited molecules; the influence of collisions on the excitation and dissociation; and the study of molecules other than SF_6, including the first demonstration of molecular dissociation of triatomics like ozone and carbonyl sulphide.

This field is also receiving considerable attention from the theorists, where two main positions could be identified. One believes that the interpretation of multiple photon excitation is primarily a spectroscopic problem, the other assumes that a statistical treatment without consideration of spectroscopic details is appropriate. Both positions were defended excellently at the conference and many new arguments were put forward.

Laser control of chemical reactions was the other area of central interest. Such control can presently only be executed under very special conditions, i.e. in molecular beams or very low pressure gas flows and for special reaction systems, i.e. those involving only small molecules and atoms. This type of work yields very detailed information on collision dynamics and chemical reactivity of state-selected species. The laser in this case is not only a valuable and necessary tool for the preparation of reagents, but also serves as a diagnostic tool for identification and analysis of the reaction products. One is approaching then, in this case, the dream of full control over a chemical process at all stages, limited however to academic applications.

The other parts of the conference programme mentioned above are complementary to the goals described. In particular, suitable laser sources with fine tunability over large wavelength regions are still scarce and much of the work in laser chemistry must, therefore, still be oriented towards laser development. Major progress was reported here both in the infrared and in the ultraviolet spectral ranges, the latter concentrating on rare gas halogen laser systems. First applications of such lasers to ultraviolet photochemistry provided unexpected results in so far as mostly nonlinear processes were observed. This suggests that multiphoton excitation may perhaps become as popular in the UV as it is in the IR now.

The two other areas in the conference programme, laser spectroscopy and molecular relaxation, were somewhat smaller in content owing to the fact that these subject areas are commonly represented in other specialized international meetings. Molecular relaxation studies were reported in the gas phase and in condensed phases. Ultrafast vibrational relaxation of polyatomic molecules was discussed in a classical paper. Vibrational relaxation studies in the gas phase were characterized by the use of tunable laser sources, and by the study of molecules which are more complicated than the diatomics upon which previous work had mostly concentrated. Laser augmentation of processes occurring at low temperatures in matrices and on surfaces is a subject many people talk about. It is surprising then that this very important and exciting future prospect for laser chemistry was only sparingly represented at this conference. The few papers in this area, however, from England and France were excellent and we can look forward to a continuation in this direction.

In conclusion, the Edinburgh Meeting was an International conference with a European flavour, and the review of the various aspects of laser chemistry provided there was acknowledged to be fruitful and productive by the participants. The proceedings of this conference are now in print and will appear as Vol. 6 of Springer *Series in Chemical Physics.*

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*M. Poliakoff**
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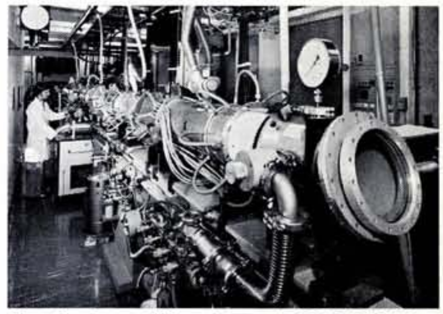
(M-P-G Garching)
** On detachment*

Progress with Iodine Lasers for Fusion Experiments



The final amplifier stage of ASTERIX III at Garching.

In 1977, the small group of lasers suitable for fusion-oriented plasma experiments acquired a new member: the photochemical iodine laser. The active medium of this laser is gaseous C_3F_7I which decomposes upon irradiation with UV light into C_3F_7 and I ($^2P_{1/2}$). The laser operates on the magnetic dipole transition $^2P_{1/2}$ - $^2P_{3/2}$ of atomic iodine at 1.3 μm.

The work on this laser system at the Projektgruppe für Laserforschung der Max-Planck-Gesellschaft resulted in the construction of the 1 TW system known as ASTERIX III. It became operational in 1976 and is now used for plasma experiments.

In the ASTERIX III laser, a single 1 mJ pulse is switched out of a pulse train produced in an acousto-optically model-locked oscillator, then to be amplified in four consecutive amplifiers of increasing size, the last stage having a length of 10 m and producing a nearly diffraction limited beam of 16 cm diameter. A total energy of 360 kJ is discharged into xenon flashlamps to pump the laser. One shot can be delivered every eight minutes.

Asterix III is now used for experiments in which the plasma production process in plane targets is studied. Powers up to 1 TW in pulses of about 300 ps duration give intensities up to 2×10^{16} W/cm^2 on the target. The power of the prepulses is smaller than 1 kW, so that even very sensitive targets are not damaged before the arrival of the main pulse energy. No deterioration of the beam quality due to nonlinear effects in the medium or the other optical components could be observed and the focus spot size as measured, was found to be close to the ideal. This was obtained without using any costly beam quality improving components, such as spatial filters. Another advantage of the iodine system is that it is not sensitive to damage by light reflected from the plasma. This is because the reflected light is Doppler broadened and shifted and consequently only a small portion of it lies within the amplification bandwidth of the laser. Finally, pulse duration and bandwidth measurements reveal that the iodine laser pulse is transform limited. This confirms the observation of smooth pulses with no substructures.

In conclusion, the operation of ASTERIX III has demonstrated that all the requirements for relevant laser fusion experiments are met by the iodine laser. As to performance, complexity and cost, it compares well with the other fusion lasers, although its potential for further improvement has not yet been fully exploited. Where as a few years ago the Nd-glass laser system was a clear choice for laser plasma studies at high powers, this latest progress with a gas laser operating at a similar wavelength, makes iodine a serious contender for the future.

G. Brederlow
(M-P-G Garching)

Laser—Plasma Interactions

The XII European Conference on Laser Interaction with Matter (ECLIM) was held in Moscow from 11-15 Dec., eight years since ECLIM was last held there, when laser technology was still relatively primitive. As a particular example, the energy then available from a pulsed CO_2 laser was only 10J, with a peak power of ~ 10 MW. Of comparable importance, the absorption coefficient for radiation having wavelengths between ½ and 10 μm as a function of incident angle, polarisation and intensity, and as a function of plasma composition and initial distribution, had not been characterized in systematic experiments; nor were existing measurements well co-ordinated with available theoretical (mostly analytic) models of relevant linear and non-linear interactions.

At this conference, although no fundamental break-through was reported, overall progress in the field has been significant and encouraging.

Advances in laser technology have been particularly striking, with 10 kJ, 27 TW, Nd: glass and 10 kJ, 20 TW, CO_2 laser systems successfully commissioned in the past year at the Lawrence Livermore and Los Alamos Scientific Laboratories respectively. All of the 1 μm and ~ ¼ of the 10 μm power has already been symmetrically focused on to gas filled microballon "exploding pusher" targets. DT neutron yield increases with incident Nd laser power to an (unoptimised) 3×10^{10} neutrons at 27 TW; scaling at both wavelengths fits quasi-analytic models. Significant thermonuclear burn will, however, require the experimental achievement of an isentropic compression of the target's core, so more complex layered microballoon "ablative burn" targets are now receiving increasing experimental attention.

At incident powers $< 10^{12}$W, the KMS and KALMAR (Lebedev) Nd lasers have demonstrated compressions approaching × 35 (hydrogenic) solid-state densities; using cryogenic targets and α emission spectroscopy, KMS claim that this compression is partly adiabatic. In summary, available "driver" powers have increased tremendously over the past eight years — for CO_2 lasers by a factor of 10^6; ideas advanced for larger systems (regenerative relayed amplifiers, stimulated Raman/Brillouin convertors, etc.) suggest that 0.1 ~ 1 MJ drivers (predicted to be of practical interest) may well be operational within the next decade.

Developments in the understanding of laser-plasma interactions, and of the necessary diagnostic techniques, are equally impressive. Various groups have experimentally investigated the absorption of laser light at wavelengths (λ) of $^1/_4$, $^1/_2$, 1 and 10 μm, and at intensities (I) within at least part of the range $I = 10^{10} - 10^{16}$ W/cm^2; there now appears to be universal agreement that strong density-profile modifications are induced by radiation pressure effects when ($I\lambda^2$) $\sim 10^{15}$ (W/cm^2) (μm)^2, and that resonance absorption increases the total absorption coefficient at the longer wavelengths signficantly. Related measurements suggest that much of the absorbed radiant energy is then converted to hot, non-thermal, electrons. Developments in two and three-dimensional soliton theory, and in analytic modelling of strong turbulence by the Russian school, are equally impressive.

The main topic for controversy appears to be the computer optimisation of target designs, where the avoidance of unwanted core preheating by the "hot" electrons and of possible deviations from the desired symmetry of implosion (due to Rayleigh-Taylor instabilities) poses significant modelling problems in the hydrodynamic codes. The US prefer "thick" (lower aspect ratio) double-shell designs to obviate both of these problems.

Our hosts are to be congratulated on arranging a particularly topical meeting, on the excellence and individuality of the oral translation facilities, and on the warmth of their hospitality, which more than compensated for external temperatures of < 243 K! The next meeting will be organised by the DDR Physical Society, and will probably be held in December 1979 at Leipzig.

I. J. Spalding
(Culham Laboratory)

EPS Scholarships for 1979/1980

Second List - Federal Republic of Germany

Further to the list of scholarships available in Poland, Romania and Switzerland, published in the December issue of *Europhysics News*, EPS can now announce the availability of five scholarships in the Federal Republic of Germany.

These are at:
— the Deutsches Elektronen-Synchrotron centre DESY, Hamburg
— the Hahn-Meitner-Institut für Kernforschung, Berlin (2) and
— the Kernforschungszentrum, Karlsruhe (2)

Further details are given below.

DESY

DESY is the principal national and state high energy physics laboratory that has specialized in electron machines. A 7 GeV synchrotron was followed by DORIS, the 3+3 GeV e^+e^- rings and PETRA the 19+19 GeV e^+e^- rings where luminosity has just reached 10^{30} cm $^{-2}$s^{-1}. Associated with DORIS is a synchrotron radiation facility.

The Scholarship is for experimental or theoretical work in elementary particle physics connected with the use of DORIS or PETRA. Remuneration will be from 3000 to 4000 DM/month according to qualifications. Normal travel to Hamburg paid by the Centre.

Hahn-Meitner-Institute

The Institute is a State funded centre of fundamental nuclear research, specializing in heavy ion physics, radiation and photochemistry, solid state research and nuclear chemistry. Principal experimental machines include a 5MW reactor, a 200 MeV heavy ion accelerator and several electron accelerators.

Scholarships are for post-doctoral work in the following fields:
1. Nuclear physics and heavy ion research (Profs. Eichler, Lindenberger and von Oertzen)
2. Nuclear sold state physics (Profs, Dachs, Vogl, Wollenberger)
3. Radiation Chemistry (Prof. Henglein)

The salary paid will be between 2600 and 3500 DM/month depending on experience and responsibilities. Normal travel costs will be paid by the Institute.

The Karlsruhe Research Centre

The Karlsruhe Laboratory is one of the two national nuclear research establishments with a very broad programme of research on fundamental and applied topics, centred round a series of research and experimental reactors. The Laboratory is also host to the European Transuranium Institute.

Scholarships are for post-doctoral work in the following fields:
(Division headed by Prof. W. Klose)
1. Solid state physics
2. Nuclear physics
3. Nuclear chemistry

Remuneration is at the rate of 1800 DM/month plus 1000 DM for the first month and help with the purchase of books. Travelling is not reimbursed.

Applications should be made to the EPS Secretariat. It is helpful also if some direct contact is established between the applicant and the professor under whom he will be working.

STOP PRESS: A further Scholarship has been offered by the Gesellschaft für Schwerionenforschung in Darmstadt for research with the heavy ion accelerator UNILAC, in cooperation with an existing group. Details next issue.

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