EQEC '91

European Quantum Electronics Conference 1991

The Edinburgh Conference Centre at Heriot-Watt University was the venue for the third European Quantum Electronics Conference, held for the first time in conjunction with the UK National Quantum Electronics Conference, the tenth in the series. It took place on 27-30 August 1991 and constituted the main European forum for the presentation and discussion of all aspects of quantum electronics, ranging from the fundamental to the applied. It was organised under the joint auspices of EPS and the Institute of Physics, UK.

Over 500 scientists from more than 20 countries contributed nearly 400 papers. Participation of young physicists is one of the goals of this EQEC Conference series so it is also worth mentioning that many graduate students attended. The organizers could also welcome a significant number of participants from east and central Europe, nearly all of whom were supported by bursaries. There was also an excellent technical exhibition catering for about 50 of the leading companies and publishers in the field. Displays included products from manufacturers and suppliers of lasers, electro-optical components, optical systems and accessories.

Quantum electronics covers a wide diversity of topics as it embraces laser physics and the interaction of coherent radiation with matter. A major theme of the conference was therefore inevitably devoted to the physics of laser sources, together with related areas in quantum optical phenomena, and in nonlinear optics, dynamics and complexity. Optical interaction with condensed matter, laser spectroscopy and ultra-fast phenomena were also strongly represented. Complementary topics in laser applications spanned a wide range, including nonlinear optical devices, optical communications and sensing, material processing and other industrial applications, as well as the use of lasers in chemistry, biology and medicine.

Professor Herbert Walther (Max-Planck-Institut, Garching) opened the conference with a keynote paper on "The Micromaser and Tests of Quantum Physics" which dealt with fundamental aspects of laser physics. The physics of laser sources, the topic with the largest number of contributions, reflected contemporary trends towards small solid-state systems with extensive coverage of fibre lasers, diode lasers and diode pumped solid-state systems. This trend carried through to gas discharge lasers where RF excitation and waveguide structures were emphasised.

With future goals in mind, Professor Geoffrey Pert (University of York) gave a plenary address on X-ray lasers. The session on quantum optics concentrated on the production and properties of squeezed states and cavity quantum electrodynamics. Another plenary talk was by Professor Alain Aspect (ENS, Paris) entitled "Laser Manipulation of Neutral Atoms Close to the Quantum Regime". Atomic optics and atomic interferometry represented an exciting area within laser spectroscopy, with papers on quantum effects in laser cooling also well represented (see box). The plenary paper on laser spectroscopy was given by Professor Theodor Hänsch (University of Munich) on "Ultra High Resolution Techniques", whilst Professor Marlan Scully (University of Arizona, USA) gave a plenary paper "A New Approach to the Acceleration of Charged Particles by Lasers".

Applications of laser spectroscopy continue to expand and were represented, for example, by the plenary talk of Professor Vladimir Letokhov (USSR Academy of Sciences) entitled "Quantum Electronics and Laser Biomedicine".

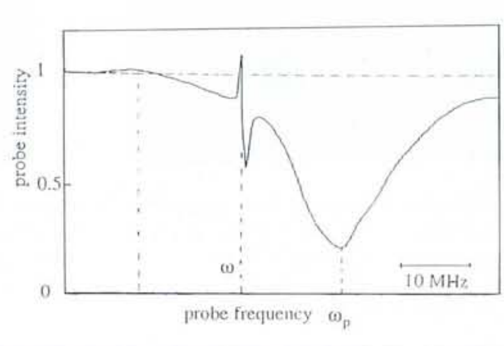
Nonlinear optics was covered to equal extents by fundamental studies of dynamics and complexity and by its application in the realisation of nonlinear optical devices. Nonlinear dynamics, and in particular chaos and instabilities in both lasers and optical devices, constitutes an important part of the field and, together with the most recent advances concerning spatial-temporal pattern formation (box overleaf), was well covered at the meeting. The plenary talk in this area was given by Professor Tito

Non-Linear Spectroscopy with Trapped Atoms

Recent years have seen dramatic progress in the use of laser light to cool and trap neutral atoms. Inherent limitations of purely optical sub-Doppler laser cooling (SDLC) techniques for small clouds of vaporised atoms using six orthogonal intersecting laser beams (a so-called "optical molasses") have been overcome by loading optically trapped atoms into a magnetostatic trap comprising a system of magnetic coils. As in the purely optical technique, cooling arises from the the non-adiabatic response of moving atoms lagging behind changes in the optical field.

D. Grison, B. Lounis, C. Salomon *et al.* from the Laboratoire de Spectroscopie Hertzienne, Paris, reported at EQEC '91 that the beam from an additional, weak laser beam used to probe Cs atoms in a magneto-optic trap resonates when its frequency ω_p is scanned about the frequency ω of the trapping laser beams (see figure). This is a stimulated Raman effect in agreement with recent SDLC models where optical pumping due to the trapping beams produces population differences between the Zeeman sub-levels and various light shifts in the Cs ground state. The widths of the resonances indicate that the Cs atoms have an effective temperature below 0.2 mK.

The new technique will lead to interesting information on the internal and external states of trapped, ultra-cold atoms. For instance, more refined data analysis may indicate whether the Cs atoms have a band structure for the atomic external degrees of freedom.



Stimulated Raman effect in cold cesium atoms trapped magneto-optically. The intensity of the absorbed probe beam is plotted as a function of the probe frequency ω_p. Three resonances (indicated with dashed lines) are observed, with those at and below the frequency ω of the trapping beams showing gain [D. Grison et al., 1991].

Arecchi (Istituto Nazionale di Ottica, Florence) entitled "Space-Time Complexity in Nonlinear Optics".

While it is virtually impossible to summarise the field of laser applications, areas receiving special attention included optical storage, switching and logic devices, and the many facets of laser metrology, including remote sensing, interferometry, holography and fibre-optic sensors. High power laser applications included laser fusion and laser plasma interactions, and industrial applications in materials processing.

Finally, the atmosphere at the conference was very social and was highlighted by a pleasant dinner on the Heriot-Watt campus. Having EQEC '91 coincide with the well-known Edinburgh Arts Festival, offering many possibilities to relax from physics during the evenings, was not fortuitous.

In my opinion, and in the opinion of many participants, EQEC '91 was carefully organised and very successful. The conference chairmen were Professor Robert Harrison and Dr. Julian Jones (Heriot-Watt University). The international programme committee and the EPS Quantum Electronics Division were chaired by Professor Peter Knight (Imperial College, London) and the IoP Quantum Electronics Group by Professor Geoffrey New (Imperial College).

The next EQEC conference will take place in Florence, Italy, from 11-13 September 1993 in the week preceding the EPS-9 General Conference, which will also be held in Florence. It will be organised by Professor M. Inguscio, Istituto Nazionale di Ottica, Largo E. Fermi 6, I-50125 Florence, Italy (tel./fax: +39 (55) 22 11 79 / 233 77 55).

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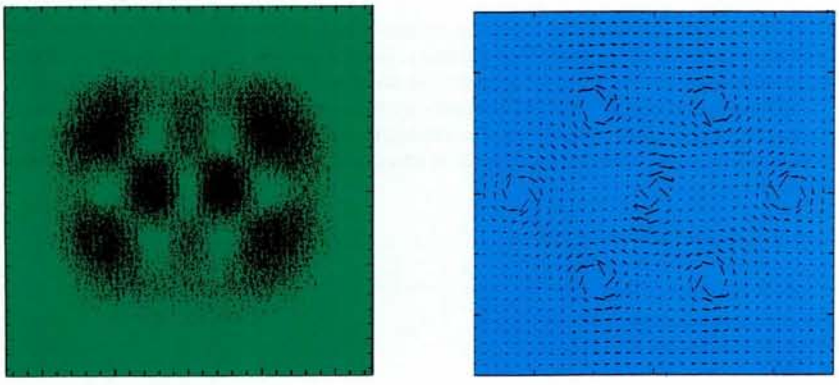
Vortex Crystals in Optical Fields

Turbulence, spontaneous pattern formation and other spatial and spatio-temporal phenomena are well known in, for example, hydrodynamic systems driven far from equilibrium. However, in spite of optical fields being governed by the same wave equations, clear evidence has only recently been obtained for spatial instabilities in the structures of electromagnetic fields transverse to the direction of propagation. For example, F.T. Arecchi and co-workers [*Phys. Rev. Lett.* **67** (1991) 3749] at the Istituto Nazionale di Ottica, Florence, use a laser ring cavity with a pin-hole aperture to control the number of transverse modes that can oscillate in a laser beam with one-dimensional oscillations generated by passing it through a laser pumped, optically non-linear crystal. Point-like "defects" or "optical vortices" are observed on a transverse section through the beam, where the amplitude of the complex, two-dimensional field goes to zero and the phase changes by a multiple of 2π around each defect. Unlike waves in materials which can be visualised in terms of displacements of matter, the phase is measured using an external laser beam as a reference.

M. Brambilla, M. Cattaneo, L.A. Lugiato *et al.* reported at EQEC '91 some calculated transverse patterns for a simple laser system comprising spherical mirrors with a narrow atomic gain line exciting selectively the modes of a single frequency-degenerate family. Vortices were identified and it was demonstrated, furthermore, that different stable patterns ("vortex crystals") formed in the same region of parameter space (see figure), with spontaneous transitions between patterns as the control parameter was adjusted. Increasing the number of families excited gave rise to complex dynamical patterns (*e.g.*, patterns rotating with time).

Aside from the fundamental interest, there is considerable technical importance attached to transverse optical patterns, especially stable "crystalline" arrangements, as one foresees their being used to encode and process information.



Calculated transverse optical patterns for a laser with spherical mirrors and a narrow atomic gain exciting a single family of modes show a regular "crystalline" arrangement of seven vortices. Regions of low intensity in the left-hand figure correspond to positions where the electric field phase gradient, plotted on the right, is singular. [M. Brambilla et al., 1991].

Europhysics Notes

● Recommendations for Danish Physics

Several problems prompted Denmark's Minister of Education and Research to commission a **review** in 1991 of the country's publicly funded physics by a Steering Committee chaired by O. Hansen from the Brookhaven National Lab in the USA. The committee's final report issued in December, concluded that Danish physics research, with its long tradition, is internationally competitive: it should grow in step with technical progress. But some two-thirds of tenured physicists are over 50 years old, so the present moratorium on hiring is "suicidal". Tripling annual recruitment to tenured university posts within the present funding is proposed (*via* early retirements and by shifting external research grants to senior staff to free-up funds). Organizational structures should change to support: collaboration between different activities at the 3 large universities; consolidation of some parts of the 4 main institutes; inter-institute links; at least one world-class activity at each of the 5 small universities. The creation of a **Fund for Basic Research** (spending 200 MKRD of "new money" each year) announced recently by the Government may help in implementing the proposals.

● ILL Users Lobby

ILL Users are being urged to write to their national representatives on the ILL Board of Directors and to research ministers to indicate that the decision to refurbish the Institute's damaged high-flux reactor should be taken as soon as possible, independent of the negotiations concerning UK participation. The UK's SERC is considering a 46% reduction in its annual participation from 1994 [*EN* **22** (1991) 222]. The preferred option (replacement of the complete reactor vessel) can be carried out in 1992/3 within the normal operating budget.

The outcome of the next meeting of the ILL's Associates (on February 13) may affect thinking on how to progress a feasibility study for a European spallation neutron source. A proposal due to be sent to the Commission of the EC in May would normally involve the UK's Rutherford-Appleton Laboratory which operates ISIS, the world's leading spallation source. Further afield, a spallation source is being considered in the context of the AUSTRON project for a major central European initiative.

● ICTP Budget Passed

The Italian Government has passed into law an increased (by 18%) contribution to the budget of the International Centre for Theoretical Physics, Trieste, for 1991-98:: the IAEA and UNESCO contributions for 1992 remain at the 1991 level. The ICTP was obliged to reduce activities (*e.g.*, five schools in 1992 have been cancelled) despite a $ 3 M loan from the Iranian Government [*EN* **22** (1991) 222] to meet its cash flow.