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, electronic 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 operation 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 Hänisch (University of Munich) on "Ultra High Resolution Techniques", whilst Professor Marian 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 opposite), 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 vapourised 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 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 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 ωp. 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).

Mathematica™
A System for Doing Mathematics by Computer
A Wolfram Research Inc. product

□ Numerics - Works with numbers of arbitrary magnitude and precision.
□ Symbolics - Encyclopaedia of mathematical functions and operations used in arithmetic, algebra and analysis. Procedural, functional and mathematical programming.
□ Graphics - 2D, 3D and animated PostScript graphics.
□ Text processing - Fully interactive reports and textbooks.
□ Runs on - MS-DOS based computers; Macintosh, Apollo, Hewlett Packard, IBM AIX/RT, MIPS, Silicon Graphics, Sony, Sun, VAX.

Now available in Europe from:
MathSoft Overseas, Inc.
PO Box 641, 1211 Geneva 3, Switzerland
Tel. +41 (22) 46 52 60
Fax +41 (22) 46 59 39
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. Lugliato 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).