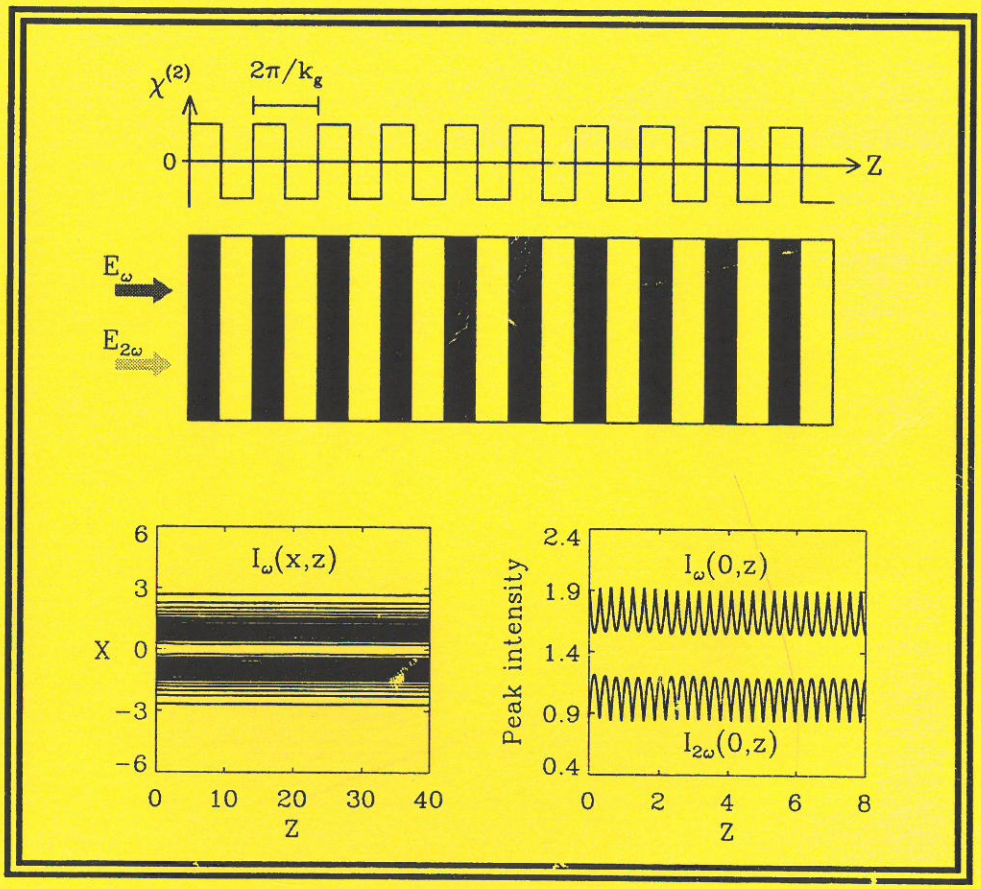
Australian Optical Society

NEWS



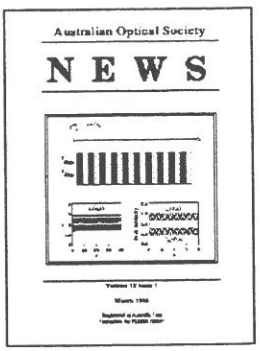
Volume 12 Issue 1

March 1998

Registered by Australia Post
Publication No: 233066 / 00021

MARCH 1998 VOLUME 12 NUMBER 1

AOS NEWS



COVER :

A collection of figures from the article on phase-matching in nonlinear media, in this issue (p11).

The top diagram shows a sketch of a crystal with a periodic, square modulation of the nonlinearity. By continually adjusting the phase of the second harmonic in this way, this harmonic can be kept in phase with the pump beam, enabling greater conversion efficiency.

The lower two figures show the excitation of a soliton in a slab waveguide with first-order quasi-phase-matching. Left: contour plot of the intensity of the pump beam $I_\omega=|E_\omega(x,z)|^2$. Right: peak intensities of the pump beam and first harmonic.

SUBMISSION OF COPY:

Contributions on any topic of interest to the Australian optics community are solicited, and should be sent to the editor, or a member of the editorial board. Use of electronic mail is encouraged, or else submission of hard copy together with an ASCII text file on floppy disk.

Where possible, diagrams should be contained within the document or sent as separate encapsulated post-script files. Figures on A4 paper will also be accepted.

ADVERTISING:

Potential advertisers in *AOS News* are welcomed, and should contact the editor.

EDITOR
Duncan Butler
CSIRO Tel. & Ind. Phys.
PO Box 218
Lindfield NSW 2070
Tel: (02) 9413 7302
Fax: (02) 9413 7474
Duncan.Butler@tip.csiro.au

DEADLINE FOR NEXT ISSUE :
14th May, 1998

ARTICLES

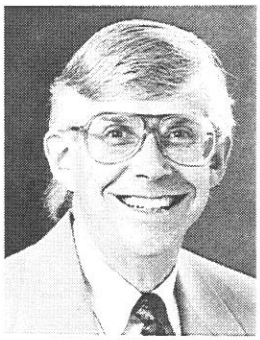
DEPARTMENTS

AOS News **is the official news magazine of the Australian Optical Society. The views expressed in *AOS News* do not necessarily represent the policies of the Australian Optical Society.**

President's Report

All the vital signs

From my point of view, the Australian Optical Society appears to be in a robust condition. Under any reasonable form of diagnosis, it displays all the vital signs. That is no cause for self-satisfaction or complacency, but at the same time it does no harm to take stock of our strengths and successes from time to time.



One sure sign of good health was our remarkably successful AOS XI national conference in Adelaide last December, building on a long tradition of top-rate AOS conferences. At a time when much of science (particularly physical science) is supposedly in retreat, AOS XI attracted approximately 270 registrants - an all-time AOS record. But attendance alone is not the only measure by which AOS XI would be judged to have been successful: the generally high quality of the scientific programme, the enthusiasm of its participants and the lively conference atmosphere were also vitally important.

I am sure that all who attended the AOS XI conference (which is reviewed elsewhere in this issue) will want to join me in repeating the thanks and congratulations that Jesper Munch, Murray Hamilton, Peter Veitch and their fellow AOS XI organisers deserve for staging the conference so capably.

Those on the AOS XI email address list will recall that I sought some email-based *post mortem* feedback from attendees about aspects of the conference and other AOS-related matters. While this is a bit like applying a stethoscope to one's own chest, it has nevertheless been an interesting exercise in getting wise after the event. My thanks to the 10% of attendees who took the trouble to respond and contribute to a body of opinion that should be useful to future AOS conference organisers.

Virtually all of these respondents endorsed the view that I have already expressed about the general excellence of the conference. In the words of a previous AOS conference chairman: "...it was a terrific conference partly because of its size leading to large and energetic poster sessions." Most people agreed that the poster sessions were an important feature of the conference and that their value and status should not be underrated. Concerning invited papers, there was firm opinion that we "should be more adventurous in inviting new and young people to give plenary talks." Few had problems with two parallel sessions for contributed papers, although there was concern about the separation between the two lecture theatres and the poor timing of some speakers, which combined to impede session-hopping. The debate about the absence of a conference dinner continues, but many found that Adelaide's Rundle Street restaurant district made up for it in the end. Adelaide is obviously regarded as a nice place to hold a conference (which augurs well for the Australian Institute of Physics national convention there in 2000, in which the AOS intends to take a prominent part). Many commended the Trade Exhibit (including off-campus visits), one with the remark: "...embarrassing how much trouble our distributors go to in the midst of such financially poor clients". Likewise, the pre-conference workshops got a high approval rating - and deservedly so.

Inevitably, there were a few post-AOS XI gripes (*e.g.*, some talks not up to scratch, illegible projection slides, posters put up too late or taken down too early, car parking problems, registration desk difficulties, shortages of vegetarian pizza, my questionnaire being too long - touché! - and so on ...).

One view that was put very strongly by just a few of the respondents was that AOS conferences needed more "emphasis on traditional optical areas to balance the program", that "AOS is in danger of alienating the non-academic technical workers" and that we must "show relevance of our work for the benefit of the Australian industry and community ... (thus) promoting the role of optics to its full potential." There was also a plea for stronger links with the local fibre optics and photonics community (which, I am glad to say, is already on AOS Council's agenda for future conferences).

Concerning AOS business, I am still disappointed that I mismanaged the time allocation for open discussion at the AOS members' meeting on the Friday of AOS XI - too much talk from the lectern and not enough listening, alas! Many people regret that, for administrative reasons, the AOS Annual General Meeting has become separated from the AOS conference, thereby losing the benefit of a wide-ranging audience to discuss issues at the AGM. We shall see what we can do about that in the future.

On the positive side, two distinct pleasures for me at AOS XI were to present the prestigious 1997 AOS Medal to Professor Jim Piper (Macquarie University) before his opening plenary lecture and to announce the selection of Mr Chris Freund (CSIRO, West Lindfield) for the 1997 AOS Technical Optics Award. A few days after AOS XI, AOS Council also approved the double-headed award of the 1998 AOS Postgraduate Student

Prize to Ms Marlies Friese (University of Queensland) and Mr Justin Blows (Macquarie University). Details are given elsewhere in this issue.

This bill of health for the AOS concludes by noting some satisfying feedback to my President's Report in the previous issue of *AOS News*. Elsewhere in this issue, you can read for yourself a Letter to the Editor from Dr Rod Watkins (Scan Optics, Adelaide) which provides some interesting perspectives to the brief historical remarks that I made in my previous Report. It is encouraging that (a) somebody actually reads my Reports and (b) there really are opportunities for discourse and reflection within our Society!

- Brian Orr

AOS MEDAL

AUSTRALIAN OPTICAL SOCIETY

The Australian Optical Society is seeking nominations for the fourth award of this medal, which is for an outstanding contribution or contributions to the field of optics in Australia by a member of the Australian Optical Society.

Previous winners of the medal have been:

1995: Mr Bill James
James Optics, Melbourne;
1996: Dr Parameswaran Hariharan
University of Sydney and CSIRO;
1997: Professor Jim Piper
Macquarie University.

This Medal is the most prestigious award of the Australian Optical Society. It would normally be presented only to a nominee at an advanced stage of his or her professional career and with a strong and sustained record of authority, enterprise and innovation in the field of optics in Australia.

Nominations for the 1998 AOS Medal Winner should include brief personal details and a curriculum vitae emphasising the main contributions made by the nominee to Australian optics.

Two letters of recommendation should also be provided. Nominations may be made either by or on behalf of any eligible candidate. The selection panel reserves the option to seek additional information about candidates for the award.

It is hoped that the person selected to receive the medal will be able to do so at the 1998 AOS Conference, which is planned as part of the Australian Conference on Optics, Lasers and Spectroscopy (ACOLS'98) in Christchurch, New Zealand in December 1998.

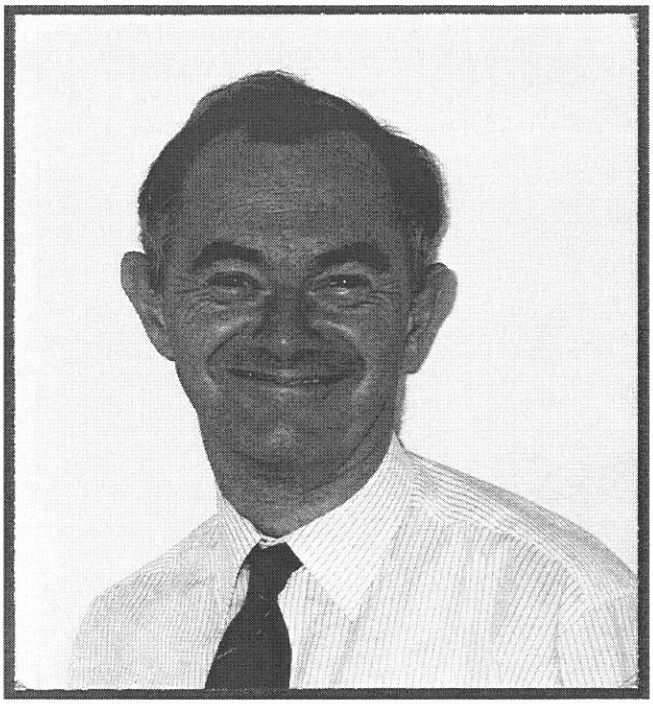
The closing date for nominations is 15 May 1998. Nominations should be sent to the AOS Secretary:

Dr Clyde Mitchell
CSIRO MST
Private Bag 33
Clayton South
Victoria 3169
Fax: (03) 9544-1128
E-mail: C.Mitchell@mst.csiro.au

New editor required!

After 2 years and 8 issues, I would like hand over the *AOS News* reins to a new editor. The *AOS News* is an easy journal to edit: there are only four issues per year, and the templates for articles and other regular contributions remain the same. Advertisements are supplied in camera-ready form. If you plan to edit the magazine on your own computer, you will require access to a laser printer and e-mail. If you are interested, please let me know :

Duncan Butler, CSIRO-T.I.P., PO Box 218 Lindfield 2070. E-mail: Duncan.Butler@tip.csiro.au



Dr. Michael Kidger: 1937 - 1998

Dr Michael Kidger, founder of Kidger Optics, died on February 1 in Sydney while on a business trip to Australia. He was 60 years old and at the prime of a distinguished career serving the optics community.

Michael studied Physics at Imperial College, gaining his BSc in 1958, and went on to specialise in Applied Optics, being awarded the MSc degree in 1959. He joined Gordon Cook at Taylor-Hobson and remained there until 1963 when he returned to Imperial College. He thrived at Imperial while working alongside Charles Wynne (the co-inventor, with Robert Hopkins, of computer-aided lens design) and Walter Welford (a teacher, physicist and optical engineer of great distinction). From 1967 to 1987, he was a lecturer there in the Applied Optics Group.

In the sixties and seventies, optical design relied on mainframe computers. Along with Doug Sinclair of Rochester, Mike was the first to realise the potential of using small computers for optical design. He adapted Imperial's mainframe optical design software — at that time sold commercially because little other software was available — for the new generation of small machines. In the late seventies and early eighties, it was obvious that optical design was quickly moving out of academic departments into small companies, and Mike co-founded Kidger Optics with his wife Tina. He retained a part-time teaching post at Imperial, but his company proved to be so successful that he left Imperial in 1987. Kidger Optics, together with Sinclair Optics, were the trailblazers of optical design software for personal computers. Mike's pioneering steps helped to change the way optical design is done around the world, and now we can buy optical design packages for personal computers from many sources.

Michael Kidger's contributions to teaching are perhaps less well known, but are fondly remembered by generations of students at Imperial College, and more recently by those who had the good fortune to attend his Short Courses. In recent years, he came to Australia each summer to teach at a number of institutions. This also allowed him to pursue his passion for cricket.

Michael Kidger is survived by his wife, Tina, and children, Julia and David, who have lost a devoted husband and father. The optical community has lost a friend and dedicated contributor. Fortunately, his foresight and planning will ensure that Kidger Optics shall remain a strong presence in optical design in the years to come.

(We are grateful to Prof Chris Dainty for providing much of this material.)

A message to the Australian Optical Society from Tina Kidger:

Dear friends,

Michael had a very special place in his heart for Australia and his Australian friends and colleagues. He really loved Australia and, of course, Cricket. It was his delight to have been present at the only match when the Poms managed to beat the Aussies.

I would like to thank all of you for the wonderful tributes you are sending to me and kind offers of help. I hope that I shall be able to meet some of you again soon.

With warm wishes to you all,

Tina Kidger

A Memorial has been established to honor the memory and celebrate the life and work of Michael by providing educational assistance to deserving students in the field of optics. Donations may be directed to:

Michael Kidger Memorial Fund
c/0 SPIE - The International Society for Optical Engineering
PO Box 10
Bellingham
WA 98227-0010 USA

Letter to the Editor

3 December 1997

AOS News
Editor

Dear Sir:

I was interested to read in the President's Report (AOS News, December 1997) the comments concerning the contribution of scientists such as Isaac Newton and John Dalton, who are best known for their work in physics and chemistry, to the fields of colour and vision.

The division between physical optics and physiological optics, which today seems to be so great, is largely a phenomenon of the present century. The names of many of the outstanding contributors to the sciences of colour and vision are well known to modern physicists.

The first treatise on defective colour vision was published in 1777 by Joseph Huddart [1], who wrote in the Philosophical Transactions of the Royal Society "An Account of Persons who could not distinguish Colours". He described a Quaker shoemaker named Harris who had great difficulty in distinguishing the colours red and green. This paper raised immediate interest. Many more colour abnormals were quickly identified, including a large group which were extensively examined by John Dalton [2] in 1798. Dalton's interest was stimulated by the fact that his own colour vision was defective; having noticed that reds appeared very dark, he proposed that this was caused by the selective absorption of red light by the vitreous humour in his eyes.

This suggestion was immediately opposed by Thomas Young [3] (who had two years earlier published his two-pinhole diffraction work). Young believed the cause to lie in the retinal receptors concerned with colour vision. He pointed out that only three different receptor types were necessary to explain the known facts of colour matching. This "trichromatic theory" was developed and the implications made clear by Herman von Helmholtz, who was a Professor of Physiology for many years before he became Professor of Physics in Berlin, in 1866 [4] and the Young-Helmholtz theory remained one of the greatest contributions to colour vision knowledge for the next century. Young, incidentally, in 1801 also made a remarkably good attempt to describe the optical system of the human eye and produced a very accurate table of the optical constants of the eye, and this work provided the foundation for Helmholtz's later detailed discussion which remains the basis of our knowledge of image formation of the eye.

The modern classification of defective colour vision is due to James Clerk Maxwells who, in 1855 (five years before his work on electromagnetic radiation was published), studied two groups of colour defectives and found that while some needed a mixture of three colours to match any spectral colour, others needed only two. He named these "trichromats" and "dichromats" .

So far as the contribution by Newton goes, the magnitude of his conceptual and philosophical steps is sometimes lost because the optical science of Opticks (1704), the Optical Lectures (1728) and the Principia form such a strong basis of modern optics that we do not easily see what came before. Some of the giants on whose shoulders Newton stood certainly seem in historical perspective to have been of only moderate size. Newton's teacher in optics, Isaac Barrow, was the first Lucasian Professor of Mathematics at Trinity College Cambridge (the post now held, of course, by Stephen Hawking). Barrow held the position from 1663 to 1669, when he resigned in favour of Newton. Although physical optics had developed quickly with Kepler's Dioptrice in 1611 and Descartes' La Dioptrique in 1637, the understanding of colour was crude. Descartes thought that colours were produced by different spin velocities of the particles of light. Barrow believed that white light was produced by smooth surfaces, red light by surfaces with microscopic concave and convex irregularities, and blue light by alternate black and white particles. As for green light, "Green is closely related to blue. Let keener minds explore the difference; I would not venture a guess." [6]

Newton was aged twenty-three when he carried out his prism experiment in 1666. Within ten years his frequency theory of colour was widely accepted, except for the vehement dissent by Robert Hooke which ended only with Hooke's death in 1703. Newton showed that the colour of light was not affected by reflection or refraction and described accurately the formation of rainbows. He showed that white as well as all colours can be produced by a mixture of three properly chosen primary colours, and later it was James Clerk Maxwell who, between 1860 and 1865, determined the intensities of red, green and blue light needed in such a mixture to match each spectral colour.

The science of optics has for most of its history been indistinguishable from the science of vision. Both groups have lost something in the modern separation of the two.

- Rod Watkins, Scan Optics

[1]. Huddart, J. (1777) *An account of persons who could not distinguish colours.* Phil. Trans. of Roy. Soc. Lond. 67, 260.

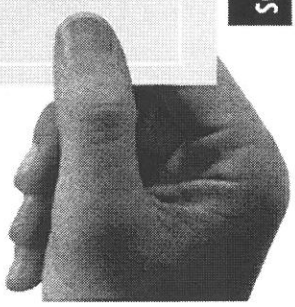
[2]. Dalton, J. (1798) *Extraordinaryfacts relating to the vision of colours: with observations.* Me. Manchr. Iit. phil. Soc. 5, 28.

[3]. Young, T. (1802) *On the theory of light and colours.* Phil. Trans. of Roy. Soc. Lond. 92,12.

[4]. v.Helmholtz, H. (1866) *Handbuch der Physiologischen Optik Voss,* Leipzig. English translation by J.P.C. Southall 1924 for the Optical Society of America.

[5]. J.C. (1855) *On the theory of colours in relation to colour blindness.* Trans. Scot. Soc. Arts 4, Part III. Reprinted in Scientific Papers I, 119, Cambridge University Press.

[6]. Barrow, I. (1669) Lectiones XVIII *(Opticorum Phenomenon)* English translation by H.C.Fay, The Worshipful Company of Spectacle Makers, London.



RECENT AOS AWARDS

The 1997 AOS Medal: Professor Jim Piper

The Society's eleventh national conference (AOS XI) in Adelaide last December began with a presentation of the 1997 AOS Medal to Professor Jim Piper of Macquarie University. This prestigious award was made in recognition of Jim's many contributions to optics in general and laser science, technology and applications in particular. A detailed citation appeared in the June 1997 issue of *AOS News*.

In recognition of this award, Jim Piper presented the opening lecture of the AOS XI conference. He chose the following title: "Engineering gain - developments in high-power, high-beam-quality copper lasers". It is hoped to publish the content of that lecture in a future issue of *AOS News*.

Jim Piper (left) and Brian Orr at the AOS Medal presentation at AOS XI, Adelaide, December 1997.

The 1997/8 AOS Technical Optics Award: Chris Freund

This award was advertised in the June 1997 issue of *AOS News*. According to its terms of reference, it "recognises those who have made a significant achievement in technical optics, not necessarily in a manner manifested by an extensive academic record or a traditional academic reputation" and is for work carried out principally in Australia.

AOS Council was unanimous in approving the presentation of the 1997/8 AOS Technical Optics Award to Mr Christopher Freund (CSIRO Division of Telecommunications and Industrial Physics, West Lindfield, NSW). This decision was announced at the AOS business meeting on Friday 12 December 1998, during the AOS XI conference.

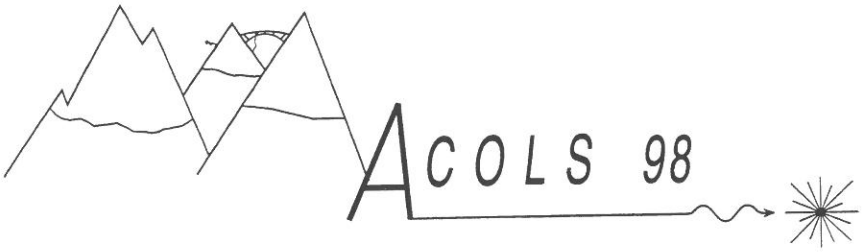
Chris Freund has worked as an optical technician with the CSIRO since 1974 and his activities span a wide range of design, construction and assembly of complex optical instruments for the needs of research and industry. Notable areas of achievment are in developing etalons and ellipsometers. He presented two excellent poster papers at the AOS XI conference and will be invited to deliver an oral presentation at a future AOS meeting.

The 1998 AOS Postgraduate Student Prize: Justin Blows and Marlies Friese

This award - advertised in the June and September 1997 issues of *AOS News* - is intended "to encourage participation in national and international conferences by high-quality postgraduate students". On this occasion, AOS Council took the unprecedented step of awarding two full prizes to Mr Justin Blows (Macquarie University) and Ms Marlies Friese (University of Queensland). This step was taken by AOS Council on the recommendation of the three-person selection panel, which had great difficulty in choosing between four candidates of very high quality - an encouraging indication of the emerging strength of Australian optics.

Justin Blows is a First Class Honours Physics graduate from the University of Sydney and is now in his final year of a PhD at Macquarie University, working under the supervision of Dr Judith Dawes on the power scaling of diode-array-pumped solid-state lasers. He has made both theoretical and experimental studies of a novel astigmatic cavity design that is suited to asymmetric light output of diode arrays. His Prize enables him to present a research paper at the OSA conference on Advanced Solid State Lasers (ASSL'98) in Idaho this February - in fact, at time of writing, he has just returned from that conference.

After taking First Class Honours in Physics at the University of Queensland, Marlies Friese is nearing completion of her PhD studies there, with Associate Professors Halina Rubinsztein-Dunlop and Norman Heckenberg as her research supervisors. Her research project involves optical manipulation of small particles in spatially non-uniform laser fields and she intends to use her Prize to enable her to present a paper about optical torques on microscopic waveplates at the CLEO/IQEC'98 conference in San Francisco in May 1998.



Australasian Conference on Optics, Lasers & Spectroscopy

14th–17th December, 1998

University of Canterbury,
Christchurch, New Zealand

Conference Chair: Professor Wes Sandle, Department of Physics, University of Otago, Dunedin, New Zealand.

Programme areas:

- ***Atomic and Molecular Spectroscopy*** (including ultrafast phenomena)
- ***Quantum and Atom Optics*** (including BEC and Quantum Computing)
- ***Chemical and Biomedical Applications of Spectroscopy***
- ***Nonlinear Optics and Laser Development***
- ***Applications of Optics and Lasers***

Keynote Speaker Professor Carl Wieman, JILA, University of Colorado

For further information:

Web: http://www.physics.otago.ac.nz/~acols98
Email: acols98@physics.otago.ac.nz

OPTICS GRAPEVINE

News from the World of Optics

Australian Conference on Optics, Lasers and Spectroscopy

University of Canterbury
Christchurch, New Zealand
14-17 December, 1998
(details p10)

Editorial

Many apologies for the lateness of this issue, caused by the untimely intrusion of work commitments. In particular, I apologise to those who contributed to this issue and had to wait days or weeks for me to answer emails.

In addition to two scientific articles, this issue features a very brief review of AOS XI, and a summary of the AOS prises awarded recently. A tribute to Michael Kidger, who died suddenly while in Australia this year, is located on p5.

Duncan Butler

The AOS on the World Wide Web
http://www.dap.csiro.au/OPTECH/Optics-Radiometry/aoshome.htm

... STOP PRESS ...
AOS AGM AND MINI-SYMPOSIUM, 24 JULY

As *AOS News* goes to press, a decision has been made to hold the 1998 Annual General Meeting of the Australian Optical Society in Sydney on the afternoon of Friday 24 July 1998.

The AOS AGM will be preceded by a meeting of the AOS Council. Of more interest to the general AOS membership is the plan to accompany the AGM on the same afternoon by a Mini-Symposium on "Current Topics in Optics". A similar event last May at the time of the 1997 AGM proved highly successful.

I am delighted to report that the 1998 AOS AGM and Mini-Symposium will be held at the Australian Photonics CRC, Optical Fibre Technology Centre (OFTC), at the new Australian Technology Park, Eveleigh (near University of Sydney). Our colleagues at OFTC have kindly agreed to make their meeting facilities available to us and to conduct a tour of their technological facilities before the Mini-Symposium commences in mid-afternoon. We hope that this event will attract a wide-ranging audience, both from the Sydney area and from farther afield.

So please pencil 24 July into your diary. Full details of time and place, Mini-Symposium programme, AGM agenda, etc. will appear in the next issue of *AOS News*.

... Brian Orr, AOS President

New editor required!

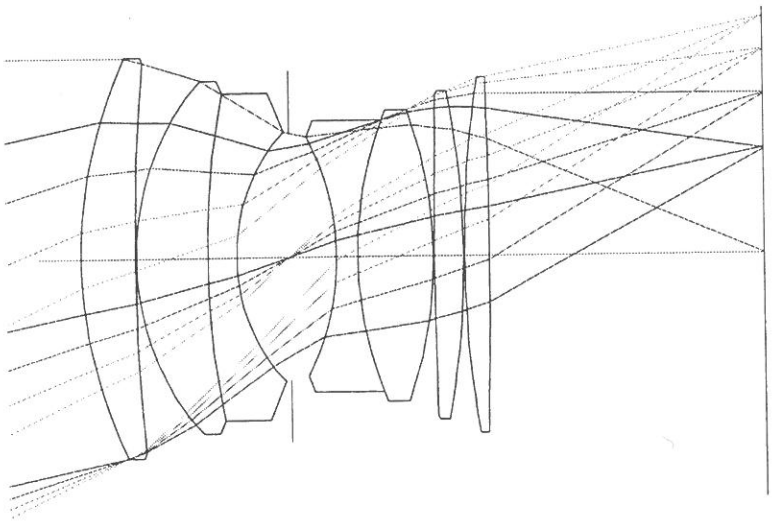
After 2 years and 8 issues, I would like hand over the *AOS News* reins to a new editor. The *AOS News* is an easy journal to edit: there are only four issues per year, and the templates for articles and other regular contributions remain the same. Advertisements are supplied in camera-ready form. If you are interested in the job, please contact : Duncan Butler, CSIRO-T.I.P., PO Box 218 Lindfield 2070. E-mail: Duncan.Butler@tip.csiro.au

*** Announcement ***
Re-scheduled Australian Course

KIDGER OPTICS

Introductory Course in Computer-Aided Optical Design
University of Sydney, Australia

June 15th – 18th 1998



In order to save money and use your software effectively, users should understand the principles of optical design, and also the most effective ways to run the software. Since our formation in 1982, Kidger Optics have run courses in various aspects of optical design, and many hundreds of optical engineers and scientists have benefited from these courses.

This 4-day course, using software from Kidger Optics, now includes new topics that are becoming important and is intended for those who are starting in optical design, and wish to have a clear understanding of:-

Paraxial optics
Ray tracing
The effects of aberrations
The principles of aberration theory
The performance of different lens types
Methods of calculating lens performance
Design of simple objectives
Design of visual systems
Design of thermal imaging systems
Reflecting and catadioptric systems
Optimisation in optical design
Effective ways to use lens design software

About 40% of the time in this course is used for lectures provided by our top optical design consultant Mr David Freeman, in the principles concerned with the above topics. The rest of the time is spent, using Kidger Optics latest software for optical design and analysis, in working through a set of graded examples.

We hope you can join us.

For further information contact:-
Kidger Optics Ltd, 9A High Street, Crowborough, East Sussex, TN6 2QA, England.
Telephone: +44) 1892 663555, Fax: (+44) 1892 664483, Email: sales@kidger.com

Quasi-phase-matching and $\chi^{(2)}$:$\chi^{(2)}$ cascading

Ole Bang
Australian Photonics Cooperative Research Centre, Research School of Physical Sciences and Engineering, Optical Sciences Centre, Australian National University, Canberra 0200 ACT, Australia

Quasi-phase-matching is a technique for matching the phase of the fundamental and harmonic beams in nonlinear optical interactions. The relative phase between these beams is adjusted at regular intervals using a structural periodicity built into the medium. Potentially, this technique allows for phase-matching in any material over a wide range of wavelengths, and using the largest component of the nonlinear susceptibility. In quadratic nonlinear (or $\chi^{(2)}$) materials, the periodic structure induces cubic nonlinear Kerr effects, which can alter the properties of the material. Examples include CW switching and solitons.

1. Introduction

Nonlinear optics is traditionally discussed in terms of the separate effects of quadratic and cubic nonlinearities. For example, quadratic or $\chi^{(2)}$ nonlinearity is associated with frequency conversion and parametric amplification, while cubic nonlinearity is usually associated with frequency degenerate processes, such as an intensity-dependent refractive index, self-focusing, solitons, and four wave mixing.

Although the cubic nonlinearity can be used for frequency conversion (third harmonic generation, electric field induced second harmonic generation, etc.), it is generally not very effective, and consequently not often used for this purpose. In contrast, the quadratic nonlinearity can effectively mimic cubic properties, and even support spatial solitons. In these phenomena the important effect is the self-induced modulation of the amplitude and phase of the fundamental beam(s).

The physics of such self-action effects requires two successive quadratic, or second order processes, in order for the net output to be back at the input frequency, (ω). This can occur via up-conversion ($\omega + \omega \rightarrow 2\omega$), better known as second harmonic generation (SHG), followed by down-conversion ($2\omega - \omega \rightarrow \omega$) or via down-conversion ($\omega - \omega \rightarrow 0$), better known as optical rectification, followed by up-conversion ($\omega + 0 \rightarrow \omega$). It is the successive nature of the processes needed to modify the fundamental beam that led to the term 'cascading' for this class of effects and to the symbolic representation $\chi^{(2)}$:$\chi^{(2)}$, as the effects are proportional to $[\chi^{(2)}]^2$.

The two key features of cascading were predicted in the first decade of nonlinear optics. The existence of a nonlinear phase shift in the fundamental wave (FW) during SHG was first discussed by Ostrovskii in 1967 [1] and the existence of solitons was predicted in 1974 by Karamzin and Sukhorukov [2]. (Incidentally, Sukhorukov's son will this year start his Ph.D. at the Optical Sciences Centre (OSC), ANU, working on $\chi^{(2)}$ effects as did his father). However, the experimental work on cascading, starting in the late 1960s, was primarily concerned with measuring the interference between $\chi^{(3)}$ and $\chi^{(2)}$-related contributions far from the SHG wavevector-matching condition $\Delta k = 2k_1 - k_2 = 0$, where k_1 and k_2 are the wavevectors of the fundamental and second harmonic (SH), respectively. In this so-called cascading limit, where the crystal length L is much larger than the coherence length $L_c = \pi/\Delta k$ it is straightforward to reduce the coupled equations for SHG to a single equation for the FW with a cubic self-phase modulation term, whose coefficient is proportional to $[\chi^{(2)}]^2/\Delta kL$. In general the cascaded contributions were therefore small, since $\Delta k L$ was large.

It was not until the late 1980s and early 1990s that experiments were made sufficiently close to the phase-match condition to show a nonlinear phase-shift of the FW in excess of π, with a dominant contribution from cascading [3]. These experiments proved that cascading is a strong effect near phase-matching, and led to a tremendous interest in its application in all-optical phenomena (see [4] for a review). A comprehensive literature now exists of experimental and theoretical studies of cascading. In particular, a significant part of the theoretical work on solitons has been done in Australia at the OSC, ANU, as a project of the Australian Photonics Cooperative Research Centre (see [5]).

In this article I consider one of the most important issues for obtaining a strong cascaded nonlinearity: phase-matching. One of the most promising techniques for achieving phase-matching is the so-called quasi-phase-matching (QPM) technique, by which a grating is

built into the medium to compensate for the mismatch. An important point about QPM, which was not realized until recently [6], is that it induces effective cubic nonlinearities, which affects the cascading process.

2. Quasi-phase-matching

Consider unseeded SHG, in which the incident FW, with frequency ω and wavelength λ, is linearly polarized along one of the crystal axes. In the crystal the FW interacts with the $\chi^{(2)}$ susceptibility and generates a SH wave at the frequency 2ω. The FW travels with a velocity determined by the index of refraction $n_1 = n(\omega)$, whereas the velocity of the SH wave is determined by $n_2 = n(2\omega)$.

In general $n_2 \neq n_1$ because of dispersion in the material, so that the fundamental and SH waves travel at different phase velocities. Since the direction of power flow between them is determined by their relative phase, the continuous phase slip due to the difference in phase velocity leads to a periodic alternation of the direction of power-flow, and a repetitive growth and decay of the SH intensity. This situation is illustrated by curve B in Fig.1.

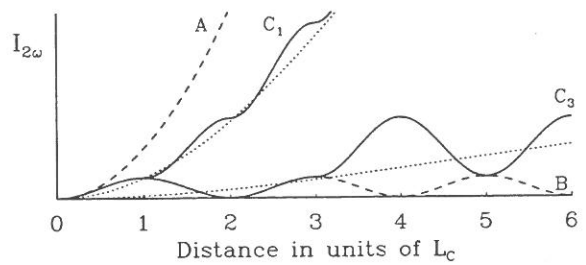


Figure 1: *Evolution of SH intensity during unseeded SHG under conditions for type I phase-matching, obtained numerically from the analytical solution, as expounded in [7]. Dashed curves A and B show phase-matched and nonphase-matched interaction in a uniform crystal, respectively. Solid curves C_1 and C_3 show first-order and third-order QPM, respectively. Dotted lines indicate the equivalent lowest-order evolution which can be found analytically.*

The distance over which the relative phase of the two waves changes by π is the coherence length $L_c = \pi / \Delta k = \lambda / 4(n_1 - n_2)$, which is also the half-period of the growth and decay cycle of the SH. If the refractive indexes are matched, the SH field grows linearly with distance, and thus the intensity grows quadratically, as shown by curve A in Fig. 1. This condition is termed phase-matching. Traditionally the techniques to achieve phase-matching have been divided into two types: In type I the incident FW is polarized along one of the crystal axes. In type II, the birefringence of an anisotropic material is used, and thus the incident FW has a polarization component along both the ordinary and extraordinary axis.

A fundamentally different method of generating continuous growth of the SH intensity is to invert the relative phase between the waves after each coherence length, where the SH intensity has reached its maximum in a cycle. The phase is thus reset periodically so that on average, the proper phase relationship is maintained. This has led to the name 'quasi-phase-matching' (QPM) for this technique of achieving phase-matching, which is typically discussed as type I.

First-order QPM, in which the relative phase is inverted every coherence length, is illustrated by curve C_1 in Fig.1, and third-order QPM, with phase-inversion every $3L_c$, is illustrated by curve C_3. Clearly, on average, growth of the SH intensity can be achieved by any odd-number QPM. However, first-order leads to the most rapid growth, and hence the largest conversion efficiency. Note that even order QPM can also occur when alternating the number of coherence lengths after which the phase is reversed. For example, second-order QPM can be obtained by periodically alternating between L_c, and $3L_c$.

One way to invert the phase is to change the sign of the nonlinear $\chi^{(2)}$ coefficient. In the early days of QPM this was done by forming alternating stacks of thin wafers of the nonlinear crystal, rotating alternate wafers by 180°. A more practical approach in ferroelectric crystals involves forming regions of periodically reversed spontaneous polarization. Such regions of one sign of the $\chi^{(2)}$ coefficient are termed 'domains', in analogy with the ferroelectric domains that creates them.

The above explanation of QPM is a purely "space-domain" description. It is mathematically more convenient, and often helps intuition, to describe the effect in Fourier space, where the domain structure is a grating in the nonlinear coefficient, with a certain grating wavevector. In this context, phase-matching occurs when the wavevector of the QPM grating equals the wavevector mismatch Δk. Additionally it is easily recognized from the Fourier point of view that any periodic structure of the nonlinear coefficient, which possesses a proper spatial wavevector component, can accomplish QPM. Thus, complete sign reversal is not required, but only a modulation is necessary, with sign reversal being a special (and the most efficient) case.

The physics of QPM was outlined already in 1962 by Armstrong *et al.*[8], but only recently have experimental difficulties been overcome and stable techniques been developed (see [9] for a review). The currently most mature techniques for QPM are electric field poling (now possible at room temperature) [10], and ion-exchange [11] of ferroelectric materials such as $LiNbO_3$ and KTP. The use of QPM in polymers is attractive, because of the high nonlinear coefficients of these

materials, but has proven difficult to control. However, recent results with QPM achieved through alternating domains of polymer and linear materials (i.e. no sign reversal), are promising [12].

As can be seen in Fig.1, the SH intensity generally grows more slowly, even using lowest-order QPM, than it does with birefringent phase matching, where the phase-mismatch is fixed at zero throughout the length of the crystal (curve A). The strength of QPM lies in its ability to accomplish noncritical phase-matching, which would otherwise be impossible, through the introduction of an additional wavevector. Thus QPM has the following advantages compared with more conventional techniques:

- No restrictions as regards material or polarization.
- Use of largest $\chi^{(2)}$ tensor component.
- Matching at any wavelength and temperature.
- Increased angular acceptance bandwidths.

It should be noted that phase-matching may also be achieved by modulation of the linear susceptibility. However, this technique has been difficult to implement, because the amplitude of the linear index modulation must be comparable to the dispersion in order to achieve efficient conversion [9].

3. Induced Kerr Effects

So far QPM has mainly been discussed in terms of simply matching the wavevectors of the fundamental and SH waves, and thereby enabling the efficient SHG, and CW switching known to be possible at exact phase-matching.

In 1996 the $\chi^{(2)}$ group at the OSC started working on how the QPM grating affects the properties of spatial solitons. In doing so we discovered that independent of the geometry (bulk media, planar, or channel waveguides) QPM not only leads to phase-matching, but also induces cubic nonlinear terms, such as self- and cross-phase modulation (SPM and XPM), in the effective averaged dynamical equations [6]. Let me briefly explain the physics behind this induced cubic nonlinearity, and discuss some examples of the effects it can introduce.

Consider a QPM crystal as sketched in Fig.2, in which the $\chi^{(2)}$ susceptibility is modulated by a periodic grating with domain length π/k_g. The evolution of the amplitude of the FW, $E_\omega(z)$, and the SH, $E_{2\omega}(z)$, is governed by the coupled equations (see [4,8])

$$i\frac{dE_\omega}{dz} + g(z)\chi E_\omega^* E_{2\omega} e^{-i\Delta kz} = 0 \qquad (1)$$

$$i\frac{dE_{2\omega}}{dz} + g(z)\chi E_\omega^2 e^{i\Delta kz} = 0 \qquad (2)$$

where χ is proportional to the effective nonlinear coefficient. The grating is described by the function $g(z)$ of amplitude 1, which has an infinite Fourier spectrum of spatial harmonics of the grating wavevector k_g

$$g(z) = \sum_n g_n \exp(ink_g z) \qquad (3)$$

where $g_{2n} = 0$ and $g_{2n+1} = 2/i\pi(2n+1)$ for the square function shown in Fig. 2.

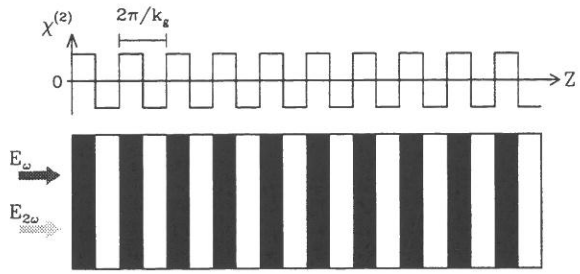


Figure 2: Sketch of a crystal with the typical square QPM modulation of the $\chi^{(2)}$ nonlinearity.

The grating introduces a 'reference wavevector', which for mth order QPM is simply mk_g. Expanding E_ω and $E_{2\omega}$ in a Fourier series of spatial harmonics of mk_g, we obtain the dynamical equations for the average amplitudes $w = \langle E_\omega \rangle$ and $v = \langle iE_{2\omega} \rangle$ [6]

$$i\frac{dw}{dz} + \chi_m w^* v + \gamma_m(|w|^2 - |w|^2)w = 0 \qquad (4)$$

$$i\frac{dv}{dz} + \chi_m w^2 - 2\gamma_m |w|^2 v = 0 \qquad (5)$$

where $\chi_m = \chi/(m\pi/2)$ and $\gamma_m = \chi^2(\pi^2 - 8)/(m\pi^2 k_g)$. Diffraction in the transverse x and/or y direction is easily incorporated by simply adding the corresponding second derivatives [6]. Furthermore, the equations will have the same structure for any QPM modulation, as long as it is periodic, the only change being that the three SPM and XPM terms have different coefficients [6].

From the lowest-order equations $\gamma_m = 0$ we see that the average SH amplitude evolves as in phase-matched SHG in a uniform crystal, with the nonlinear coefficient reduced by a factor $m\pi/2$, which increases with the order of the QPM. This means that the conversion efficiency is reduced by a factor $(m\pi/2)^2$, which is a

well-kown property of QPM [9]. It is confirmed beautifully by curves C_1 and C_3 in Fig. 1.

However, the lowest-order equations are obtained by neglecting the coupling between the fundamental mode with wavevector mk_g and higher-order modes with wavevectors $3mk_g$, $5mk_g$, etc. This coupling is not phase-matched, but strongly incoherent, and from the averaged equations (4-5) we see that it induces effective cubic nonlinear Kerr effects in the form of SPM and XPM. However, the SPM term does not appear for the SH and the XPM coefficients are always negative. This merely emphasized that the induced Kerr effects are of a fundamentally different nature than the conventional Kerr effects inherent in any material. Consequently, the dynamics can be significantly different from the earlier analyzed cases of competing nonlinearities [13].

It is interesting that such effective cubic nonlinear terms will be induced by any kind of incoherent coupling between modes in $\chi^{(2)}$ media [14]. A simple example is SHG in a waveguide, which is single-moded at the fundamental frequency ω, but supports two modes at 2ω [14]. Incoherent coupling between modes is thus a general physical mechanism that induces cubic nonlinearity in quadratic nonlinear media.

4. Spatial Solitons

In collaboration with the group of Professor Christiansen at the Technical University of Denmark, in particular C. Balslev Clausen, we have studied the properties of spatial solitons in QPM slab waveguides. The competing quadratic and QPM induced cubic nonlinearities is found to support a novel class of stable solitons. Unlike conventional optical solitons, the QPM solitons have amplitudes that are rapidly varying around a mean value, due to the higher-order modes with wavevectors $3mk_g$, $5mk_g$, etc., introduced by the grating. Since the higher-order modes can be found analytically in terms of the fundamental average mode at k_g [6], the amplitude and wavenumber of the oscillations can be predicted. Numerical simulations of the original equations (1-2) with diffraction in the transverse x-direction (∂_x^2), as shown in Fig. 3, confirm the predictions of the amplitude and wavenumber of the QPM solitons and their stability.

An interesting question about QPM solitons is how robust they are towards fluctions in the domain length, as a result of imperfect fabrication of the grating. As can be seen from the above calculations, such fluctuations will to lowest order appear as simply a fluctuating residual phase-mismatch in the equations for uniform $\chi^{(2)}$ crystals [15,6]. Thus an equivalent question would be how fluctuations in the phase-mismatch will affect the conventional $\chi^{(2)}$ solitons.

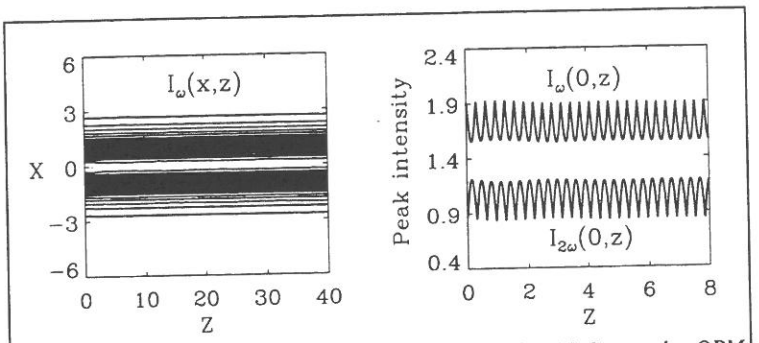


Figure 3: Excitation of a soliton in a slab waveguide with first-order QPM for $k_g=\Delta k=10$. (a) Contour plot of the intensity of the FW, $I_\omega=|E_\omega(x,z)|^2$, sampled at intervals $4L_c$. (b) Peak intensities of the FW and SH.

Using this relation, our initial numerical investigations showed that random fluctuations of the domain length reduce the phase correlation and act as an effective loss to the QPM solitons [15]. Subsequent more rigorous numerical simulations on the full system by Torner and Stegeman have confirmed this, and also shown that if the fluctuations have long-range correlations, then the solitons are strongly affected, and diffract rapidly [16].

5. Switching Properties

In collaboration with the group of Professor Lederer at the Friedrich-Schiller-Universität Jena, Germany, in particular A. Kobyakov, we have studied the influence of the QPM induced cubic nonlinearity on the amplitude and phase modulation of the FW in channel waveguides [18]. By solving the effective averaged equations analyticaly we have been able to predict configurations for efficient all-optical CW switching.

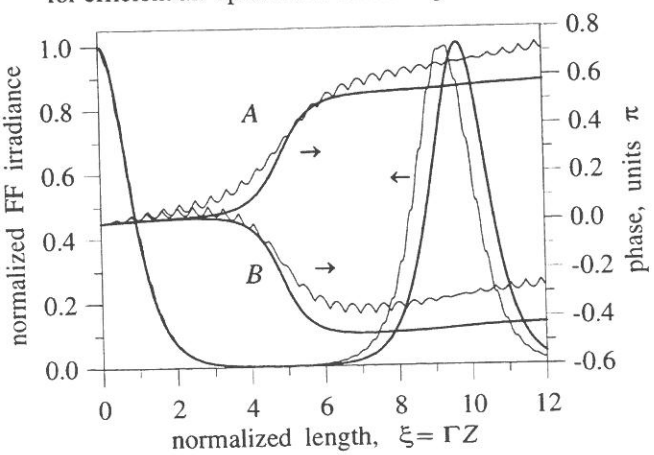


Figure 4: Evolution of the intensity and phase of the FW in a QPM $\chi^{(2)}$ channel waveguide. Thick lines: Analytical prediction from Eqs.(4-5). Thin lines: Results of direct numerical integration of Eqs.(1-2).

An example is given in Fig. 4, where we see that a weak control signal (difference in input FW intensity cannot be seen with the eye), can lead to a phase-shift of π after one cycle of interaction [18]. The analytical results are beautifully confirmed by the numerical simulations of the dynamical equations (1-2). There are some subtle points about these results. First of all, they require a nonzero residual phase-mismatch, i.e. one has to make the domain period slightly different from the coherence length. Furthermore, this switching property comes at the expense of a rather large holding intensity [18].

It is interesting that the analytical results of our group are qualitatively the same as numerical results obtained in Australia by Zhao, Town and Sceats in 1995, who studied poled optical fibres with the inherent material cubic nonlinearity taken into account [17]. Thus both the material and induced cubic nonlinearities seem to have comparable effects.

In any case, the introduction of a nonlinear grating in a $\chi^{(2)}$ medium can have interesting and advantageous effects, which are certainly worth studying in more detail. In collaboration with G. Town from the University of Sydney, and A. Kobyakov, who will visit the OSC this year for a longer period, we plan to experimentally and theoretically study the effects of cubic nonlinearity in poled fibres in order to determine whether the induced Kerr effects can be strong enough to be detected at all.

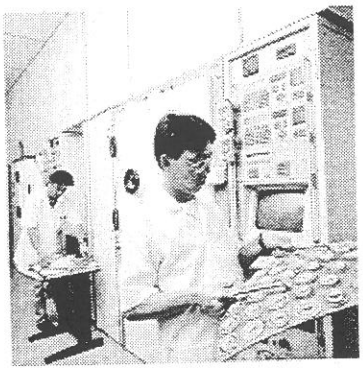
Acknowledgements

I would like to thank my colleagues Yuri Kivshar, Peter L. Christiansen, Carl Balslev Clausen, Falk Lederer, Andrey Kobyakov, and Graham Town for their many contributions to this research. Part of the work was supported by the Australian Dep. of Industry, Science and Tourism, grant no. 74.

References

[1]. L.A. Ostrovskii, JETP Lett. **5** (1967) 272.
[2]. Yu. N. Karamzin, A. P. Sukhorukov, Sov. Phys. JETP **42** (1976) 842.
[3]. N.R. Belashenkov, S.V. Gagarskii, M.V. Inochkin, Opt. Spectrosc. **66** (1989) 806.
R.DeSalvo *et al*, Opt.Lett. **17** (1992) 28.
[4] G.I. Stegeman, D.J. Hagan, L. Torner, Opt. Quantum Electron. **28** (1996) 1691.
[5]. Yu.S. Kivshar, AOS News **10** (1996) 11.
[6]. C. Balslev Clausen, O. Bang, Y.S. Kivshar, Phys. Rev. Lett. **78** (1997) 4749.
[7]. K.C. Rustagi, S.C. Mehendale, S. Meenakshi, IEEE J. Quantum Elec. **QE-18** (1982) 1029.
[8]. J.A. Armstrong *et al*, Phys.Rev. **127** (1962) 1918.
[9]. M.M. Fejer *et al*, IEEE J.Quant.Elec. **28** (1992) 2631.
[10]. P. Vidakovic *et al*, Opt.Lett.**22** (1997) 277.
[11]. M.L. Sundheimer *et al*, Opt.Lett. **18** (1993) 1397
[12]. Y. Shuto *et al*, IEEE J.Quant.Elec. **33** (1997) 349.
[13]. A.V. Buryak, Y.S. Kivshar, S. Trillo, Opt. Lett. **20** (1995) 1961. S. Trillo, A.V. Buryak, Y.S. Kivshar, Opt. Comm. **122** (1996) 200.
O. Bang, J. Opt. Soc. Am. B. **14** (1997) 51.
L. Bergé, O. Bang, J. J. Rasmussen, and V. K. Mezentsev, Phys. Rev. E **55**, 3555 (1997).
O. Bang, L. Bergé, J.J. Rasmussen, Opt. Comm. **146** (1998) 231.
[14]. O. Bang, Y.S. Kivshar, A.V. Buryak, A.De Rossi, S.Trillo, Phys.Rev.E (submitted 1998).
[15]. C. Balslev Clausen, O. Bang, Yu.S. Kivshar, P.L. Christiansen, Opt. Lett. **22** (1997) 271.
[16]. L. Torner, G.I. Stegeman, J.Opt.Soc.Am.B. **14** (1997) 3127.
[17]. Y.Zhao, G.Town, M.Sceats, Opt.Comm. **115** (1995) 129.
[18]. A. Kobyakov, F. Lederer, O. Bang, Y.S. Kivshar, "Nonlinear phase shift and all-optical switching in quasi-phase-matched quadratic media", Opt. Lett. (in press).

Advanced Thin Films



Coating applied using ion-assisted deposition (IAD) technology have advantages which will give your product the edge. Ions bombard the surface producing a dense film:

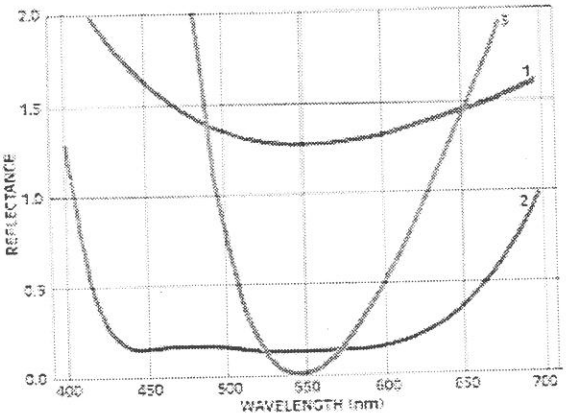
- High durability
- Consistent optical properties
- Smooth surface suitable for lasers

IAD produces tough films without the need to heat the substrate. Temperature sensitive materials can be coated :

- Plastics
- Infra-red optics
- Semiconductors
- Fire optics
- Large optics
- Crystalline material

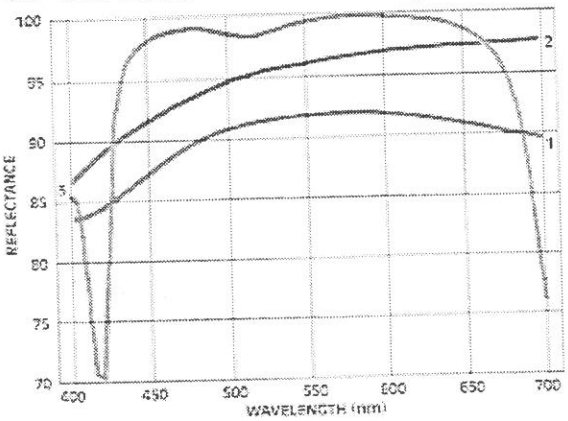
Consult Avimo's staff to discuss how IAD can benefit your products

ATF 1000 Series Anti-reflection Coatings



1. Single layer MgF2; a historic standard.
2. Board band multilayer in the wavelength range of your choice.
3. V-coating; nearly zero reflectance at a specific wavelength.

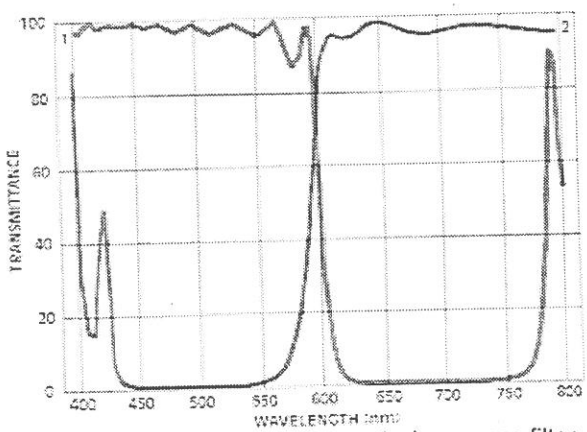
ATF 1000 Series Metallic Coatings



1. First surface aluminium protection with SiO2.
2. First surface silver with multilayer protection.
3. Enhanced first surface aluminium.

Avimo metallic coatings are protected to withstand environmental extremes. Second surface reflective coatings are also available.

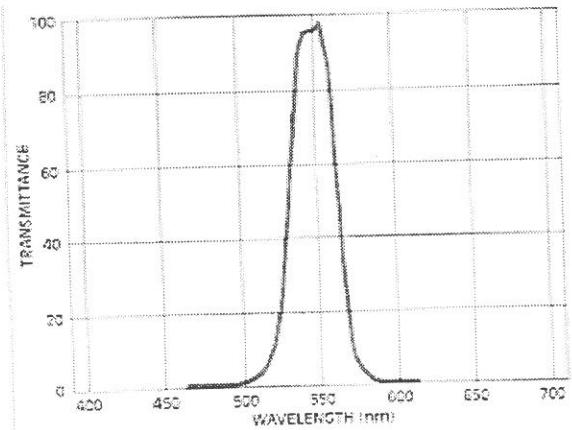
ATF 5000 Series Dielectric Edge Filters



1. Short pass filter. 2. Long pass filter.

The primary wavelength, the slope of the edge, the blocking properties and the transmitting properties can all be designed and controlled to suit your requirements.

ATF 6000 Series Dielectric Bandpass Filters



Avimo will design and produce filters to meet your requirements for central wavelength, the full width at half max and blocking properties.

The manufacturer has a policy of continuous improvements and reserves the right to make changes to this product without prior notice.

As a "Center of Coating Excellence" for precision optics, Avimo has developed conventional physical vapor deposition as well as ion-assisted deposition (IAD) technology to produce high performance optical thin films. Choose from our lists of proven coating designs or have our thin film team design a coating to meet your specific needs. For further details, please contact :

Avimo Electro-Optics Pte Ltd
A Subsidiary of Avimo Group Ltd
14 Fifth Lokyang Road . Singapore 629763
Tel : 2655122 . Fax : 2651479 . E-mail : aeo@pacific.net.sg

AVIMO
ELECTRO-OPTICS PTE LTD

REQUIRE ANY OF THESE ?

Optics	**Scanners**	**Filters**
Optical Accessories	**Beam Analysers**	**Protective Eyewear**
Acousto-Optics	**Electro-Optics**	**Energy Meters**
Gas Lasers	**Solid-State Lasers**	**Semi-Conductor Lasers**
Detectors	**Power Meters**	**Rods & Crystals**
Spectroscopy	**Radiometry/Sensing**	**Power Supplies**

We represent all the above items (& many more)

PRODUCT ENQUIRIES Ph: *1800 07 4450*

Laser Electronics (Operations) Pty Ltd ACN 010 679 115

Low Temperature Polarised Absorption Spectroscopy of Microcrystals Made Easy

Elmars Krausz
Research School of Chemistry, Australian National University, Canberra, ACT 0200
email: krausz@rsc.anu.edu.au web: http://rsc.anu.edu.au/~krausz/

We have upgraded our microcrystal absorption spectrometer system with computer-optimised optics and improved ergonomics. The system functions over a 260-2600 nm wavelength range, with ease and sensitivity, on crystals as small as 20 μm, in the temperature range 4-300K and with resolution better than 1 cm^{-1}. The significance of the technique to condensed phase spectroscopy and materials research is discussed.

1. Crystal Absorption Spectroscopy

Optical absorption spectroscopy is valuable in identifying the electronic excited states of matter. However, for matter in a condensed state, the inhomogeneity may lead to broadening of the linewidths. For example, linewidths greater than 1000 cm^{-1} (0.1 eV) may be found in solutions and glasses. Laser techniques, such as spectral hole-burning and fluorescence line-narrowing, can be used to obtain very narrow spectral features from inhomogeneously broadened spectra [1]. However, the techniques are complex, require careful interpretation, and are generally restricted to the lowest excited state(s). An alternative is to perform the spectroscopy when the sample is in a crystalline state, since crystal media suffer less inhomogeneous broadening. If experiments are done below 20 K, spectral features with width ~1 cm^{-1} can be seen. Single crystal measurements also have the advantage of providing polarisation information.

Much of the understanding of condensed phase chemical spectroscopy (and optical devices) has evolved from continuing studies on robust, doped materials, such as ruby (Cr^{3+} in Al_2O_3), which can be prepared with a convenient size (1-10 mm) and concentration. For more 'chemical' chromophores such as metal co-ordination complexes, it is relatively unusual to find a suitable transparent crystalline host for absorption measurements. This necessitates measurements on either solutions, which entail the inhomogeneous broadening problems mentioned above, or the use of undiluted (often called 'neat') crystals of the substance.

The need for a microcrystal spectrophotometer becomes paramount when large crystals (>1 mm) are difficult to grow, and optical densities of larger crystals become too high (>2). The key advantages of microcrystal spectroscopy are that: small crystals often have high optical quality; there are usually many crystals to choose from; and the small crystals have low optical densities.

2. Spectrophotometer Design Guidelines

For absorption A, the incident (I_0) and transmitted (I) intensities are related by the Lambert law,

$$A = \log_{10} \left(I_0/I\right) . \qquad (1)$$

In most spectrophotometers, incident light is split into sample and reference beams by a rotating mirror. I_0 depends on wavelength and may have a dynamic range greater than 10^6. The two beams are recombined at a detector to provide values of A.

The ability to measure small absorption values is always limited by the photon shot noise associated with I_0. In the visible region, an arc or incandescent light source can provide ~1 μW (10^{12} photons/s) in a 1 nm bandpass. The statistical variance of n photons is $\sqrt{n}$.

When I and I_0 contribute to the noise independently, the noise in A, δA, is

$$\delta A = \delta\left(\log I - \log I_0\right) = 2.3\sqrt{\left(\frac{\delta I}{I}\right)^2 + \left(\frac{\delta I_0}{I_0}\right)^2} . \qquad (2)$$

Thus, an absorption value of A = $3.2\text{x}10^{-6}$ can be measured in 1 s with signal-to-noise ratio of one. The inherent sensitivity is usually degraded by other factors.

At lower values of I_0, δA falls as $\sqrt{I}$ if there are no other sources of noise. Photomultipliers have some dark current and quantum efficiency limitations but serve as near perfect detectors of visible radiation. In the near-infrared, it becomes necessary to use photodiodes: Si to 1.1μm, Ge to 1.6μm, and InSb to 5.5μm. These have successively higher intrinsic dark currents *and* greater response to thermal background radiation. When photodiode detectors are used, it becomes necessary to use high gain amplifiers. These introduce noise, particularly when the diode impedance is low. Optimal performance is achieved by using the smallest

photodiode held at the lowest practicable temperature. Photodiodes characteristically have higher quantum efficiencies than photomultipliers. If I_0 is high enough that the shot noise exceeds the electronic noise [2] of the diode/amplifier combination, the signal-to-noise improves. With a 1 mm diameter silicon diode (responsivity of about 1 A/W) coupled to an $R = 10^6\ \Omega$ transimpedance amplifier, the thermal Johnson noise current i_R in the resistor is

$$i_R = \sqrt{\frac{4k_BTB}{R}}\ , \qquad (3)$$

and the shot noise i_{sh} for a photocurrent current i_{dc} is

$$i_{sh} = \sqrt{2qi_{dc}B}\ . \qquad (4)$$

Here, k_B is the Boltzman constant, T is the absolute temperature, q is the charge of an electron, and B is the bandwidth (in Hz) of the measurement. At 300 K, these become equal when $i_{dc} = 5\text{x}10^{-8}$ A, corresponding to a 50 mV amplifier output and ~$5\text{x}10^{-8}$ W light level. The system is limited by the thermal background when the background generates more than 50 mV of amplifier output.

A key consideration is the choice of A (as varied by thickness of the sample, etc.) so that the signal-to-noise is optimised. The situation is quite different for photomultiplier and diode based measurements. The noise, δI, in a diode/amplifier has two components, one from shot noise and the other from an effective dark current noise. These can be expressed as the number of quantas involved (n's) as

$$\delta A = 2.3\sqrt{\left(\frac{\delta n}{n}\right)^2 + \left(\frac{\delta n_0}{n_0}\right)^2} \qquad (6)$$

where $n=n_0\times10^{-A}$ and

$$\delta n = \sqrt{n+n_d}\ ,\quad \delta n_0 = \sqrt{n_0+n_d}\ . \qquad (6)$$

The signal-to-noise (for fixed n_0) is a function of A and the ratio n_d/n_0. Figure 1 shows that the optimal A is about 1 when the system is noise limited. There is a dramatic decrease in signal-to-noise for values of A greater than q when n_d approaches n_0. This is because little of the incident light reaches the detector, leaving the dark current noise to dominate the measurement. A thinner, though smaller crystal will often give better spectra because of this effect. Smaller A values do place greater demands on the quality of optical baselines, however.

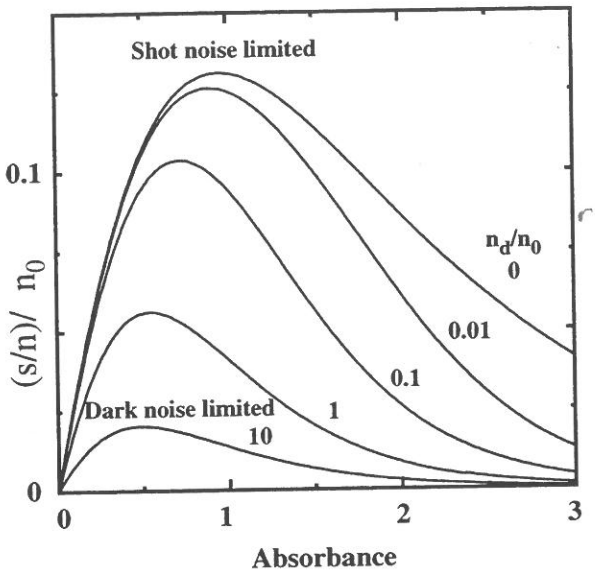


Figure 1: The obtainable signal-to-noise as a function of A. Here n_0 is the (effective) incident number of photons and n_d the (equivalent) number of noise photons.

3. Single Beam Advantages

Absolute measurements of the absorption of microcrystals are not normally undertaken. Factors associated with crystal shape and size, surface quality and internal scatter make such absolute determinations difficult. Most commonly, absorption values are made relative to spectral regions where there is little or no absorption. If the source and detector are sufficiently stable, the spectral dependence of I_0 can be stored in computer memory. A sample introduced into the beam is measured under the same conditions, and an absorption spectrum is calculated from the transmitted intensity.

Although the absolute value of I_0 is not of interest, it is critical that its value, relative to zero, be accurately known. A GPIB controlled lock-in amplifier can change its gain and operating characteristics so that seamless intensity measurements with a dynamic range well over 10^9, can be easily obtained.

A number of significant advantages are won via the single beam approach; the optical construction of the instrument is simpler, more flexible and more compact. The accumulated influence of the condensing optics, cryostat windows, are included in the pre-recorded "reference beam"; baselines become more accurate; the electronics are standard and simple; the computer code running the instrument can be readily changed, optimised or adapted.

In addition, there is a sensitivity advantage: I_0 curves (baselines) can be rapidly recorded using relatively high light levels and do not contribute noise. I_0 is usually a slowly varying function of λ and need only be sampled sparsely. I_0 values between these points can be estimated

by interpolation.

4. The New Spectrometer

A schematic of the system is presented in Fig. 2. It represents an evolution of the design presented previously [3], which is built around a 1 m monochromator. The light source remains a fan cooled 24 V 150 W quartz halogen lamp, imaged 1:1 on the entrance slit. The absolute stability of the DC source and chopper is critical.

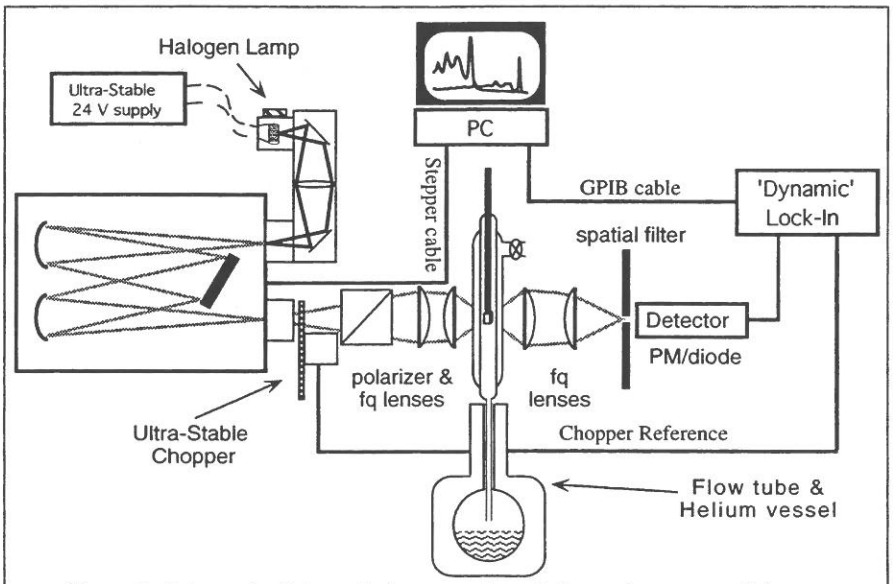


Figure 2: Schematic of the optical, cryogenic and electronic systems of the new spectrophotometer.

The new spectrometer uses fused quartz lenses to condense the beam rather than reflecting objectives. Although reflecting objectives are achromatic, computer simulation with Beam 3 code [4], revealed that the throughput is enhanced with lenses. The objectives block the central cone of the condensed beam. This central part is the most effective section of the beam when light has to propagate through a small crystal and its mask. Furthermore, the lens system is far cheaper and more compact.

The optical design shown in Fig. 3 utilises optical aberrations to convert the image of the monochromator slit to a 'spot'. More than 90% of the light passes through a 50 µm aperture. Light from the sample aperture is transferred to a detector with a diameter of 100 µm.

The Beam 3 package was initially used to generate an optimal design for the optical system. The dimensions of commercially available lenses, similar to those in the optimal design, were then used as an input to Beam 3 to create the final design. The design criterion was to optimise light throughput, not image quality. The positions of the lenses in the final design were optimised for the appropriate refractive index range for fused quartz ($1.44 < \eta < 1.48$). This allowed a design of the lens adjustment system to be finalised.

The new spectrometer works extremely well, showing an improvement in throughput of between 5 and 10 over the old system. In the visible region, baseline noise and reproducibility is around $1\text{-}3\times10^{-4}$ ΔA with a 50 µm hole and a 0.4 nm bandwidth. The ergonomics of the system have been very much improved by its compactness and the addition of the spatial filter, which reduces effects due to stray light.

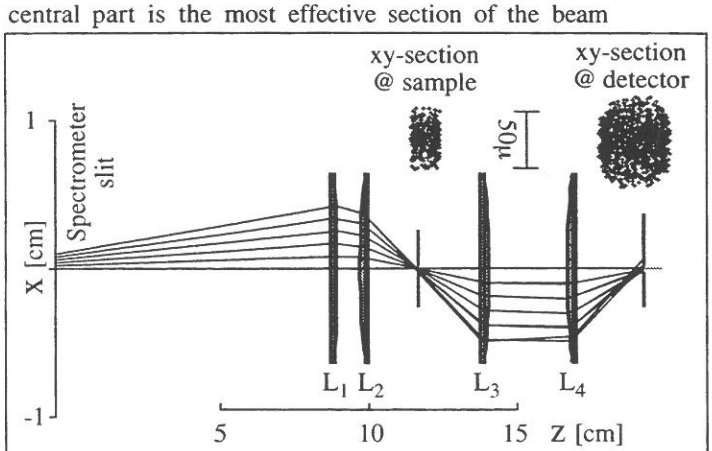


Figure 3: Fused quartz condensing and transfer lens design. Ray tracing is given for the top half of the input lens and is symmetric. L_1 has a 50 mm focal length and L_2-L_4 have focal length of 25 mm.

5. Developments and Interests

We plan to add a CCD camera to facilitate alignment of the light beam and sample. We are also looking at the possibility of computer tracking the lens focus to allow 'autofocus' operation. A single beam absorption spectrometer can also be readily adapted [5] to allow specular reflectance measurements of small crystals.

We are in the process of constructing a prototype 'CrystalCary'. This combines the very low stray light prism/grating double monochromator characteristics of a (recycled) Cary 17 spectrophotometer with our single beam lens optics, a PC and GPIB electronics. This will allow operation from the UV (180 nm) to the near IR (2.4 µm) without the need for grating or filter

changes. The resolution and noise performance may not quite match our dedicated system. However the resulting system would be relatively inexpensive and could also be offered commercially.

Over the last decade, our single beam spectrometer has proved to be easily the most capable crystal absorption spectrometer available worldwide. It has been used on many projects within the Research School of Chemistry and has also attracted collaborations with other groups in Australia and overseas. These studies have concentrated on metal ions in solids, or more generally metal co-ordination complexes.

Any transparent microcrystal showing colouration under the microscope is a good candidate for measurement with our system. Systems that have been studied in recent years include potential 'neat' laser materials, metamagnets, xeolites and systems with unusual oxidisation states and/or geometries. We are also collaborating with the Research School of Earth Sciences to measure temperature dependent spectra of tiny fluid inclusions in silica and minerals.

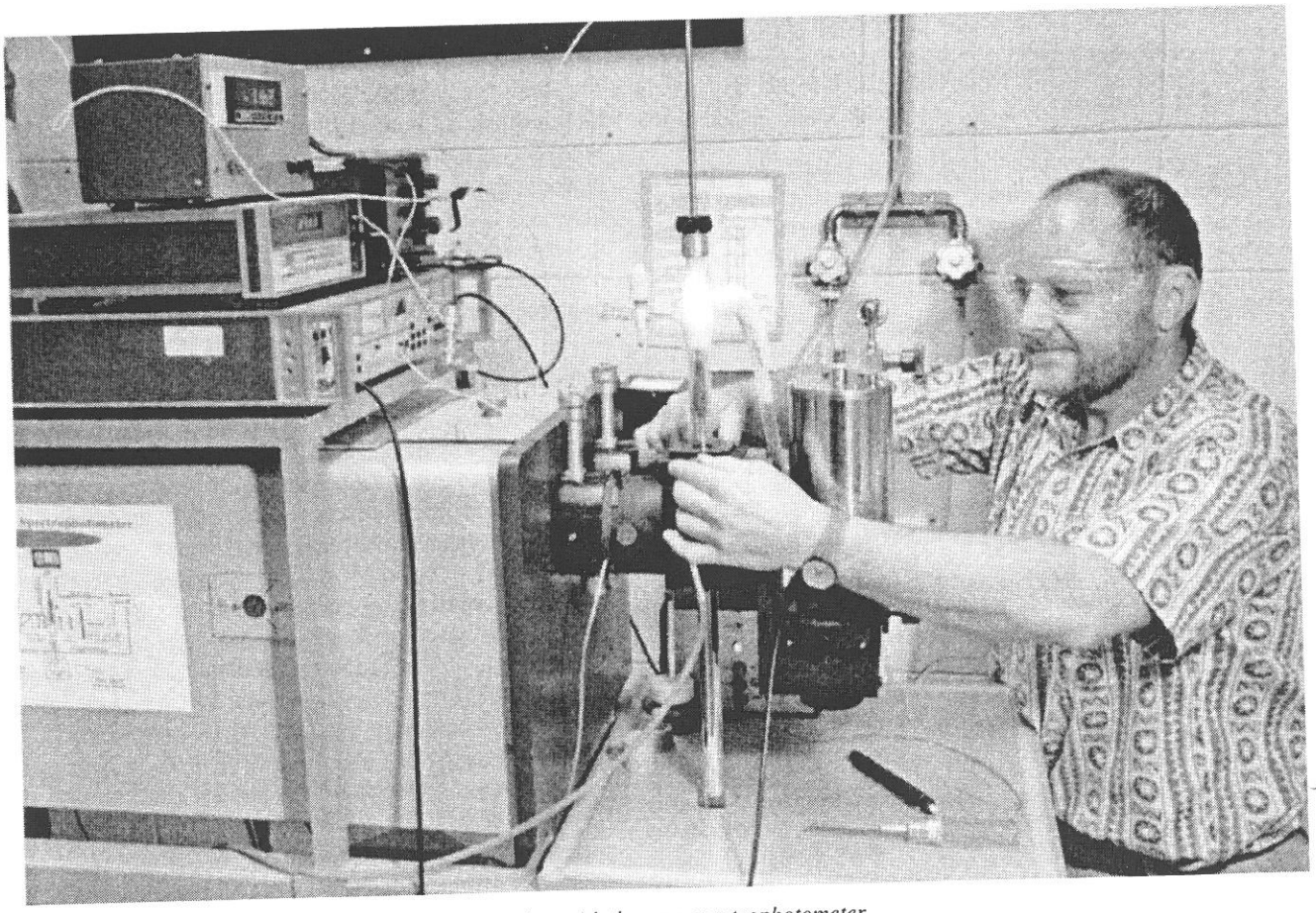
The capacity to optically characterise small crystals over a wide spectral range is relevant to many studies in chemistry and materials science. Practical applications are becoming more immediate as sensors, optical devices (such as lasers) become more compact.

Acknowledgment

The invaluable technical assistance and persistence of Mr. Keith Jackman is gratefully acknowledged.

References

[1] H. Riesen and E. Krausz, Comments. Inorg. Chem. **14,** (1993) 283-307.
[2] E. Krausz, Aust. J. Chem. **46**, (1993) 1041-1054.
[3] H. W. Ott *"Noise Reduction Techniques in Electronic Systems"*, John Wiley & sons (1976).
[4] Beam 3 Optical Ray Tracer, Stellar Software http://www.stellarsoftware.com/
[5] E. Krausz. and A. Ludi, Inorg. Chem. **224**, (1984) 939-943.



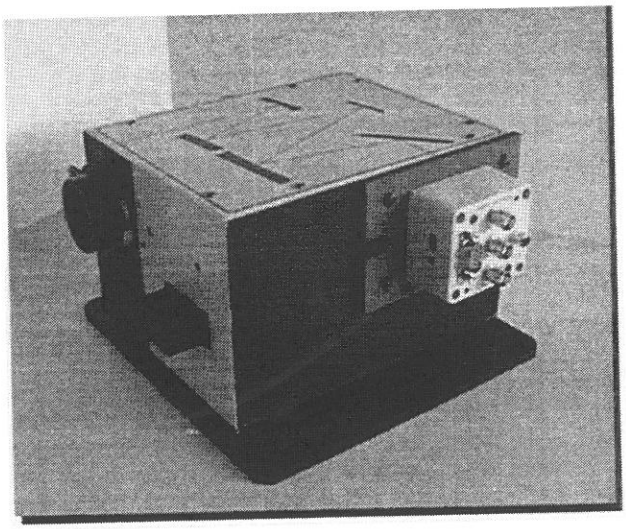
The author with the new spectrophotometer.

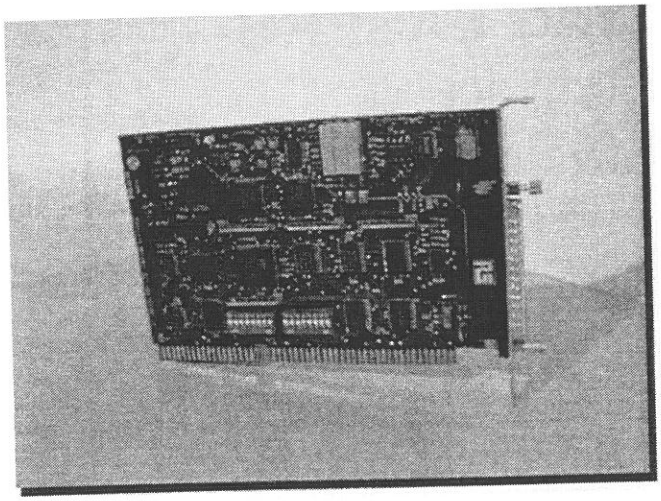
Affordable Multichannel Optical Spectroscopy

LARRY 2048

Linear CCD Array Detector...

- 2048 Element Linear CCD Array
- UV - 1100 nm
- 5 ms Minimum Integration Time
- Software / External Trigger
- PC Interface
- Upgrade Spectrometers To Linear Array Capability





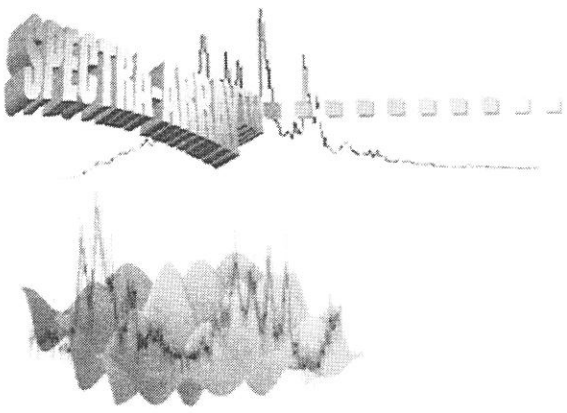
LAD-1250

High Speed Data Acquisition...

- 1.25 MHz 12-bit A/D
- Hardware / Software Trigger
- 8 Analog Inputs
- 2048 Word FIFO Buffer
- 8 Digital Inputs & Outputs
- PC AT Bus Format

Total Spectroscopic Software Solutions

- Data Acquisition
- Instrument Control
- Data Processing
- Open Architecture For Complete Customization
- Publication Quality Data Presentation
- 32-bit Performance

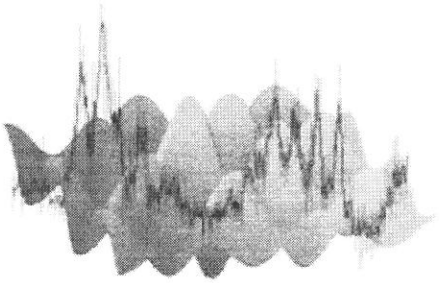


SPECTRA-SOLVE™ ***for Windows 95***

The Professional Data Analysis & Acquisition Software For Scientific Application

LAS TEK

Laboratories Pty Ltd
Australia

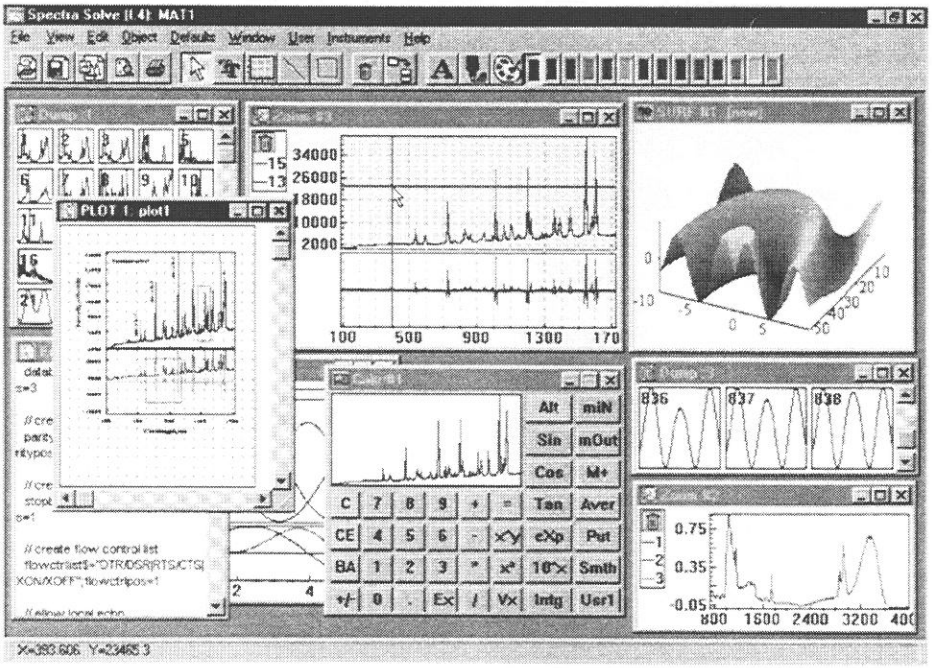


LAS TEK
Laboratories Pty Ltd
Australia

SPECTRA-SOLVE™ *for Windows 95*

The Professional Data Analysis & Acquisition Software For Scientific Application

"SPECTRA-SOLVE™ Is Not Just For Spectroscopists But Designed For Scientists, Engineers And Technical Professionals..."



- **Data Acquisition**
- **Instrument Control**
- **Data Processing**
- **Spectral Arithmetic**
- **Advanced Curve Fitting**
- **Fourier Analysis**
- **Smoothing**
- **Import & Export Data**
- **Publication Quality Data Presentation**
- **3D-Plotting**
- **Powerful Scripting Language**
- **Custom Dialog Control**
- **Open Architecture For Complete Customization**
- **DLL, VXD Support**
- **OLE, DDE Features**
- **32-bit Performance**

Designed by a leading group of spectroscopists with many years of research experience, SPECTRA-SOLVE is a powerful and flexible software platform dedicated to data *acquisition / control*, *analysis* and *presentation*.

A powerful native programming language, operating directly within SPECTRA-SOLVE, allows you to create custom acquisition / control and analysis routines to automate and run your laboratory efficiently.

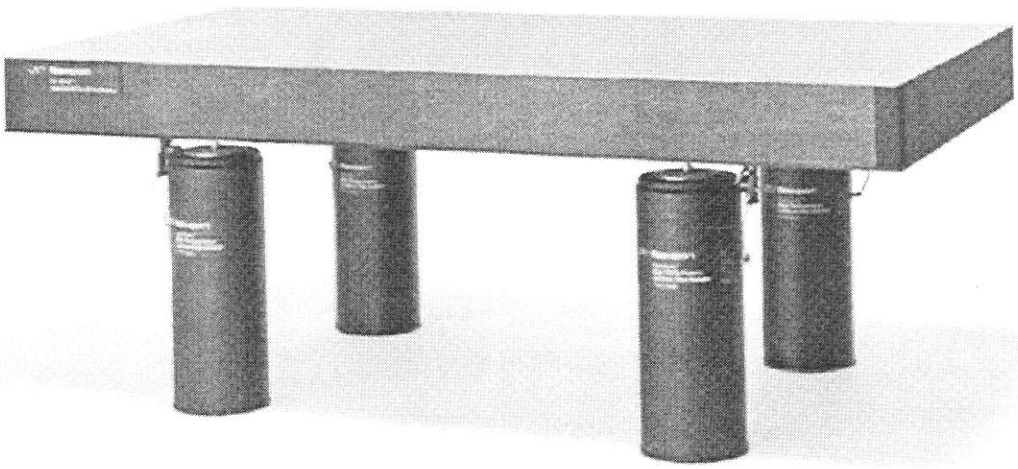
Lastek Laboratories Pty Ltd
10 Reid Street
THEBARTON SA 5031
AUSTRALIA

Tel: 61-8-8443 8668 Fax: 61-8-8443 8427
Email: lastek@saschools.edu.au
http://www.saschools.edu.au/lastek/lastek.html

Newport Tables Outperform All Others. Here's Why....

Coherent SCIENTIFIC

1. **Proprietary Tuned Damping**
2. **Self-damping Side Panels**
3. **Lighter Tables for Superior Rigidity**
4. **Precision Platens for Superior Flatness**
5. **Proprietary Bonding Technology**
6. **Patented, Corrosion Proof Sealed Mounting Holes**
7. **Non-resonant, Free Standing Legs**
8. **Exclusive Hybrid Chamber Isolator Design and Performance**
9. **Unrivaled Technology Leader**
10. **Proven Performance; >25,000 Systems in >25 years**



Please contact Coherent Scientific for more information:

Neil McMahon — neil@cohsci.com.au
Margaret Skipworth — margaret@cohsci.com.au
Bill Petreski — bill@cohsci.com.au

cohsci@cohsci.com.au
Ph: 08-8352-1111
Fax: 08-8352-2020

Coherent Scientific

Suppliers of high quality products and service to the Australian and New Zealand laser and opto-electronics communities.

Products include:

- **Nanosecond Pulsed Lasers**
- **Ultrafast Lasers**
- **CW Lasers**
- **OPO and OPA Systems**
- **Industrial Laser Systems**
- **Medical Laser Systems**
- **Laser Accessories, Components and Consumables**
- **Laser Workstations**
- **Laser Diagnostics**
- **Vibration Isolation Systems**
- **Mechanical Components**
- **Fibre Optics**
- **Optics**
- **Educational Kits**
- **Electronic Instruments**
- **Imaging Systems**
- **Spectroscopy Systems**

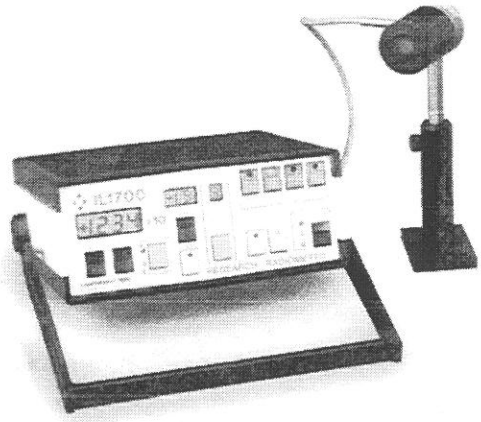
See us at AOS-XI Adelaide December '97

See us at APCC Sydney December '97

Coherent Scientific Pty Ltd 116 Burbridge Road, Hilton SA 5033
Phone: (08) 8352 1111 Fax: (08) 8352 2020
E-mail: cohsci@cohsci.com.au Web: www.cohsci.com.au

News from **WARSASH Scientific**

Now available:

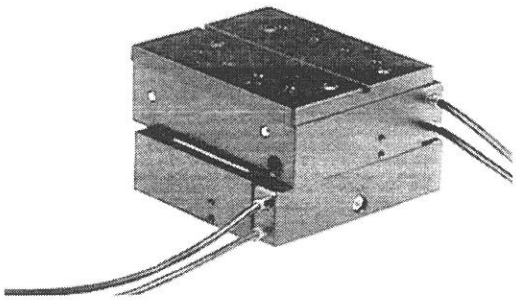


International Light's IL1700 research radiometer

the most versatile current measurement instrument in the world,
can autorange during exposure integrations over its entire 10 decade dynamic range

Replacement flash lamps from Heraeus Noblelight

for pumping standard solid-state laser systems and specific OEM requirements



PI's novel QuickScan Voice-Coil scanning & positioning system

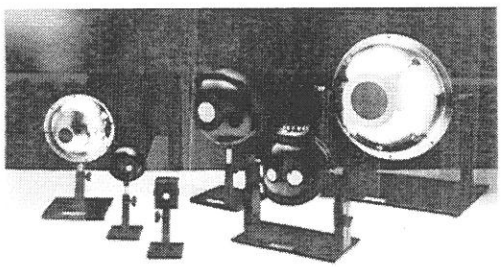
speedy, accurate, with resolution of 0.1µm, reaches velocities up to 250 m/sec over 5mm range

Takos range of optics and coatings

high damage threshold, custom optical coatings, filters UV-IR, windows, waveplates, beam-splitters and other systems requirements

Labsphere's reflectance/ transmittance integrating spheres

made from highly reflective diffuse material, for use in the laboratory, the field, underwater and space

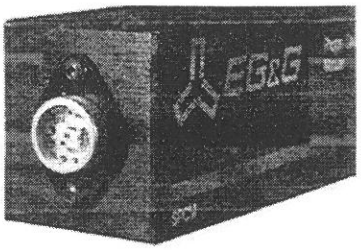


from **WARSASH Scientific** at tel: (02) 9319 0122 - fax: (02) 9318 2192
email: warsash@ozemail.com.au - website: http://www.ozemail.com.au/~warsash

Serving Australian Scientific Research & Industry

News from **WARSASH Scientific**

Now available:



From EG&G Canada a new single photon counting module

self-contained, detects single photons over wavelength range of 400-1060 nm.

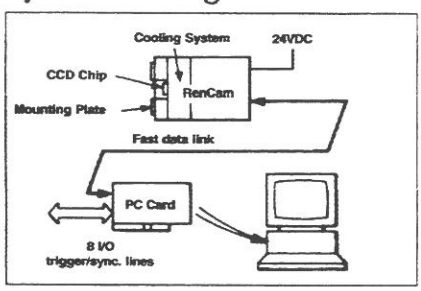
Labsphere's new BFC-450 Bispectral Fluorescence Colorimeter brochure

describes the advantages of bispectral measurement and how the instrument uses a dual monochromator method to accurately calculate fluorescent colour under any CIE standard illuminant

RenCam low noise CCD detector from Renishaw

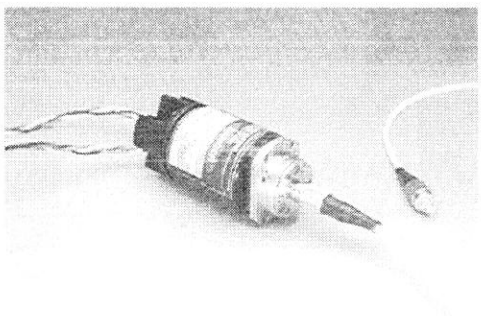
highest level performance for the most demanding spectroscopy and imaging applications.

System Configuration



Piezoelectric Ceramics from PI Ceramic

for a wide range of standard or custom designed PZT ceramics for applications from accelerometers and acuators to sensors



New fibre coupled temperature controlled diode lasers

from Micro Laser Systems, in a wide variety of wave-lengths with high output powers

from **WARSASH Scientific** at tel: (02) 9319 0122 - fax: (02) 9318 2192
email: warsash@ozemail.com.au - website: http://www.ozemail.com.au/~warsash

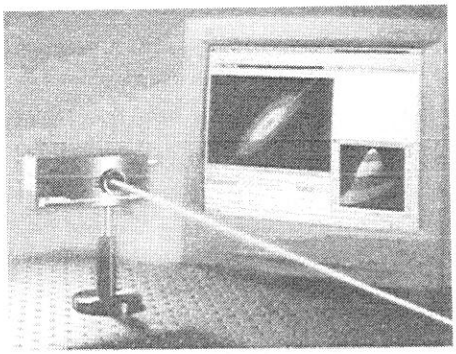
Serving Australian Scientific Research & Industry

NEW

PHOTON ENGINEERING

FAST ACCURATE LASER BEAM PROFILING MADE EASY

With *BeamPro* from Photon Inc.

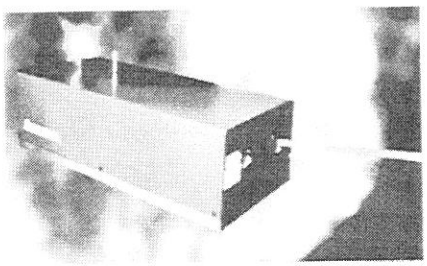


With a host of features *BeamPro* provides the ultimate in flexibility and ease of use with a quantum leap in laser beam profiling technology:

- Built-in variable attenuator for safe use over a wide incident power range for pulsed or CW beams.
- Plug-in PC card for flexibility in any R & D, QA, or process control setting.
- Slim-line head allows placement inside optical systems.
- Measure beamwidths down to 95 μm. Better than any camera based product previously available.
- Powerful MS-Windows based software.

TUNABLE PULSED ALEXANDRITE LASERS

From Light Age, Inc

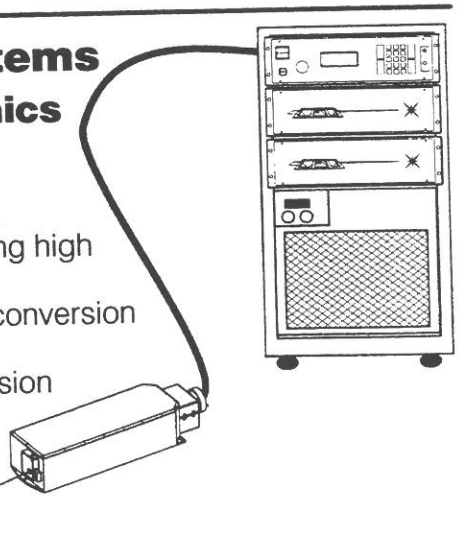


- Fundamental tunable from 720-800 nm.
- 190-2400 nm range with frequency conversion options.
- 10-300 mJ pulses over entire UV / VIS / IR range.
- 100 ps - 2 μs pulse widths available.
- Diode laser injection seeded for 5-100MHz linewidths
- Solid state replacement for pulsed dye lasers and excimer lasers

Also Available: CW UV laser NUV0 with 5 - 10 mW output at 360 - 400 nm

All Solid State Industrial Laser Systems

from Cutting Edge Optronics



- 50 and 100 W CW, 100 and 200 mJ pulsed models.
- All solid-state diode pumped ruggedness and reliability.
- Nd:YAG slab and rod models to suit the most demanding high power applications.
- Full range of options including Q-switching, frequency conversion and fibre coupling.
- Applications include marking, micro machining, percussion drilling, cutting, coating removal, micro welding and scribing.
- Compact and efficient design.

PHOTON ENGINEERING
Postal: PO Box 10269, Gouger St Shipping: 1st Floor, 123 Wright St
Adelaide, South Australia, 5000
Tel (08) 8410 4599 Fax (08) 8410 4544
email: photeng@ozemail.com.au
website: http://www.ozemail.com.au/~photeng/index.html

PHOTON ENGINEERING

Specialists in Solid State Lasers

LASERS

- Scientific and Industrial Lasers
- High Power Diode Lasers
- High Power Diode Bars and Arrays
- Diode Pumped Nd Lasers (1 mW up to 200 W)
- Laser Electronics / Diode Drivers
- Harmonic Generation
- Laser Components
  (Laser Crystals / Nonlinear Crystals / Q -switches)
- OPOs (tunable and monolithic fixed wavelength)
- Flashlamp Pumped Nd Lasers
  (Q-switched / SBS compressed / modelocked)
- Tunable Alexandrite Lasers (UV / VIS / IR options)

CONTACT US FOR A FREE CATALOGUE

ACCESSORIES

- Laser Stabilizers / Power Controllers
- Tunable Imaging Filters
- Laser Beam Profilers
- Optical Diagnostic Equipment
- Power Meters
- Optical Components
- Beam Attenuators
- Autocorrelators

PHOTON ENGINEERING
Postal: PO Box 10269, Gouger St Shipping: 1st Floor, 123 Wright St
Adelaide, South Australia, 5000

Tel (08) 8410 4599 Fax (08) 8410 4544
email: photeng@ozemail.com.au
website: http://www.ozemail.com.au/~photeng/index.html

B&W TEK

Cutting Edge Optronics, Inc.

Cambridge Research & Instrumentation, Inc.

EKSMA

GPC

LIGHT AGE, INC.

Light Solutions Corporation

Molectron

NEW FOCUS, Inc.

PHOTON Inc.

RPMC

SUPER OPTRONICS

THORLABS

Wavelength Electronics

AOS XI

~ Remembered ~

The bi-annual AOS conference has a fine tradition of social and scientific excellence. The 1997 conference was no exception. Held in the heart of Adelaide and attracting over 270 delegates (the largest attendance yet) AOS XI was a memorable occasion which brought together a large fraction of the optics community.

The conference was proceeded by workshops in Quantum Coherence, Propagation, and Gravitational Wave Interferometry. These two-day affairs set the scene by allowing closer interaction between delegates of related disciplines, and provided an informal stage for discussion.

The conference itself was consisted of plenary sessions followed by parallel sessions during most of the day. Parallel sessions were necessary because the number of papers submitted to the committee was so large, but were also considered a good idea because they increased the chance of finding a talk of interest. With the optics community in Australia being so diverse, this option was appreciated by most.

The large number of submissions meant that about seventy percent of papers were given as posters, the poster sessions taking up the afternoon on each day of the conference. Although most authors seem to prefer to give oral presentations, the poster sessions gave rise to the greatest scientific interaction. The inclusion of pizza and refreshments meant the sessions were long and successful.

The poster sessions took place along side the trade exhibit — one of the largest held at an AOS conference (probably because Adelaide is the headquarters of commercial optics in Australia). The exhibiters' efforts, including wine tasting and M&Ms, were appreciated by all.

Adelaide itself deserves a mention as one of the finest venues for a conference. The lecture theatres, accommodation, and food were all within walking distance of each other. The restaurants of Rundle street, in particular, will be fondly remembered. They assisted one of the great opportunities presented by AOS XI : the chance to meet and talk with other members of the optics community (a rare event in the light of its geographical spread).

The conference organisers were faced with a difficult decision concerning the conference dinner. Because the conference was close to Christmas, the venue needed to be booked early — before the conference attendance figures were known. Rather than risk financial ruin, it was decided that a reception would take its place. This reception saved the day (despite large groups of hungry students who patrolled the exits from the kitchen who ambushed anyone carrying food).

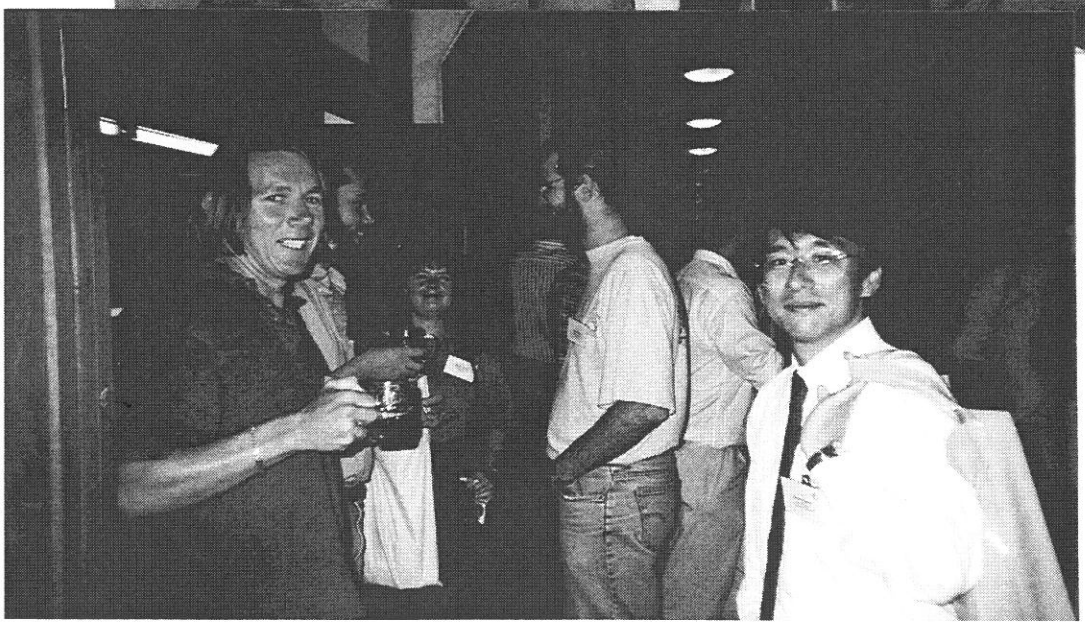
The cost of accommodation ($15 per night in the nurse's residence at the Adelaide Hospital) was a significant factor in allowing people from all walks of optics to attend. Hopefully, cheap accommodation of this kind will be a feature of future conferences.

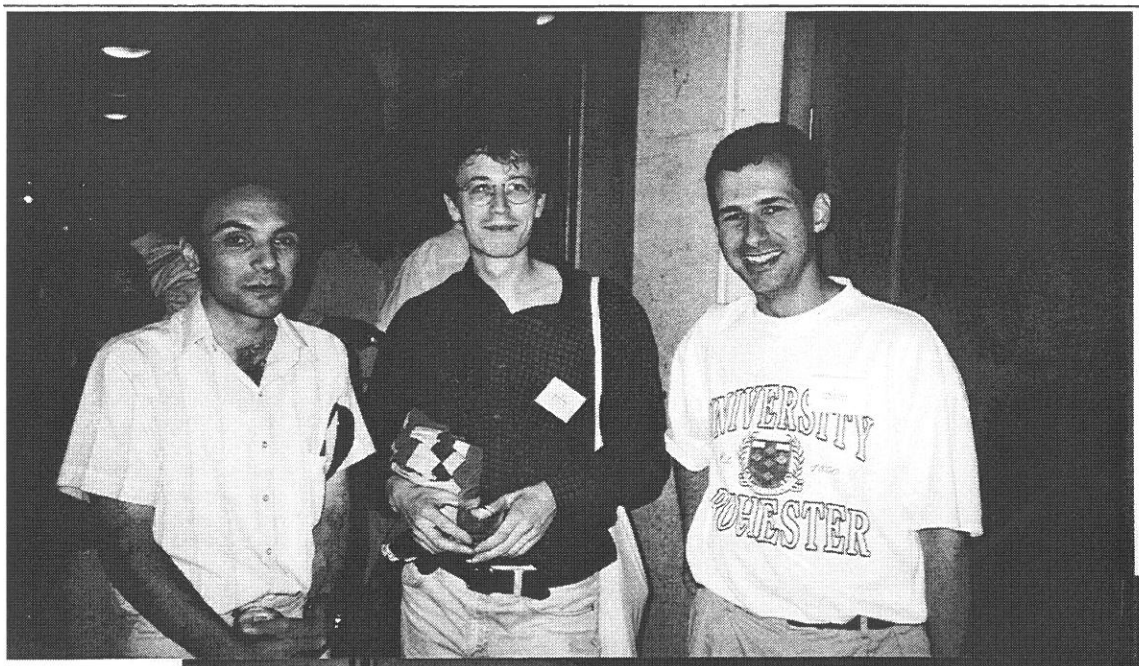
The next AOS conference is ACOLS in Christchurch, New Zealand. The next in the bi-annual series of AOS meetings will be in 1999 in Melbourne, where it looks as though they have upgraded the south bank to the stage where it may be fit for an AOS conference!

Finally, many thanks to the AOS XI organising committee and the conference sponsors, in particular Coherent Scientific who sponsored one of the invited speakers.

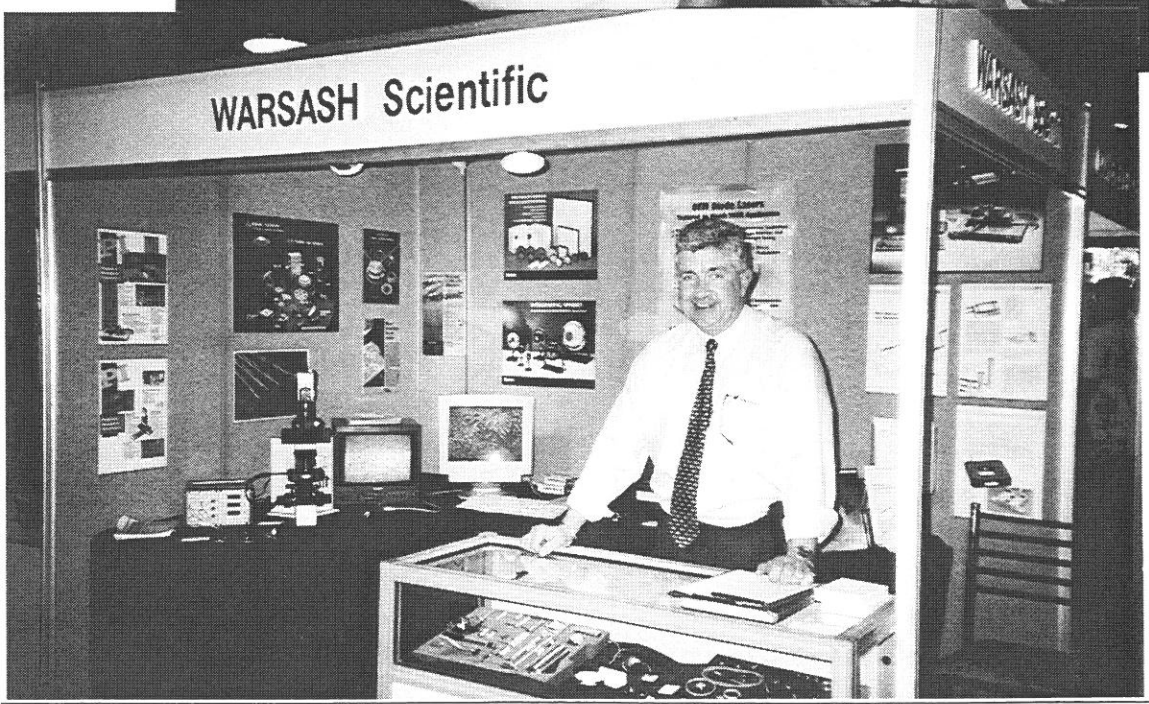
The organising committee :	
Jesper Munch (chair)	(University of Adelaide)
Murray Hamilton (sec'ry)	(University of Adelaide)
Peter Veitch (treasurer)	(University of Adelaide)
P. Teubner	(Flinders University)
N.Jones	(Coherent Scientific)
Andrew Masters	(Coherent Scientific)
John Hermann	(DSTO)
Robert Seymour	(DSTO)
Ann-Marie Grisogono	(DSTO)

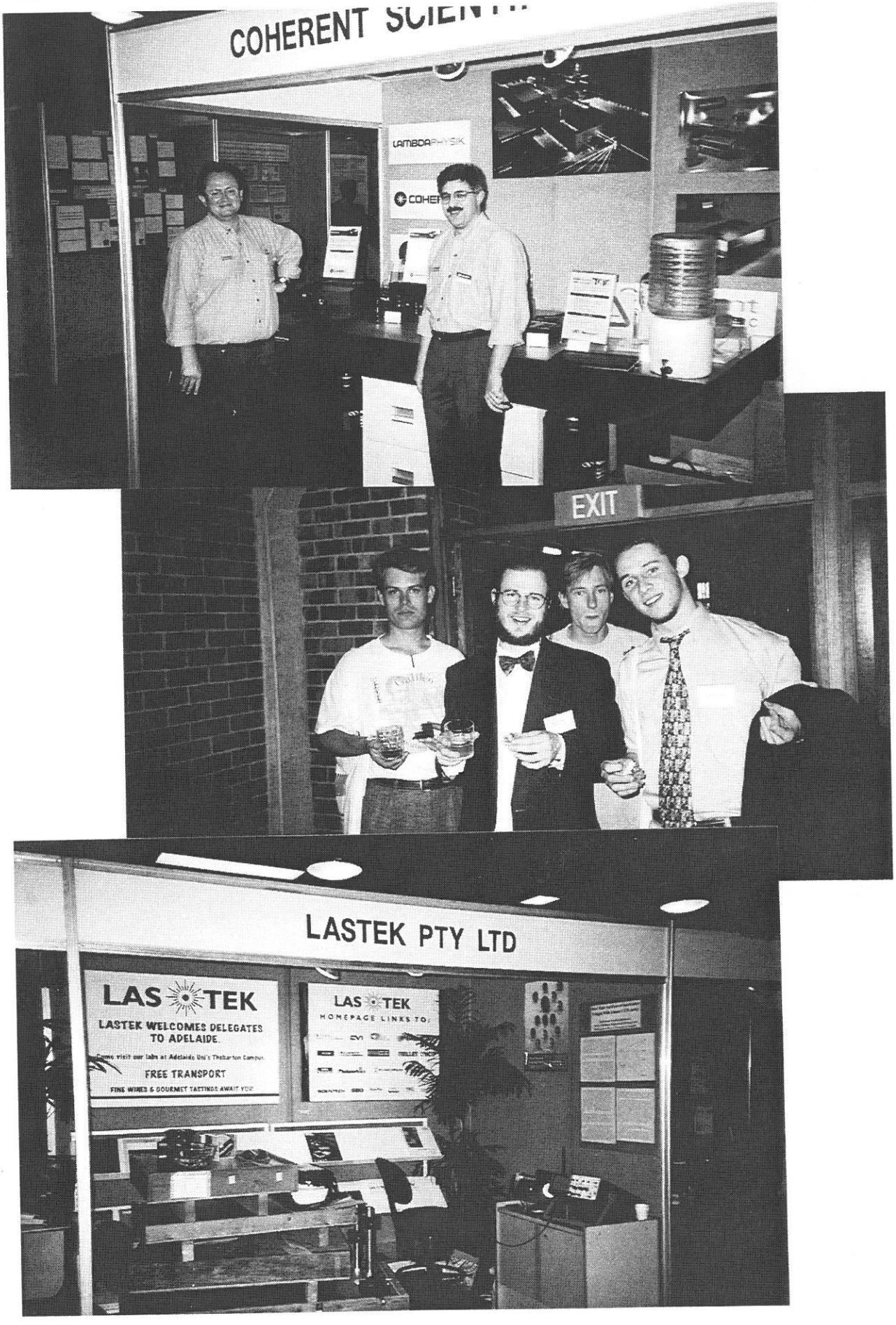
The following photographs were taken at the poster session on Friday afternoon at AOS XI - Ed




UNIVERSITY
OF CHESTER


PHOTON ENGINEERING


WARSASH Scientific


COHERENT
LAMBDAPHYSIK
EXIT
LASTEK PTY LTD
LAS TEK
LASTEK WELCOMES DELEGATES TO ADELAIDE.
FREE TRANSPORT
LAS TEK
HOMEPAGE LINKS TO:

OSA 1998 OSA Membership Application: ■ Regular ■ Student

Name _____ Date _____
Last First Middle

Please fill in both addresses below, then tell us which one you'd like us to use.

1. Business/Academic Address

Institution _____

Street _____

P.O. Box/Mail Stop _____

City _____ State _____ Zip _____

Province _____ Country _____ Postal Code _____

Phone _____ Fax _____

E-mail Address _____

2. Home Address

Street _____

P.O. Box/Mail Stop _____

City _____ State _____ Zip _____

Province _____ Country _____ Postal Code _____

Phone _____ Fax _____

Preferred Mailing Address: ☐ Home ☐ Business

EDUCATION

Highest Degree Awarded
☐ Bachelor's ☐ Master's
☐ Doctorate ☐ Other (specify)_____

Discipline of Highest Degree
☐ Astronomy ☐ Biophysics
☐ Chemistry
☐ Electrical Engineering
☐ Engineering (other than electrical)
☐ Optics ☐ Physics
☐ Psychology ☐ Other (specify)_____

Year of Highest Degree_____

OTHER SOCIETY MEMBERSHIPS (circle)
AAPM, AAPT, AAS, ACA, ACS, AGU, AIP, APS, ARVO, ASA, ASEE, ASPE, AVS, COMSOC, IEEE, LEOS, LIA, MRS, NSTA, SOR, SPIE, SPS

I have previously been a member of OSA.
☐ Yes ☐ No

PERSONAL INFORMATION
(the answers to this question are for statistical purposes only and will be held in complete confidentiality.)

Date of Birth_____
MONTH DAY YEAR

Gender ☐ Male ☐ Female

Race
☐ Amer. Indian/Alaskan Native
☐ Asian or Pacific Islander
☐ Black
☐ White (non-Hispanic)
☐ Hispanic
☐ Other (specify) _____

Customize Your Membership
Select up to 5 Application Areas or Technical Groups to help us tailor your membership to your needs.

1st _____ 2nd _____ 3rd _____ 4th _____ 5th _____

APPLICATION AREAS
(AA) Commercial/Industrial/OEM Products/Component
(AB) Biomedical Instrumentation
(AC) Consumer/Entertainment Products
(AG) Instrumentation/Environmental Monitoring
(AI) Information Delivery/Communication Systems
(AL) Laser Engineering
(AM) Metrology Instrumentation
(AP) Manufacturing & Process Engineering
(AQ) Quality, Reliability & Inspection

TECHNICAL GROUPS

Information Processing Division
(IA) Optical Computing
(IB) Optical Data Storage
(ID) Image Processing
(IH) Holography

Optics in Biology & Medicine Division
(OI) Biomedical Optical Imaging
(OS) Biomedical Optical Spectroscopy
(OT) Therapeutic Laser Applications

Photonics Division
(PC) Optical Communications
(PE) Integrated Optics and Micro-Optics
(PW) Optical Sensors & Detectors
(PZ) Optoelectronics

Quantum Electronics Division
(QE) Lasers
(QL) Laser Materials Processing
(QN) Nonlinear Optics
(QY) Ultrafast Optical Phenomena

Optical Sciences Division
(SB) Atmospheric and Oceanic Optics
(SH) Fundamental and Applied Spectroscopy
(SR) Optical Physics
(SX) X-Ray and X-UV Physics

Optical Technology Division
(TA) Astronomical, Aeronautic, and Space Optics
(TB) Active & Adaptive Optics
(TE) Systems & Instrumentation
(TF) Optical Design
(TG) Optical Thin Films
(TJ) Lithography
(TM) Optical Fabrication & Testing

Vision & Color Division
(VC) Color
(VK) Vision
(VM) Applications of Visual Science

STUDENT MEMBERS (Must be completed before application can be processed)

Do you belong to the student chapter at your institution? ☐ Yes ☐ No
Would you like information about starting a student chapter? ☐ Yes ☐ No

I certify that the above named applicant is a bona fide student devoting more than half time to activities with the institution.

_____ Date

_____ Print Name of Faculty Member

_____ Signature of Faculty Member

TYPE OF EDUCATIONAL INSTITUTION
☐ Two-year college
☐ Four-year college
☐ University

Expected Graduation Date _____

TYPE OF DEGREE BEING PURSUE
☐ Astronomy
☐ Biophysics
☐ Chemistry
☐ Electrical Engineering
☐ Engineering (other than electrica
☐ Optics
☐ Physics
☐ Psychology
☐ Other (specify) _____

(For office use only) Membership approved _____ **7EFLA**

OSA Member Dues & Journal Order Form

Subscription Orders *(Number of issues per year)*	Regular Member			Student Member			
	Domestic	Canada/ Mexico/PUAS (Surface)	Other Countries (Air Freight)	Domestic	Canada/ Mexico/PUAS (Surface)	Other Countries (Air Freight)	
†Applied Optics: One division (12) (specify) _____	$ 58	$ 81	$ 120	$ 29	$ 52	$ 91	
Two divisions (24) (specify _____&_____)	$ 88	$ 132	$ 203	$ 45	$ 89	$ 160	
Three divisions (36)	$ 102	$ 161	$ 269	$ 51	$ 110	$ 218	
†The divisions of Applied Optics are *Optical Technology and Biomedical Optics (OT)*; *Information Processing (IP)*; and *Lasers, Photonics, & Environmental Optics (LP)*							
Optics Letters (24)	$ 66	$ 92	$ 123	$ 32	$ 58	$ 89	
Optics Letters Online Only	$ 35	$ 35	$ 35	$ 25	$ 25	$ 25	
Optics Letters Print and Online	$ 75	$ 101	$ 132	$ 55	$ 81	$ 112	
Journal of Lightwave Technology (12)	$ 56	$ 56	$ 128	$ 30	$ 30	$ 102	
Journal of the Optical Society of America A: Optics, Image Science, & Vision (12)	$ 55	$ 79	$ 117	$ 28	$ 52	$ 90	
Journal of the Optical Society of America B: Optical Physics (12)	$ 55	$ 79	$ 117	$ 28	$ 52	$ 90	
Journal of the Optical Society of America A & B (24)	$ 98	$ 144	$ 223	$ 49	$ 95	$ 174	
Optics & Spectroscopy (12)	$ 116	$ 138	$ 162	–	–	–	
Journal of Optical Technology (12)	$ 101	$ 115	$ 128	–	–	–	
Optics & Photonics News (12)	INCLUDED WITH MEMBERSHIP			INCLUDED WITH MEMBERSHIP			N.C.

Membership Dues *(Based on a calendar year)*

Regular Membership ($80 per year; $45 after June 30, 1998) $ _____

Student Membership ($30 per year; $41 joint SPS) $ _____

Books/electronic products (product name) _____ $ _____

TOTAL DUES AND SUBSCRIPTIONS $ _____

PLEASE INCLUDE PAYMENT. OSA DOES NOT INVOICE.

I hereby certify that this information is correct and that the journal(s) I subscribe to are for my **personal use and personal library only.**

Signature _____ Date: _____

(NOTE: There are no special student rates for *Optics & Spectroscopy* and *Journal of Optical Technology*.)
*Domestic subscription rates apply ONLY to U.S. & Possessions. **Airfreight is automatically included.
†You can subscribe to 1, 2, or all 3 divisions of *Applied Optics*.

Membership and journal subscriptions are based on the calendar year in which application is made. Journal subscriptions begin with the January issue unless the applicant specifies that membership and subscriptions begin January 1 of the following year.

Payment by:

☐ Check* ☐ Visa ☐ MasterCard ☐ Diners Club ☐ American Express

Credit Card Number _____ Expiration Date _____

Authorized Signature _____

*Make check payable to Optical Society of America. PAYMENT IN U.S. DOLLARS, BY DRAFT ON A U.S. BANK, IS REQUIRED. DO NOT SEND CURRENCY. IF YOUR PAYMENT IS MADE BY TRANSFER, DIRECT IT TO: Nations Bank NA, 1501 Pennsylvania Ave. NW, Washington, DC 20013, ABA #054-00-1204, OSA Acct. 20-867-84-287. You are responsible for all bank transfer fees.

PLEASE INCLUDE A COPY OF THE TRANSFER ORDER.

Domestic subscription rates apply to the United States and its possessions ONLY. Canada, Mexico, and PUAS are served by foreign surface mail. Members in all other countries receive journals by air freight.

Membership information will be mailed in 3-4 weeks. Magazines and journal subscriptions will start in 6-8 weeks.

RETURN TO: Optical Society of America, Member Services Dept., MS 112 • 2010 Massachusetts Avenue, NW, Washington, DC 20036-1023
(800) 762-6960 • (202) 416-1475 • FAX: (202) 223-1096 • E-mail:osamem@osa.org

AUSTRALIAN HOLOGRAPHIC STUDIOS P/L

ND:YLF / PHOSPHATE / GLASS LASERS

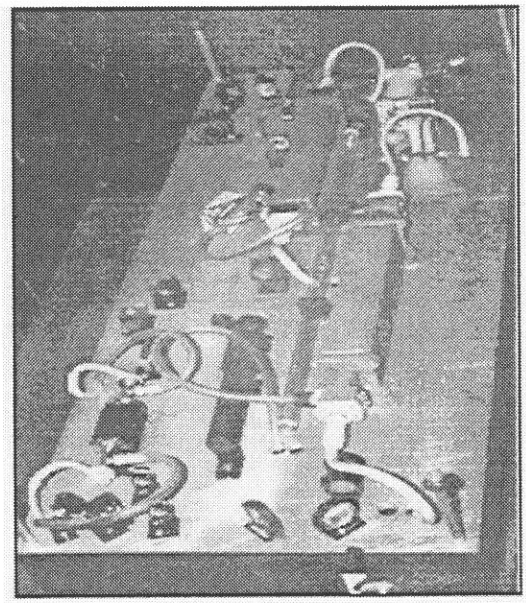
INTRODUCING THE NEW GEOLA

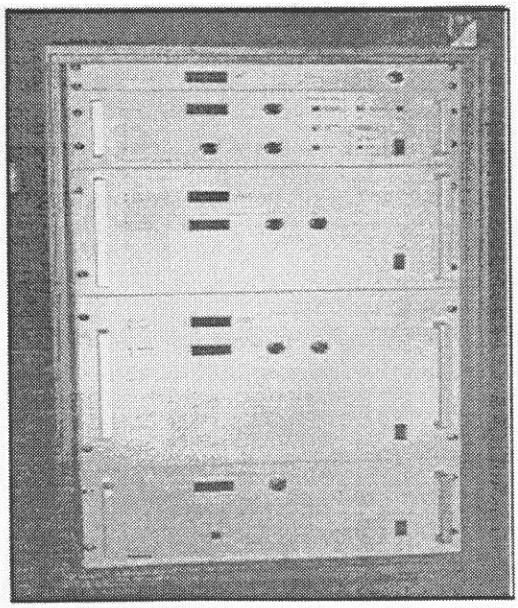
NDY-5

HOLOGRAPHY LASER

Single longitudinal mode, single shot.

Output energy.....5 Joules
Wavelength..... 526.5 nm
Repetition rate:
pilot mode.....0.5....2 pps
general mode.....1 pulse per 5 min.
Coherence length.....more than 3 m (typical 5 m)
Pulselength (1/e).....more than 25 ns (typical 35 ns)
Beam diameter.....less than 18 mm
Laser head size.....1100x450x250 mm
Laser head weight.....30 kg





INCLUDES:
- 3 Power suppliers
- Water / water heat exchanges
- Cables, internal water pipes
- Accessories

For more information please contact:

Svetlana Karaganova
A.H.Studios P/L
P.O.Box 160
Kangarilla S.A. 5157
Australia
Tel: 08 383 7255
Fax : 08 383 7244
e-mail: austholo@camtech.net.au

or Mikhail Grichine
Geola UAB
P.O.Box 343
Vilnius 2006
Lithuania
Fax/Tel: +370 2 232 838
Tel: + 370 2 232 737
e-mail: Mike@lmc.elnet.lt

Specialists in standard and custom lasers for Holographic applications

INDEX TO ADVERTISERS

CORPORATE MEMBER ADDRESS LIST

Australian Holographics Studios Pty Ltd
PO Box 160
Kangarilla
SA 5157
Tel: (08) 383 7255
Fax: (08) 383 7244
austholo@camtech.net.au

AVIMO Electro-Optics Pty Ltd
14 Fifth Lok Yang Road
Singapore, 2262
Tel: +65 265 5122
Fax: +65 265 1479

British Aerospace Australia
PO Box 180
Salisbury SA 5108
Head Office:
14 Park Way
Technology Park
The Levels, SA 5095

Coherent Scientific Pty Ltd
116 Burbridge Road
HILTON, SA, 5033
Tel: (08) 8352 1111
Fax: (08) 8352 2020
cohsci@cohsci.com.au

Electro Optic Systems
55A Monaro St
Queenbeyan, NSW, 2620
Tel: (06) 299 2470
Fax: (06) 299 2477

Electro Optics Pty Ltd
PO Box 67
Kenthurst, NSW, 2156
Tel: (02) 9654 1873
Fax: (02) 9654 1539

Francis Lord Optics
33 Higginbotham Rd
Gladesviile, NSW, 2111
Tel: (02) 9807 1444
Fax: (02) 9809 7136

Hadland Photonics Pty Ltd
19A Hampsbire Road
Glen Waverley, VIC, 3150
Tel: (03) 9560 2366
Fax: (03) 9560 8402

Jung Precision Optics
Bld 186
Contractors Area
Salisbury, SA, 5108
Tel: (08) 8287 2422
Fax: (08) 8287 2706

Kidger Optics Limited
9a High Street
Crowborougb, East Sussex
TN6 2QA
UK
Tel: +44 1892 663555
Fax: +44 1892 664483
sales@kidger.demon.co.uk

Laser Electronics (operations) Pty Ltd
PO Box 359
Southport
QLD, 4215
Tel: (075) 96 0177
Fax: (075) 96 3530

Lastek Pty Ltd
GPO Box 2212
Adelaide, SA, 5001
Tel: (08) 8443 8668
Fax: (08) 8443 8427
lastek@saschools.edu.au

OptiScan Pty Ltd
PO Box 1066
Mt. Waverley MDC
VIC 3149
Tel: (613) 9562 7741
Fax: (613) 9562 7742

Photon Engineering
PO Box 10269, Gouger St
Adelaide SA 5000
Tel: (08) 8410 4599
Fax: (08) 8410 4544
photeng@ozemail.com.au

Raymax Applications Pty Ltd
16 Ross Street
Newport Beach, NSW, 2106
Tel: (02) 9979 7646
Fax: (02) 9979 8207

Rofin Australia Pty Ltd
Unit 4 42-44 Garden Boulevard
Dingley, VIC, 3172
Tel: (03) 9558 0344
Fax: (03) 9558 0252

Spectra-Physics Pty Ltd
25 Research Drive
Croyden, VIC, 3136
Tel: (03) 9761 5200
Fax: (03) 9761 5600

Warsash Scientific Pty Ltd
PO Box 1685
Strawberry Hills, NSW, 2012
Tel: (02) 9319 0122
Fax: (02) 9318 2192
warsash@ozemail.com.au

AUSTRALIAN OPTICAL SOCIETY

1998 Subscription Renewal Form

Please check all details before returning completed form by the **1st of January 1998**:

Title _____ Initials _____

First Name(s) _____

Surname _____

Employer/Institute/Company _____

Telephone Number _____

Fax Number _____

Email _____

Affiliations AIP ☐ OSA ☐ SPIE ☐

Main Activities (number up to three in order of importance)

First _____ Second _____ Third _____

1 astronomical optics
2 atmospheric optics
3 communications and fibres
4 electro-optics
5 fabrication and testing
6 information processing
7 lasers
8 optical design
9 optical physics
10 radiometry, photometry & colour
11 spectroscopy
12 thin films
13 vision
14 quantum optics
15 nonlinear optics
16 teaching
17 holography
18 (.....)
19 (.....)
20 (.....)

SUBSCRIPTION RATES (per calendar year)
Corporate : A$ 250 p.a. Associate: A$ 125 p.a. Member: A$30 p.a. Student: A$10 p.a.

***PAYMENT METHOD** (Please tick box)*

Cheque* ☐ Mastercard ☐
Money order ☐ Bankcard ☐
Visa ☐

Send payments to:

A/Prof Barry Sanders
School of MPCE, Macquarie University
Sydney, NSW 2109, AUSTRALIA
Tel: (+61) 02 9850 8935
Fax: (+61) 02 9850 8115
Email: barry.sanders@mq.edu.au
Web: www.physics.mq.edu.au/~barry/

* Cheques payable to "THE AUSTRALIAN OPTICAL SOCIETY"

If paying by credit card please complete ALL boxes in this authorization. Incomplete forms cannot be processed.

EXPIRY DATE ___/___

CARD NUMBER ☐☐☐☐ ☐☐☐☐ ☐☐☐☐ ☐☐☐☐

CARDHOLDER _____ AMOUNT A$ _____

SIGNATURE _____ DATE _____

* Please do not staple cheques onto this form, use a paperclip instead.

UPS PRINTED BY THE UNIVERSITY PRINTING SERVICE