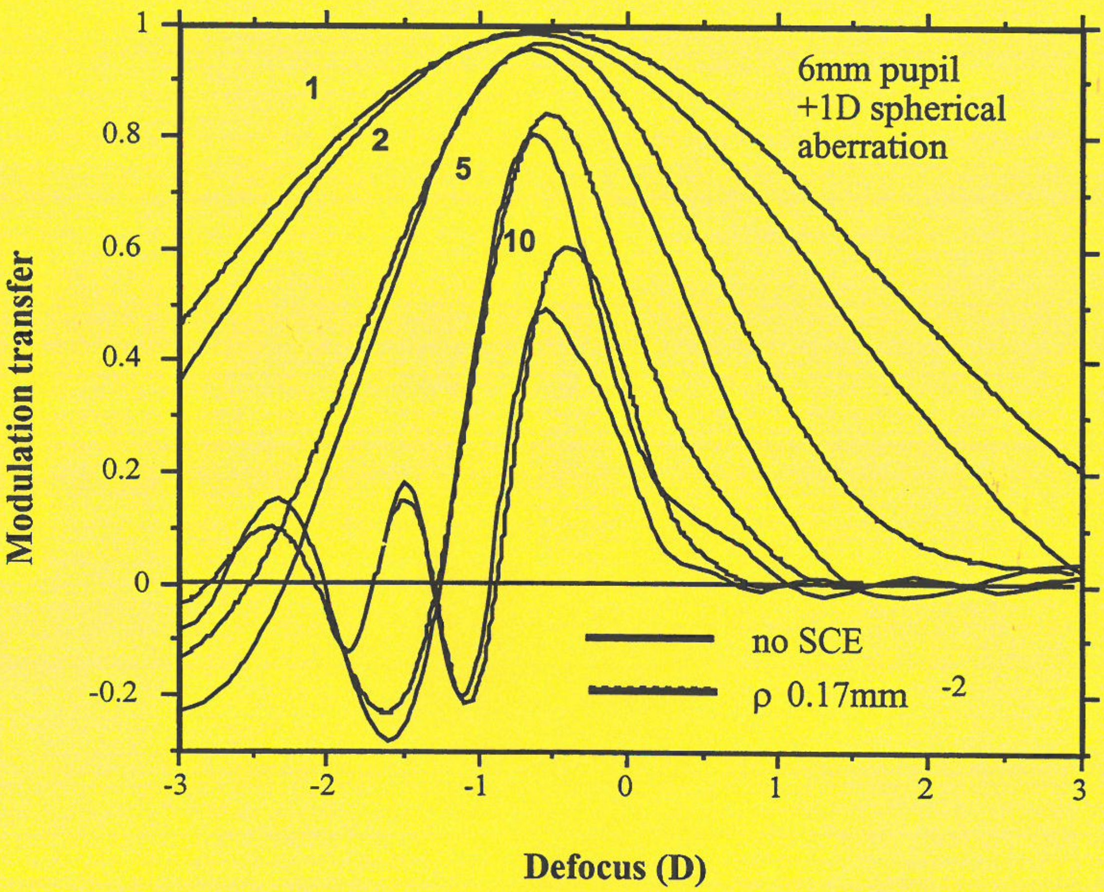
Australian Optical Society

NEWS



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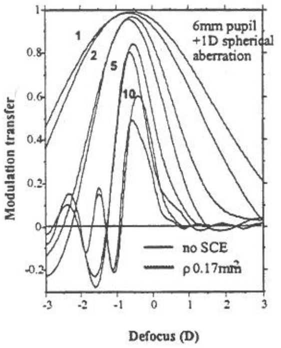

COVER:

An objective wave aberration employing a wavefront sensor technique from an investigation into the Stiles-Crawford effect for a 6mm diameter pupil illuminated with 550nm light. Other results and a planned experimental investigation into the phenomenon are also presented.. (See the article on page 9).

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EDITOR
Shaun Griffin
Baldwin Shelston Waters
60 Margaret Street
Sydney NSW 2000
Tel: (02) 9777 1111
Fax: (02) 9241 4666
ShaunGriffin@bswip.com.au

DEADLINE FOR NEXT ISSUE:
1st March, 2000

ARTICLES

Stiles and Crawford constructed an apparatus for determining the pupil size of an eye. Some of the results of their research established that light passing into the eye through the centre of the pupil appeared brighter than light passing through the peripheral portion of the pupil. Planned experimental investigations into the influence of this phenomenon are presented.
- David A Atchison

DEPARTMENTS

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President's Report

It was not long ago that many of us met at the latest AOS conference in Sydney and already the organization of the next AOS conference is in full flight. Our next conference is to be held in conjunction with the AIP Congress in Adelaide in December 2000. Murray Hamilton is chairing the program committee for the AOS conference and I am sure that very soon we will hear about an exciting scientific program for the meeting.

On 24 November some of us participated in "Science Meets Parliament Day" organized by FASTS We were represented by Barry Sanders, Keith Nugent and myself. This event was modeled on the 3rd Annual Science and Technology Congressional Visits Day in the US where 200 scientists and engineers from 37 states made a large number of visits to House and Senate offices to discuss the long-term importance of Science and Technology in the US. This was a very successful event. Our Australian "Science Meets Parliament Day" in Canberra was also a very successful. Participating scientists and technologists came from nearly all 45 Member Societies of FASTS, with over 30 from the Institute of Physics. It involved pairs of scientists and technologists visiting MP's and Senators throughout the day to discuss with them the value of Australia's investment in Research & Development. One highlight of the event was the reception in the Parliament House for 300 scientists and MPs hosted by the

President of the Senate, the Speaker and the Minister. We met key Parliamentarians such as Deputy Prime Minister John Anderson, Education Minister David Kemp, Communication Minister Richard Alston. Two thirds of all MPs and Senators met with scientists on the day. Many of the MPs were fascinated by accounts of research which is being carried out in Australia, so that many of the meetings that were scheduled as a 30 minutes meetings extended to an hour.

The major notion for this meeting was to discuss the need for support for science and technology as it is an investment in the nation's social and economic well being. You can find on the WWW photos from this event. The address is (www.usyd.edu.au/su/fasts/1999/SmPphotos.html).

If Australia is to participate fully in the knowledge-based economy, the science policy needs to be carefully looked over. Our universities and other research institutions have to be supported at levels that permit first-class education and internationally competitive research.

The Science Meets Parliament Day was extremely well organized and I believe that it served its lobbying purpose very well.

20 December 1999

Halina Rubinsztein-Dunlop
President
Australian Optical Society

Joint International Symposium on Optical Memory and Optical Data Storage 1999

Daniel Day

Optoelectronic Imaging Group, School of Communications and Informatics
Victoria University of Technology, PO Box 14428 MCMC 8001 Vic

July of this year marked the start of the Joint International Symposium on Optical Memory and Optical Data Storage (ISOM/ODS 99), a conference which brought together the R&D sections of some of the largest international companies working in optical data storage. As a recipient of the 1998 Australian Optical Society Postgraduate Prize I was given the opportunity to attend and present a paper at the conference. The following is an overview of the conference.

The ISOM/ODS 99 conference was held at the Sheraton Kauai Resort on the Hawaiian island of Kauai. The conference covered the latest advances in optical technology that could be used to increase the storage capacity of current optical data storage devices through to the development of near-field and holographic data storage systems.

The conference was opened with a paper by M. Takeda, from the Giga Byte Laboratories, Sony Corporation. The paper was titled 'Deep UV mastering with a write compensation technique realizing over 20 GB/layer capacity disc'. Takeda reported on the use of a solid-state 266 nm laser to write a CD size disc with a density of 14 Gbit/inch^2. The rest of the topics covered during the first day summarised the research that has been conducted in an attempt to increase the capacity of current DVD technology, ranging from noise reductions to quasi-near-field optical heads.

The second day concentrated on the design and testing of new phase change materials in optical data storage. However the second session of the day considered applications of all this new technology. A talk by P. Wehrenberg from Apple Computer titled 'DVD copy protection issues: consensus and implementation", discussed the use of content scrambling and water marking for copy-right protection of DVD-videos. Another presentation, by M. Yoshioka from Fujitsu described the concept of superdistribution as a solution to Intellectual Property Rights protection and how it could be implemented with optical disk hardware and software.

That afternoon I gave a talk 'High-density erasable three-dimensional optical bit data storage in a photorefractive polymer using two-photon excitation', which gained wide spread acceptance. The talk demonstrated my experimental research to date, which included a rewritable CD size disk with a capacity of 30 Gbytes, to future work in fabricating an optical data storage system with the ability to record 3 Tbytes per CD.

Wednesday saw another session on materials, as well as testing and evaluation of optical systems. The afternoon session on blue lasers was started by I. Ichimura from Giga Byte Laboratories, Sony Corporation, with 'Optical disk recording using a GaN blue laser diode', which won the ISOM/ODS 99 award. Interest among a majority of the conference participants was sparked by Ichimura's paper, which demonstrated the use of a GaN (λ=400 nm) blue laser diode to produce a DVD with a density of 20 Gbytes and a data transfer rate of 25 Mbps.

The last session for Wednesday was a panel discussion on technology fusion of optical recording and magnetic recording. The purpose of this panel meeting was to try and generate some ideas on where a combination of optical and magnetic recording systems could lead in the future.

The final day of the conference covered the topics of current material technology, coding and channels, near-field and superresolution. Based on the material covered at this conference there will have to be some form of direction change to keep increasing the capacity of current optical data storage systems, other than reducing the wavelength of the incident light. These directions are likely to come in the form of solid immersion lenses, near-field, holographic or three-dimensional optical data storage systems.

I would like to thank the Australian Optical Society for awarding me the 1998 Postgraduate Prize, which allowed me to attend this conference. I learnt a great deal about what is the current state of optical technology in this field, as well as meeting some of the people responsible for these advances. The opportunity to attend this conference displayed Australia as a world leader in research into the future development of high-density optical data storage.

Letter to the Editor

Is there an accent on the name Perot?

As a new member of the AOS, let me start by congratulating the Editorial Staff on a fine publication.

In the last issue, my august colleague, W.H. "Beatty" Steel, asks whether there is an accent on the name Perot and concludes that there should not be one. He also mentions the matter of Boulouch as the possible inventor of the Fabry-Perot interferometer.

Like Beatty, I also spent a month in Marseilles albeit three decades later in 1994. Similarly, I looked into some of the history surrounding Fabry and Perot's work. I was there attending the conference on astronomical instrumentation.

Readers might like to consult the final paper in the proceedings "Tridimensional Optical Spectroscopic Techniques in Astronomy", Astronomical Society of the Pacific, series volume 71 (1995). My French colleagues Georgelin and Amram provide a (near) complete bibliography for Fabry and Perot and a history of how they came to develop their interferometer.
They managed to obtain a birth certificate for Alfred Perot from the Musee de Metz and indeed Perot is spelt without an accent. Ministerial decrees also refer to Perot without the accent. But on occasion, Perot did use an accent in publications and this may have been a Gallic affection in deference to his northern colleagues. Therefore I concur with Beatty that, like Abbe, Fabry-Perot has no accent.

The Boulouch quirk is also discussed by Georgelin and Amram. They point out that Raymond Boulouch had the brilliant idea to use Foucault's half-silvered plates to reproduce Fizeau's famous experiment. While this is the physical context of the Fabry-Perot interferometer, he appears not to have appreciated the significance of his discovery, which is at odds with Duffieux's assertion.

It might interest the reader to know, the multi-beam interference phenomenon was observed and understood with radio waves in Heinrich Hertz's laboratory only a year after the invention of the Fabry-Perot interferometer in 1894.

Joss Hawthorn
Anglo-Australian Observatory

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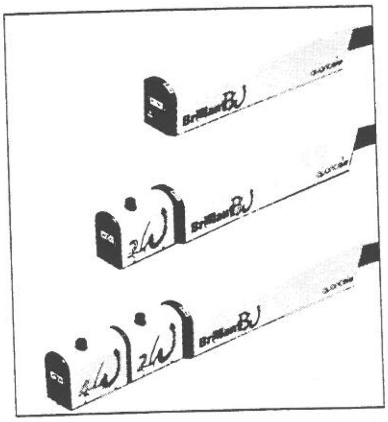

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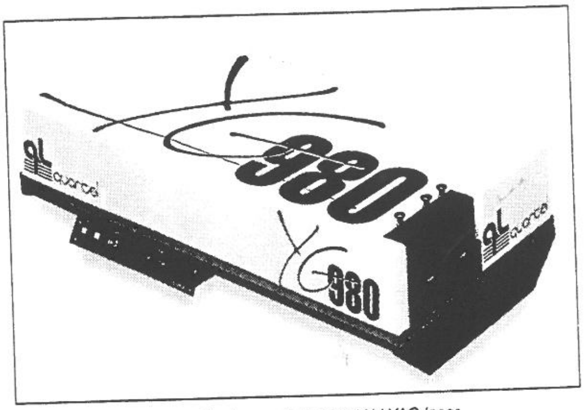

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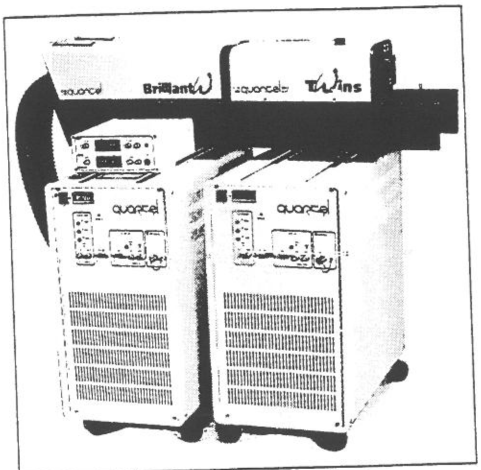

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THE STILES-CRAWFORD EFFECT AND ITS INFLUENCE ON VISUAL PERFORMANCE

David A. Atchison

School of Optometry, Queensland University of Technology, Australia

Introduction

In 1933, Stiles and Crawford built a device for measuring pupil size of the eye [1]. Assuming that each part of the pupil contributes equally to the retinal image, they reasoned that if a uniform light beam fills the pupil, then retinal illuminance would be proportional to the pupil area. They added a second light beam that passed through a small area centred in the pupil and performed brightness matches between a retinal image derived from the entire pupil area and that derived from the small beam. As pupil size increased, significant departures occurred from the expected relationship.

Investigating further, Stiles and Crawford established that light passing into the eye near the centre of the pupil appeared brighter than light passing through peripheral parts of the pupil. This effect has become known as the Stiles-Crawford effect of the first kind. Later they found that there were colour effects (apparent hue and saturation changes) associated with change in pupil entry position [2], and these became known collectively as the Stiles-Crawford effect of the second kind. This paper deals with the Stiles-Crawford effect of the first kind only (SCE).

The SCE is a retinal effect due to the wave guide nature of the rod and cone photoreceptors, although particularly the latter. The cones are responsible for vision at moderate to high lighting levels. There have been many investigations, including Australian contributions [3-6], into how the shape and size of the photoreceptors influence the magnitude of the SCE.

The SCE has been expressed mathematically in different ways, but a Gaussian equation provides a good fit for pupil diameters up to 6 mm:

$$SCE\ (X, Y) = \exp[-\rho\ (X^2 + Y^2)]$$

Allowing for different magnitudes in the X and Y directions, and for decentration of the function, this becomes

$$SCE\ (X, Y) = \exp[-\rho_x(X - X_0)^2 - \rho_y(Y - Y_0)^2]$$

Here (X, Y) are co-ordinates in the entrance pupil of the eye, (X_0, Y_0) are the entrance pupil co-ordinates for the peak of the function, and ρ_x and ρ_y are measures of the distribution of the photoreceptor alignments in the X and Y directions. Millimetre units are typically used for the dimensions. Under moderate to high lighting levels and for foveal (central) vision, mean and 97.5% upper limits of the ρ_x and ρ_y co-efficients are $0.12mm^{-2}$ and $0.17mm^{-2}$ [7]. Using the mean co-efficient gives a variation in the function of about 7 times from the centre to the edge of an 8mm pupil. It must be remembered that in the low luminances which are usually needed for large pupils, the SCE will have small co-efficients and thus be relatively unimportant.

Despite its retinal origins, the SCE is sometimes modelled optically as a filter placed in front of the eye, in which the density of the filter decreases from the centre towards the edge of the filter. This is known as an apodization [8]. For image quality considerations, the SCE can be incorporated into point spread function and optical transfer functions by including it in the pupil function f(x, y) as

$$f(x, y) = \sqrt{[SCE\ (X, Y)]}\ \exp[i2\pi W(X, Y)/\lambda]$$

where W(X, Y) is the wave aberration function and λλ is the wavelength.

The SCE has consequences in photometry, and is often taken into account in visual experiments when comparing vision at different pupil sizes e.g. increasing pupil size from 2mm diameter to 8mm pupil diameter provides an increase in effective retinal illuminance of about 9 times rather than 16 times.

The SCE is also considered to play a role in ameliorating the influence of the peripheral rays passing into the eye which may be severely affected by defocus and aberrations. However, there is little evidence to support this. I am undertaking a theoretical and experimental investigation into this, and this article describes the progress so far. Some of the work has been previously reported [9].

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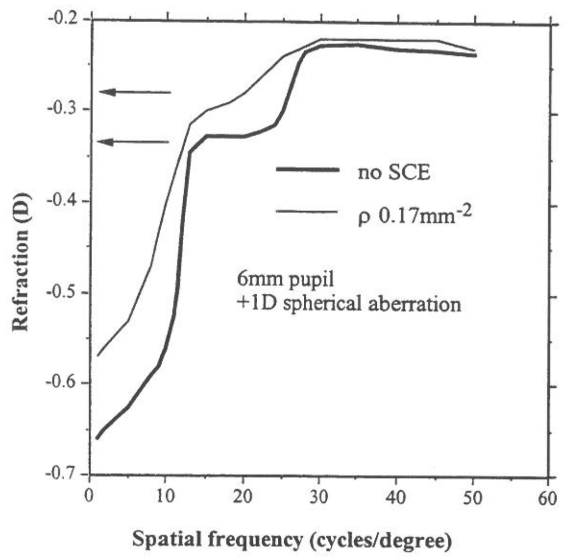

Figure 1 Refraction (defocus) which produces the maximum modulation transfer for various spatial frequencies in the presence of 1D spherical aberration and a 6mm diameter pupil. This is shown for no SCE and for SCE ($\rho = 0.17mm^{-2}$). The arrows indicate refractions at 20 cycles/degree.

Theoretical investigations

These studies were conducted using model eyes with different levels of aberration, pupil sizes and SCE levels. The main image criterion used was modulation transfer, which is the ratio of image to object contrast for an object with a sinusoidally varying luminance profile. Modulation transfer is determined for a range of spatial frequencies to give the modulation transfer function (MTF). For the eye, the MTF needs to be determined for object spatial frequencies of up to about 60 cycles/degree, beyond which the retina cannot resolve detail. Thirty cycles/degree corresponds roughly to 6/6 (or 20/20) vision.

The refraction of the eye done by Optometrists is a balance between aberrations and defocus. Figure 1 shows how the refraction depends on spatial frequency for a large pupil of 6mm with 1D of spherical aberration (a large amount). Refraction is highly sensitive to spatial frequency, but the influence of a large SCE on this is very small, amounting to a maximum effect of 0.16D at 10 cycles/degree. Prescription steps are in 0.25D intervals, so it would be expected that the SCE is unimportant in refraction.

Figure 2 shows MTFs for "in-focus" optics when 1D spherical aberration is present for a 6mm pupil. Defocus has been introduced of the amounts indicated by the arrows in figure 1 in order to obtain the best focus at 20 cycles/degree. An SCE of $\rho_e = 0.17mm^{-2}$ improves the optics by about 0.2-0.3 log units in the range 20 - 50 cycles/degree.

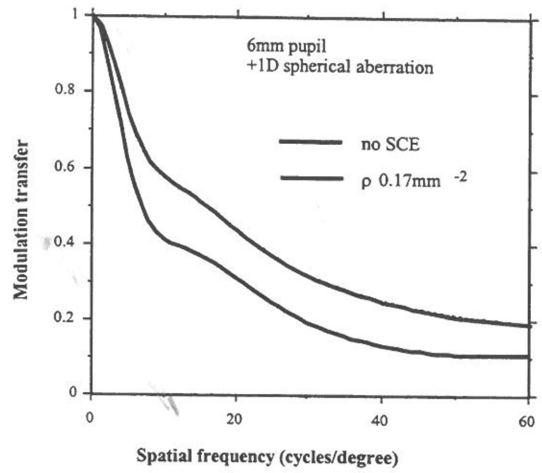

Figure 2 MTFs for in-focus optics in the presence of 1D spherical aberration and a 6mm diameter pupil. This is shown for no SCE and for SCE ($\rho = 0.17mm^{-2}$).

Figure 3 shows the dependence of modulation transfer on defocus for a range of spatial frequencies when there is 1D positive spherical aberration for a 6mm pupil. The results are asymmetric, with the modulation transfer being greater on the negative side than on the positive side. With the addition of the SCE ($\rho_e = 0.17mm^{-2}$), the slopes are shallower. The increase in the defocus corresponding to the first zero crossing is regular for negative defocus, with a steady percentage as the spatial frequency is lowered. There is considerable variability on the positive side with negligible changes for 5 and 10 cycles/deg but considerable changes for 2 c/deg (from 1.5 to 3.8 D) and 1 c/deg (from 3.1 to 5.0 D, but not shown in figure).

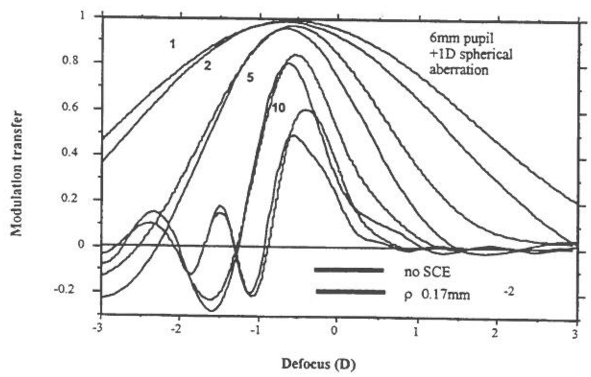

Figure 3 Modulation transfer as a function of defocus for various spatial frequencies in the presence of 1D spherical aberration and a 6mm diameter pupil. This is shown for no SCE and for SCE ($\rho = 0.17mm^{-2}$).

Submission Guidelines

The *AOS News* is always looking for contributions from its members. Here's a short summary of the how to make a submission.

What can you submit?

** Scientific Article*
A scientific paper in any area of optics.

** Review Article*
Simply give a run down of the work conducted at your laboratory, or some aspect of this work. Authors of scientific or review articles will receive proofs by fax.

** Conference Report*
If you have been to conference recently, writing a short report would be greatly appreciated.

** News Item*
Any newsworthy stories in optics from Australia or abroad.

** Book Review*
If you have read an interesting (and relatively new) book in some field of optics please consider a review for the *AOS News*.

** Cartoon or drawing*
If you have some artistic bent why not consider submitting a cartoon!

How can you submit?

💻 The easiest way is by email. Either send the document text in your mail, or attach a word processor file using Eudora or your favorite mail program. We accept nearly all file formats. (Famous last words!).

🗁 If you don't have an email account, or cannot send diagrams or pictures via email, we are happy to accept hard copies. (One copy only is required).

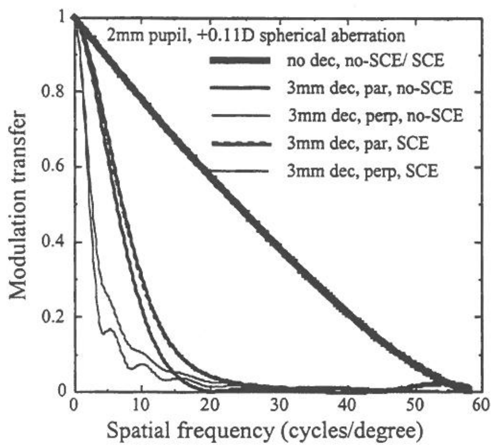

Figure 4 MTFs with a 2mm diameter pupil in the presence of 0mm and 3mm pupil decentration horizontally, both without and with the SCE (ρ = 0 and $0.12mm^{-2}$, respectively). Wavelength 589nm. Target orientations parallel to (par) and perpendicular (perp) to the direction of pupil decentration.

Unlike the case in Figures 1-3, often the pupil of the eye is not well centred in the eye. This affects aberrations and hence image quality. Figures 4 and 5 show comparisons between image quality without and with an average SCE, when there is some spherical aberration before the pupil is decentred. The decentrations shown place the decentred pupil edge 4mm from the centre of the centred pupil.

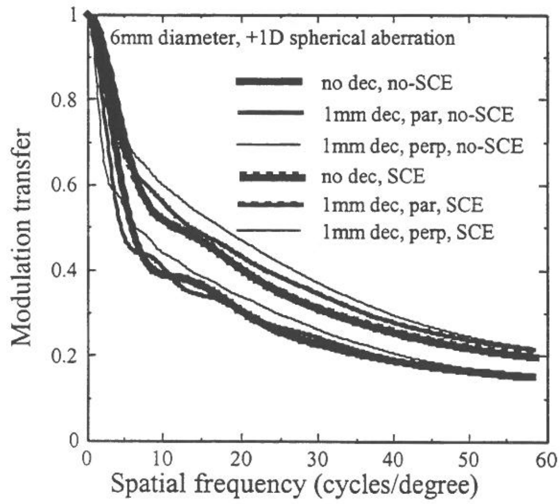

Figure 5 MTFs with a 4mm diameter pupil in the presence of 0mm and 2mm pupil decentration. Other details are as for figure 4.

Fig. 4 shows results for a 2mm pupil diameter for 0 and 3mm decentration. The 3mm decentration has a marked effect on image quality. However, the SCE has negligible influence on image quality for the centred pupil, and even at 3mm decentration its influence is small. Its main effect is some improvement in the MTF for a target orientated in the direction of pupil decentration. Fig. 5 shows results for a 6mm pupil diameter for 0 and 1mm decentration. The SCE's influence is similar for centred and decentred pupils at 0.1-0.15 log unit. Results for a 4mm pupil diameter at 0 and 2mm decentration are intermediate between those shown in these two figures.

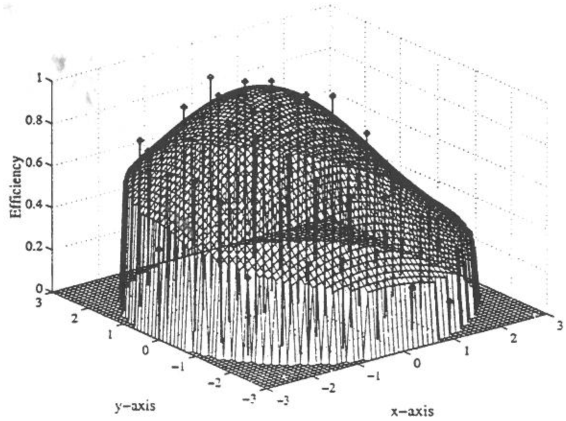

Figure 6 The SCE measured for one subject.

To summarise the theoretical work described here, for defocused optics the Stiles-Crawford effect does not appear to provide much improvement when defocus is of the opposite sign to spherical aberration. When defocus and spherical aberration are of the same sign, particular combinations can provide reasonable effects (Figure 3). In particular the undulations in the MTF, beyond the spatial frequency at which the first zero would otherwise occur, are reduced considerably. Pupil decentration seems to cause a considerable deterioration in image quality, even in the absence of transverse chromatic aberration. The SCE seems to have little role here in ameliorating this effect with magnitudes being no larger than 0.2 log units (Figures 4-5).

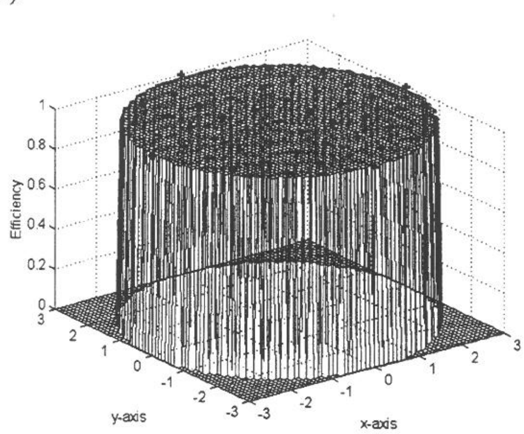

Figure 7 The residual SCE for the subject in figure 5 after correction with a filter.

These theoretical results indicating that the importance of the SCE has been exaggerated in the past. However, there is always the possibility that there are unseen factors or errors in the theory. Accordingly, I am commencing experimental work to find whether the theoretical results can be supported.

Experimental investigations

The SCE is being measured in individual subjects by a psychophysical technique in which the luminance of a small spot seen through a variable point in the pupil just disappears into a larger spot seen through a reference point in the pupil. To test the influence of the SCE, various measures of spatial visual performance will be taken when the eye is both uncorrected with respect to the SCE and when SCE neutralising filters correct it. Figures 6 and 7 show the SCE of one subject before and after the correction by a filter. Spatial visual experiments will include refraction, contrast sensitivity and visual acuity in the presence of different amounts of pupil decentration, and determining subjective transverse aberrations and comparing these with objective aberrations (an example of which is shown in Figure 8).

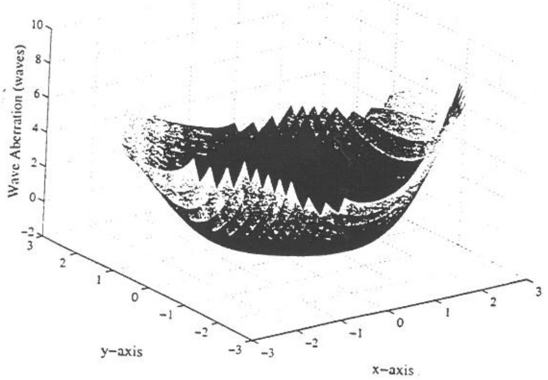

Figure 8 Wave aberrations measured for one subject using a wavefront sensor technique. The pupil diameter is 6mm and aberrations are measured in waves (550nm).

Acknowledgement

I thank Dion Scott and Peter Pejski for their help preparing this article. Figures 1-5 are based on figures in Optical Society of America publications.

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THE 2000 AOS MEDAL

The Australian Optical Society is seeking nominations for the fifth 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
1999:	Professor Dan Walls University of Auckland

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 2000 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 next AOS Conference (which will form part of the AIP congress in Adelaide in December 2000).

The closing date for nominations is 30 March 2000.

Nominations should be sent to the Secretary:

Dr Clyde Mitchell
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Private Bag 33
Clayton South
Victoria 3169

Fax: (03) 9544-1128

E-mail: clyde.mitchell@cmst.csiro.au

The Michael Kidger Memorial Scholarship in Optical Design

The Michael Kidger Memorial Scholarship was established in 1998 to honor Michael Kidger, a well-respected teacher and member of our technical community. The Scholarship will be awarded to a student in the field of optical design.

The first award of the Scholarship will be $4,000.The winner will be announced in July 2000.

The selection criteria for the scholarship are:

The Scholarship is to be awarded to a student of optical design.

The candidate must meet the entry criteria for the chosen course of study or research.

The candidate must submit a summary (five pages maximum) of his or her academic background and interest in pursuing training or research in optical design. Limited supporting material may be attached.

Guidelines for the letters of recommendation:

The two letters of recommendation that a candidate submits to the committee will play an important role in the selection of the winning candidate. It is therefore in each candidate's best interests to obtain letters that most adequately describe their abilities and potential contributions to the field of optical design.

Writers of the letters should:

1. Be recognized and knowledgeable in the field of optical design.
2. Be familiar with the candidate's educational background, personality and current technical abilities, as well as their potential for professional development.
3. Clearly state, in some detail, how the candidate meets the selection criteria for the scholarship (described in the scope, below) and deserves the award of the scholarship.

Submission of letters:

1. The writer of the letter seals it in an envelope and sends it to the candidate.
2. The candidate includes the 2 letters, unopened, with the application form and their own summary, mailed to SPIE.

The technical summary, along with the application form and two letters of recommendation, must be sent by May 1, 2000 to:

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E-mail: education@spie.org

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2000 Michael Kidger Memorial Scholarship Application Form

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Chair/Department Head	
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Undergraduate year:	1	2	3	4	5	
Graduate year:	1	2	3	4	5	6

Degrees pursued:	Subject/Major:
Beginning (year):	Completion (year):

Optics-related courses, projects and activities with dates and grades:

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Proposed research or course of study (course or thesis, and institution)

Based on your demonstrated ability, explain briefly how the awarding of this Scholarship to you will contribute to long term development in the field of optical design (attach summary of five pages or less, as well as supporting materials)

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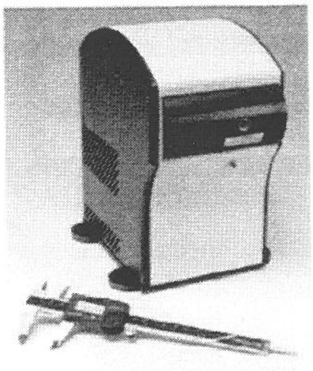

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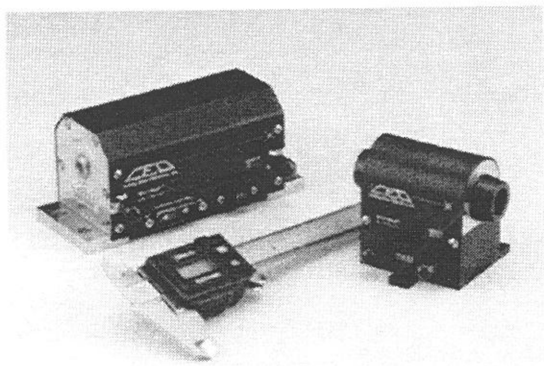

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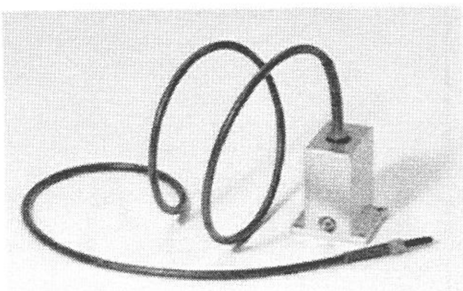

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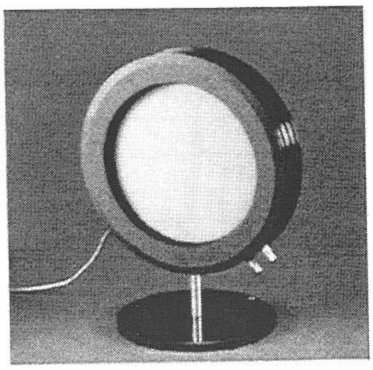

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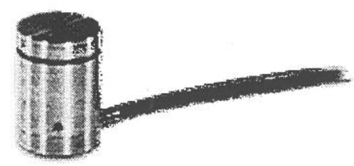

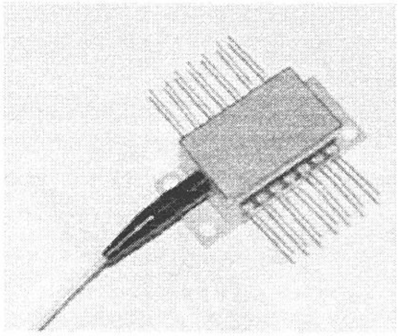

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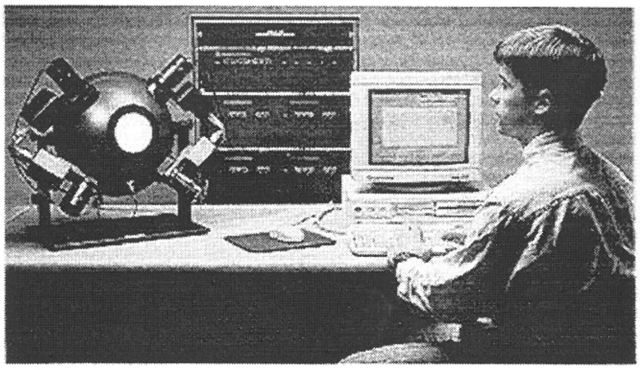

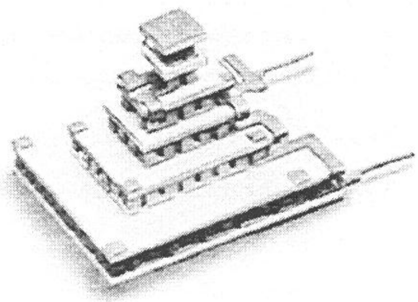

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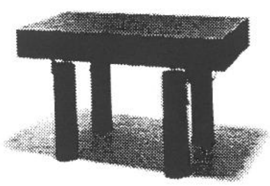

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AUSTRALIAN OPTICAL SOCIETY

AOS 2000 : THE 13TH CONFERENCE OF THE AUSTRALIAN OPTICAL SOCIETY

ADVANCE NOTICE

The Australian Optical Society AOS2000 will be held at the University of Adelaide 11-15 December 2000, as part of the biennial Australian Institute of Physics Congress AIP2000. There will be a plenary lecture, a number of invited lectures as well as contributed talks and poster sessions. Contributions will soon be invited in any area of optics.

VENUE

The conference will be held at the Nth Tce. campus of the University of Adelaide with the trade exhibit and poster sesions in the student union. December is early summer and Adelaide is at its best, surrounded by clean beaches and excellent wine-growing districts. Rundle St. with a large variety of cafes and restaurants is nearby.

PLENARY SPEAKER

Professor Sajeev John of the University of Toronto has accepted an invitation to present the Coherent Scientific Plenary Lecture. (His specialty is photonic bandgaps.)

REGISTRATION & ACCOMMODATION

Registration and accommodation are being handled by the organisers of AIP2000, and intending participants should visit the homepage of the congress where the necessary forms will be found when they are available. A wide variety of hotels and other accommodation is available close to the University. A list of suggestions will be made available on the conference web-page. Information on fees can be found on the AIP2000 page. There will be a single fee for all participants of the congress, entitling them to attend any of the subconferences of AIP2000, including AOS2000.

AOS2000 PROGRAM COMMITTEE

M Hamilton (chair), University of Adelaide
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SUBMISSION OF ABSTRACTS

This is being being handled by the organisers of AIP2000, and intending participants should visit the homepage of the congress where the necessary forms will be found when they are available.

For further information please fill out the preregistration/request form on the
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Mar 5-10	Optical Fiber Communication Conference	OSA	Baltimore, Maryland
Mar 7-12	CLEO Conference on Lasers and Electro-Optics	OSA	San Francisco, CA
Mar 7-12	QELS - Quantum Electronics and Laser Science	OSA	San Francisco, CA
Jul 30-4	SPIE Annual Meeting	SPIE	San Diego, CA
Sep 10-15	CLEO/Europe2000 - Conference on Lasers and Electro-Optics	OSA	Nice, France
Sep 10-15	IQEC - International Quantum Electronics Conference	OSA	Nice, France
Nov 3-8	Photonics East	SPIE	Boston, MA
Date	*Meeting* *2001*	*Contact*	*Location*
Feb 12-14	Photonics West	SPIE	San Jose, CA
Feb 18-23	Optical Fiber Communication Conference	OSA	San Francisco, CA
May 6-11	CLEO - Conference on Lasers and Electro-Optics	OSA	Baltimore, Maryland
May 6-11	QELS - Quantum Electronics and Laser Science Conference	OSA	Baltimore, Maryland

This list of optics related conferences is compiled from several sources and should be used as a guide only. Furter information can be obtained from:

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