Faraday Partnerships

smartmoves

The Newsletter for the Smart Optics Faraday Partnership

ISSUE NUMBER 4 • DECEMBER 2003

Success in BT 3!

The third round of the RCUK Basic Technology calls included a new 'instrument', the feasibility/consortium building award. This 1-year grant was conceived in part to develop ideas to a level where they are suitable for submission as a full bid to a future Basic Technology call.

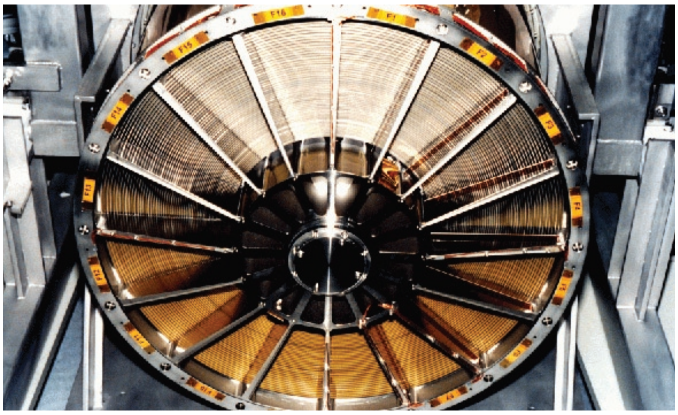


Photo ESA

X-ray mirror shells on-board ESA's XMM-Newton spacecraft

A Smart Optics team led by Peter Doel from the Optical Science Laboratory at UCL has been awarded a grant for their **Smart X-ray Optics** bid. This project will investigate the application of adaptive optics techniques to the challenging domain of X-ray optics, with important applications in lithography, biology, surface physics and astronomy. The consortium includes members from King's College London, the University of Edinburgh and the Gray Cancer Institute. Please contact Peter for more information. **apd@star.ucl.ac.uk**

Farnborough Air Show 2004

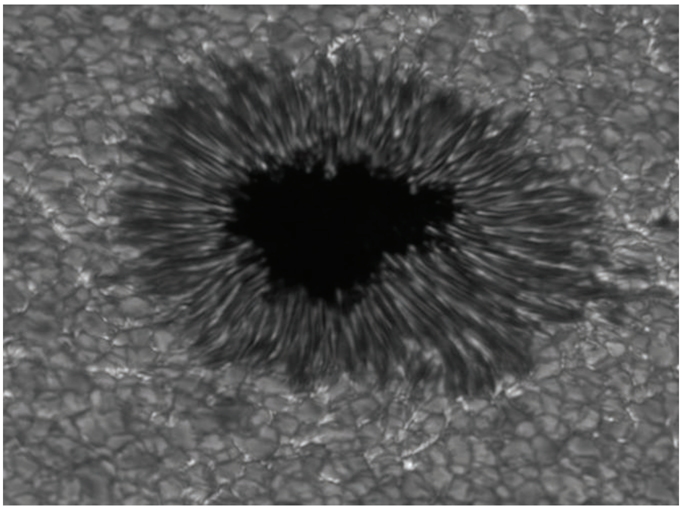
The 2004 Farnborough Air Show will be taking place from 19th–25th July, and will have a a sizeable space pavilion, with a presence by **NASA**, **ESA**, the **BNSC** and of course **Smart Optics** . . . If you have any space-related activites to promote then please contact Steve. **sjw@mssl.ucl.ac.uk**

New Grant Scheme

The DTI have just announced the new 'Grant for Investigating an Innovative Idea'. **www.businesslink.org/r-d** This scheme is designed to help fund consultancy from business mentors and subject specialists for developing new products, processes or services. The grant will cover 75% of the cost of the use of approved mentors, up to a maximum of £12K, with the average expected to be around half that, and with the applicant providing not less than two days of effort to the project per day of consultant time. The Smart Optics technology translators have been accredited as mentors by the DTI, so if you have an innovative idea for this scheme please contact Mark, Jon or Steve.

Advanced Technology Solar Telescope

In late 2003 a consortium of US institutions will be presenting a bid to the USA's National Science Foundation to build a new 'Advanced Technology Solar Telescope (ATST). This $160M project seeks to build a 4m aperture, adaptive optics based observatory to study the Sun in unprecedented detail, in order to answer some fundamental questions about how the Sun works. The main driver for this large aperture is the need to spatially resolve two fundamental length scales in the solar atmosphere: the photon mean-free path and the pressure scale height. To determine these, a resolution of 70 km is required in the Sun's photosphere, translating to a resolution of 0.1 arc-seconds.



An image of a sunspot and the surrounding photosphere taken by the Dutch Open Telescope (DOT) in the G-band at 0.2 arc second resolution.

Another driver for the large aperture is time resolution. The number of photons-per-angstrom-per-second is independent of aperture size at the diffraction limit. Photospheric structures can move with surface speeds of 7 km/s, so for 0.1 arc-second or smaller features, integration times must be very short to avoid spatial smearing—this means that the total number of available photons collected with diffraction-limited spatial resolution actually decreases with increasing aperture—hence to obtain the necessary signal-to-noise ratio at a given spatial resolution, the required aperture is larger than that suggested by diffraction alone.

To allow simultaneous coverage of large enough regions of the Sun will need a field of view of 5 arc-minutes and the diagnostic spectral lines of interest have a wavelength range of 0.3 to 35 µm: clearly this telescope will have a number of technical challenges!

The baseline design employs an aspheric 4m off-axis primary mirror with a

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POPS: A Prototype Pick-off Arm for Future Astronomical Instrumentation

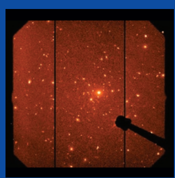
Suzanne Ramsay Howat (skr@roe.ac.uk), UK Astronomy Technology Centre, Blackford Hill, Edinburgh, EH9 3HJ. **David Robertson** (d.j.robertson@durham.ac.uk), Department of Physics, Rochester Building, Science Laboratories, South Road, Durham. DH1 3LE

Amongst the features of existing large, and future very-large telescopes (VLTs) is the resulting large focal plane. For cost and physical reasons it is often impractical to fully populate these focal planes with detectors—especially as the fields that they are viewing are sparse. Various techniques have been used to move detectors around a focal plane, and this article describes a novel technique being developed for cryogenic applications. This project—POPS (Precision Optical Pick-off System)—is funded through the PPARC Industrial Partnership Support Scheme (PIPSS) and is supported by the Smart Optics Faraday Partnership.

Cryogenic carbon fibre pick-off arms are a new technology for astronomy. The UK Astronomy Technology Centre and The University of Durham Astronomical Instrumentation Group are collaborating with EADS Astrium, to develop a prototype pick-off arm that has potential for use in the next generation of astronomical instruments. Applications are envisaged on existing 8m ground-based telescopes and for future space and ground based telescopes.

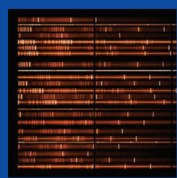
A single instrument might employ many of these robotic pick-off arms, allowing simultaneous spectroscopic analysis of 20 – 30 different objects in the focal plane, greatly increasing the efficient use of detector real estate and making the best use of limited telescope time.

What is "Multi-Object" Spectroscopy?



An image of a field of stars and galaxies is used to set positions for 'slitlets' in a mask

The multi-object slit mask is made, and then inserted at the telescope focal plane



Spectra of the selected sources can then be measured at the detector

The image plane of a large telescope can contain hundreds of objects which astronomers would like to investigate spectroscopically. This is traditionally done using either a pre-fabricated slit mask or a pre-set arrangement of optical fibres, 'picking-off' the appropriate regions of the image. These techniques are either fixed, or have limited scope for adjustment. This sequence of images illustrates the 'traditional' multi-object spectroscopy being used by the Gemini Multi-object spectrograph (GMOS).

The challenge is to engineer an accurate method for moving pick-offs around inside a cryogenically cooled housing.

The goals of the POPS project are:

- to demonstrate the performance of carbon fibre in a cryogenic environment;
- to confirm that exacting tolerances on positioning and alignment can be met and maintained;
- to transfer knowledge of cryogenic mechanism design to EADS Astrium;
- to develop a design that would be suitable for the manufacture of significant numbers of arms.

The POPS Idea

The function of the pick-off arms is to select small areas of the telescope focal plane and to relay these fields to a re-imaged focal plane, expected to be the input of an integral field unit. One application of the work carried out under the POPS technology demonstrator project has been in the conceptual design of a multi-object spectrometer 'KMOS1', proposed for the European Southern Observatory Very Large Telescopes [1]. In the KMOS1 layout, 24 pickoff arms relay small areas of the focal plane to 24 integral field units, which in turn feed 3 spectrometers.

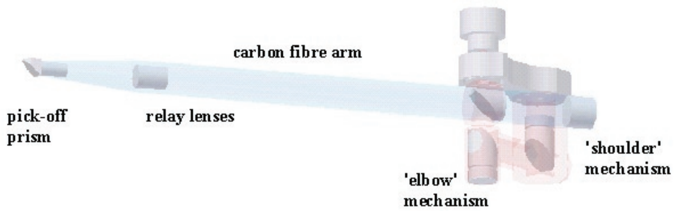


Figure 1: Schematic of optical design

A schematic layout of the POPS arm with some of the optics is shown in Figure 1. The POPS arms are designed to select a 4 arc-second field. A small (<10mm) prism of fused silica is mounted in the tapered end of a carbon fibre reinforced plastic (CFRP) tube. The telescope beam is reflected off the coated rear surface of the prism and along the arm to the 'shoulder mechanism'. The entire arm is approximately 300mm long, similar to the length of a human arm. Several aspects of the design have been borrowed from human anatomy and one of the key features of the POPS design is that the optical path length i.e. the distance light must travel from the 'wrist' through the 'elbow' to the 'shoulder', remains constant for all positions of the pick-off prism. The resulting elimination of changes in image scale as the arm moves greatly simplifies the optical design.

CFRP was chosen for the arm casings owing to the fact that it is both light and strong, minimising any self-deflection, since the arms will normally be subject to a changing gravity vector when in use for astronomy. Tight tolerances on positioning and maintaining the arm position must be met for all attitudes of the instrument. Thus, control of flexure in the arms was a primary driver of the POPS design and flexure testing is one of the key areas of the POPS test programme. Furthermore, CFRP also has some useful thermal properties—the thermal contraction of CFRP is very low and close to that of fused silica, a material already proven to have good performance for cryogenic near-infrared instruments.

How accurate is POPS?

The accuracy of repeated position of the arm has been determined using repeated measurements of the position of a target imaged through the POPS arm. The POPS requirement is that the object must be repositioned to 10% of the field size. This is equivalent to 230µm at the telescope focal plane. With this enhanced repeatability specification in mind, the POPS arm was assessed for three different operations:

- Aligning both of the arm mechanisms to known reference points ("datuming"), and then moving the arm to a target

- Single moves of the arm to a given target position from different points in the field
- Repeated moves between three field positions.

The latter represents the most efficient observing mode—where the arms are moved from one field to another without datuming. A small number of trials of the repeatability have been carried out so far and initial results are positive.

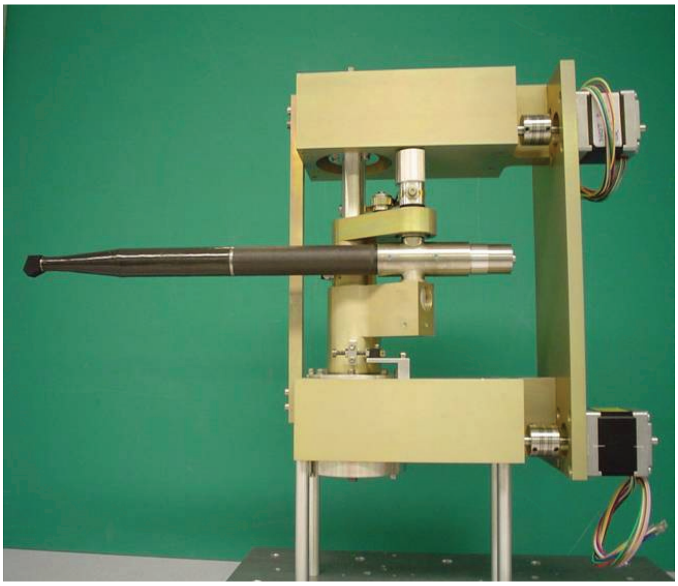


Figure 2: The prototype 'POPS' arm

A prototype cryo-arm was completed in summer 2003 and room temperature testing is underway. Testing at cryogenic temperatures is expected to take place before the end of the year. Phase B of the POPS project is learning the lessons from the Phase A prototype and studying the industrialisation of the design.

Building an instrument with this degree of duplication is well-suited to an industrial process. An important aspect of the industrial partnership enabled by the PIPSS grant is to apply techniques of mass manufacture to the cryo-arm design. In so doing, the risk and cost in developing the future instruments both for the instrument designer and the arm manufacturer will be reduced.

References

[1] http://www.mpe.mpg.de/opinas/KMOS1/

Faraday Associates

Postgraduate students working with industry on a project related to one of the Faraday Partnerships are automatically registered as "Faraday Associates". In addition to their existing studies, Faraday Associates undergo a programme of transferable skills training appropriate to the industrial context, including areas such as project management, technology transfer and negotiation skills. The Smart Optics, PinPoint, Intersect and Imaging Faraday partnerships are contributing to a Faraday Associates Management Committee, chaired by **Professor Alan Smith**. The first workshop for the associates will be taking place in December 2003. **as@mssl.ucl.ac.uk**

Smart Optics Student Profile—Diana Taulbut

I am married and live in Leamington Spa, Warwickshire and am now in the third year of my PhD at Warwick University.

I graduated from Warwick in 1987 with a degree in Engineering Science. After two years' graduate training at Automotive Products in Leamington Spa, I took up a post in the Advanced Engineering Department. There I worked on the development of automatic clutch and gearshift systems from the early analogue prototypes to the production versions—firstly at Borg and Beck, then in what eventually became a small spin-out company. This involved working with major clients such as Ford, Renault, Iveco, Toyota, Honda, Daewoo and Hyundai, building and testing prototype vehicles, developing control algorithms, spending time in South Korea, etc.

Diana Taulbut

The lack of learning or career development opportunities and the highly specialised nature of my work made me realise after a number of years that I needed to go back to University while my brain still functioned! It was very scary to leave the security of a monthly salary after so long—but I have absolutely no regrets, it's been wonderful. I have found the University very supportive. The Faraday Smart Optics project has been ideal for me in many ways. It is a real pleasure to work with people who are experts in their field, and very satisfying to be able to make contributions myself. I am very grateful for the opportunity to learn so much about new technology, about optics and ophthalmology, and to realise the value of my own professional engineering experience. I have gained insight into the cultural differences between academic research and industrial research and its management, and between the medical and automotive worlds. **Diana Taulbut esrwl@atcmail.wmg.warwick.ac.uk**

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secondary made from silicon carbide. Manufacture of these mirrors is seen as high risk, as is the thermal design strategy. Like the OWL and Euro50 telescopes, the aperture of the ATST will be pointless without adaptive optics, and initially it is expected to use a scaled up version of the system employed on the Dunn Solar Telescope. However, the size of the ATST's focal plane is such that a multi-conjugate AO system will be needed to get the best out of its capability. Four instruments are initially proposed, and it is expected that one instrument will be available for the commissioning of the telescope, with one instrument per year being delivered after that. $18M is being set aside for the development of four key instruments:

- a broad-band imager, preferably including a tuneable filter
- a visible spectro-polarimeter
- a near-IR spectro-polarimeter
- a near IR/ visible tuneable filter

The ATST team are hoping for a significant input to the project from Europe, and Steve recently attended a European consortium kick-off meeting with the UK country representative for the project, **Dr Sarah Matthews** from the Department of Space & Climate Physics, UCL **sam@mssl.ucl.ac.uk**. The choice of site for the telescope—currently between Haleakala (Hawaii), Big Bear (California) and La Palma—will affect how much European infrastructure money will be available, but there is definitely interest in our skills for telescope control; MCAO and instrument design. Further details from Steve. **sjw@mssl.ucl.ac.uk**

Technology Translation

The Smart Optics Faraday Partnership has a number of 'technology translators'—business literate scientists/engineers whose tasks include supporting projects from before inception (uncovering needs) to after completion (exploitation). They do this by spending time finding out who's got what and who needs what, and then finding ways of matching the two together. Most Smart Optics supported projects comprise teams matching up a science or technology to a commercial/industrial requirement, and can include help from Smart Optics in identifying suitable funding support, be it from research council, private sector or DTI. If you have a technology of interest to the Smart Optics sector, or an industrial or commercial need that you think might be solved by Smart Optics or a supporting technology, or already have a project in mind that the Partnership might be able to help with, then please contact one of these technology translators in the first instance:

Jon Holmes—based at Sira Electro-Optics, Kent
Email: jon.holmes@siraeo.co.uk, Telephone: 020 8468 1770

Steve Welch—based at the Mullard Space Science Laboratory, London & Surrey
Email: sjw@mssl.ucl.ac.uk, Telephone: 01483 204195

Mark Bonnar—based at the UK Astronomy Technology Centre, Edinburgh
Email: mpb@roe.ac.uk, Telephone: 0131 668 8434

Current Projects

If you have an interest in any of these currently active projects, then please contact the supporting technology translator in the first instance:

Jon: ***Ophthalmoscope***—a hand held device for ophthalmology; ***Smart Marking***—use of high power lasers and SLM generated kinoforms to perform single-flash marking; ***ALFONSO***—devices for free-space optical communications.

Steve: ***Toolkit for AO***—building a set of low-cost universal AO building blocks; ***CF Mirrors***—exploring a new method for making static and deformable mirrors out of carbon-fibre; ***Adaptable Imaging Camera***—building compound lens systems using modally addressed liquid crystal devices.

Mark: ***POPS***—developing cryogenic optical pick-off arms and supporting robotics; ***Optical Metrology and Manipulation***—using wavefront sensors as a tool for extreme metrology; ***Large Optics Manufacturing Study***—preparing the UK to compete for the production of large optics; ***EZ-headset***—exploiting new displays in helmet mounted systems.

Other Open Project Threads

If you have an interest in any of the following then we would be pleased to hear from you: use of LEDs in signage or low level lighting; endoscopy or other biomedical applications; applications for a low-cost adaptive optics 'toolkit'; surveillance; industrial requirements for ultrafast (MHz) spatial light modulators. Please contact Steve in the first instance.

Diary

Details of these events are available on our website:

15th - 16th December 2003 - Nanomaterials and Nanomanufacturing, international conference, London

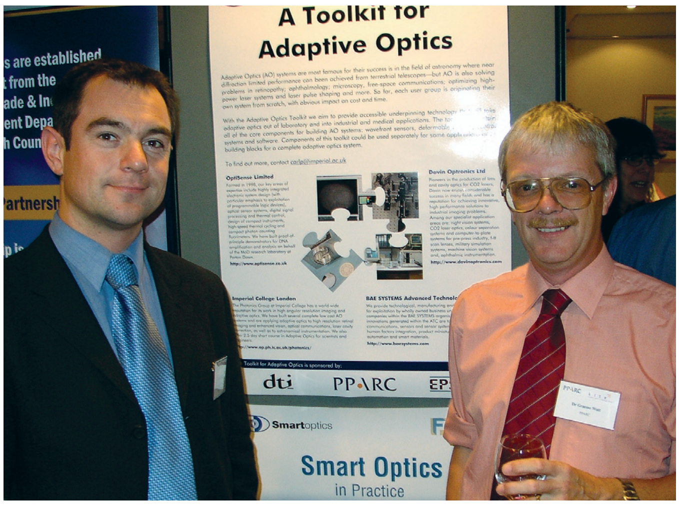
15th - 19th December 2003 - First Annual Faraday Associates workshop, UCL

8th January 2004 - Smart Bio-medical Optics Forum, Robinson College, Cambridge. Contact: Catherine.Butler@siraeo.co.uk

15th January 2004 - Deadline for Outline Applications for the LINK NHTD scheme

21st - 25th June 2004 - SPIE Astronomical Telescopes & Instrumentation 2004

19th - 25th July 2004 - Farnborough Air Show



Mark Bonnar (left) and PPARC's Graeme Watt at the PPARC Industry and Science in Space forum, September 2003

New Smart Optics Faraday Partners

Arden Photonics Ltd, wave-front sensors; **The Crystal Consortium Ltd**, smart material development; **Curran Fibres**, advanced fibres; **Gibson Index Ltd**, information provider; **Jenstar Integration Ltd**, light sensors; **MBDA (UK) Ltd**, missile systems.

The Smart Optics Faraday Partnership is Sponsored by:

dti PPARC EPSRC