Photo: M. Pedoussaut, ESA

EU Research Commissioner Dr. Janez Potočnik (right) visiting the EIROforum stand in the CER exhibition hall.

seems clear that public awareness and understanding of science is not a "side-issue" *vis-à-vis* scientific progress. Rather, it is increasingly seen as central to the future of science in a democratic society. Thus it is a burning issue across the entire world and one that must be addressed through a large number of initiatives and on an appropriate scale.

Report on the Conference on

Science Perspectives for 3D Spectroscopy

Jeremy Walsh (ST-ECF)
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About four years ago when discussions were taking place to plan the proposal to the European Commission for a Research Training Network (RTN) on 3D spectroscopy, we decided to make an international conference one of the closing highpoints of the network. At that time there were only a few 3D instruments routinely taking data on large telescopes (such as Integral on the WHT and Oasis on the CFHT) and some of us thought that a full-scale international conference on science with 3D spectroscopy might be rather difficult to fill. However, as it transpired, we had problems containing the conference in four and a half days. The RTN, called Euro3D, shared the hosting of the conference with ESO and it was held at ESO Headquarters in Garching from October 10–14, 2005.

At the inception of the Euro3D RTN, in July 2002, it was perceived that Europe had a strong instrument advantage in optical and NIR 3D spectroscopy. By 3D spectroscopy is generally meant the technique of obtaining multiple spectra over a 2D field of view; there are various implementations from scanning slits, to imaging Fabry-Perots, to integral field units (IFU) with fibres, lenslet arrays or slicers. A number of instruments were in the planning stage, not least three planned for the VLT – the IFU mode of VIMOS, the FLAMES/Giraffe Argus mode and SINFONI. However, the expertise in handling of the data was mostly confined to the instrument groups themselves and there was a perceived "difficulty" in reduction and analysis of optical/NIR 3D data. This is partly a result of the large quantities of data delivered by IFU instruments but also a reflection that significant development beyond the tools for longslit spectroscopy is required to analyse the resulting data cubes (2 spatial + 1 spectral dimension). One of the aims of the Euro3D RTN was to narrow the bridge of difficulty by training young researchers in 3D spectroscopy observation and analysis, so that they could spread the word that 3D data need not be intimidating. The RTN also planned software development, science projects, a conference and an IAC winter school.

Figure 1: The Euro3D Research Training Network (*www.aip.de/Euro3D*) initiated and sponsored this conference, together with ESO.

The RTN funding will be completed as planned at the end of this year and has proved a great success. There were ten young post-doc researcher positions spread across ten European institutes all with connections to 3D spectroscopy (AIP (Potsdam), Cambridge, Durham, IAC (Teneriffe), IAP (Paris), Leiden, Lyon, Marseille, Milan, MPE (Garching)); there was also a team from ESO but without a post-doc. Despite worries that it would

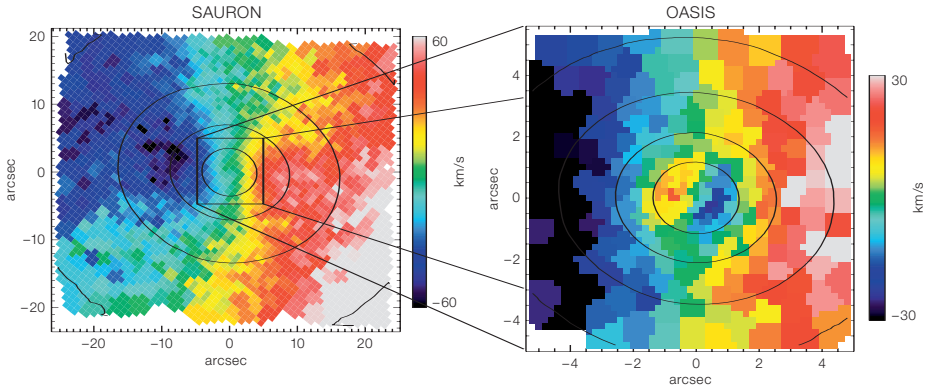


Figure 2: Kinematically Decoupled Cores (KDCs) are best viewed with IFUs. Some, however, require adaptive optics systems for their resolution as shown here in kinematic maps from OASIS, as compared with SAURON (taken from Richard McDermid's presentation).

Figure 3: Gravitational lenses recently became targets of IFU observations. Atmospheric dispersion, which shifts the position of the targets as a function of wavelength, can be used to advantage to provide spatial "super-sampling" of the IFU images (PMAS data, taken from Lutz Wisotzki's presentation, see also Wisotzki et al. 2003).

be difficult to find enough keen post-docs with interest and/or experience in 3D astronomy, all the positions were occupied and two early departures were also filled. Most of the young researchers have moved (or are about to move) on to further positions in astronomy. Six of the Euro3D post-docs presented their work at the meeting, so the aim of showcasing their work as a culmination to the RTN was satisfied.

The conference was aimed at 3D science, as there had been a previous technical workshop at Durham University in July (Integral Field Spectroscopy – Techniques and Data Reduction), which was incidentally also partly sponsored by Euro3D. At the Garching conference there were a total of 92 participants; with eight invited talks, 41 contributed talks and 30 posters (previewed by two poster oral sessions); it was a full schedule. However, there was time for a visit to the Aying brewery late one afternoon, where much beer was tasted, followed by the conference dinner, Bavarian style.

The first afternoon was devoted to an overview of current and future instrumentation to set the scene for the following science presentations. Guy Monnet (ESO) brought his many years of involvement in 3D spectroscopy to the fore in the opening review on the past and up to the present. This was followed by a review by Jeremy Allington-Smith (Durham) on current instrumentation. Then there were a number of talks on instrument projects in various states of planning and funding. Martin Roth (AIP, Potsdam) described the MUSE project with its 1′ square field and 24 spectrographs, funded for the VLT. This instrument was out-multiplexed by HETDEX, the Hobby-Eberly Telescope Dark Energy EXperiment, with its proposed 145 identically replicated IFU spectrographs described by Karl Gebhardt (University of Texas). While the science case for MUSE is centred on deep searches for high-*z* galaxies, HETDEX, with some initial funding for a prototype, aims to measure redshifts of one million galaxies to constrain the equation of state of dark energy. SINFONI, the most recent 3D instrument to go into regular operations, had an exciting entry with Frank Eisenhauer's overview of the large palette of impressive first scientific results.

The science covered at the conference was intendend to be wide and in fact covered Solar System objects, extra-solar planets, Galactic stars and nebulae, the structure of nearby galaxies, and distant galaxies out to the highest known redshifts. Santiago Arribas (IAC) described IFU observations of the planetary transit of HD 209458b which came close to the spectrophotometric accuracy of HST observations and Jean-Pierre Maillard (IAP) described applications of imaging Fourier transform spectrometry, a technique which has been eclipsed in popularity by IFU's in recent years. Most of the second day of the conference was devoted to the most mature field in which 3D spectroscopy has been applied – that of the morphology, kinematics and study of stellar populations in nearby galaxies. The Sauron survey (conducted with a dedicated instrument on the WHT) featured very prominently and Eric Emsellem (Lyon) reviewed the field and extensively used an acronym new to at least some of us: KDCs – Kinematically Decoupled Cores. It was clear that such features could not be guessed at from the surface brightness distribution and could be lost if a slit was placed along the major or minor axis of a galaxy only. The Sauron survey which has taken as a sample 72 galaxies with a representative range of properties (Hubble type, luminosity, location) is able to give statistical trends in 2D galaxy kinematic and chemical properties.

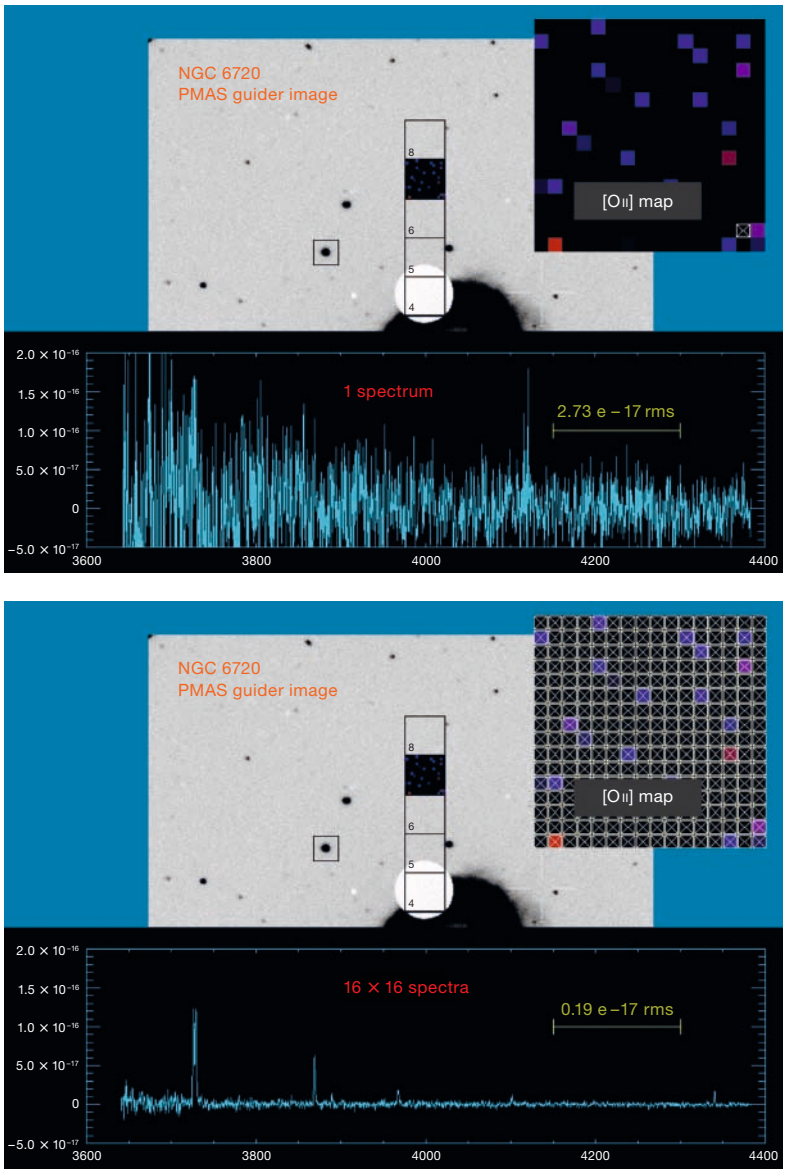
IFU observations are not only useful for well-resolved nearby galaxies, but, as described by Lutz Wisotzki (AIP, Potsdam), they are also well suited to smaller more irregular objects such as gravitational lenses. Both the lenses and the lensing galaxy can be imaged at once and spectral variations among the lenses, which can be caused by microlensing, can be simultaneously determined. In particular the strong lensing by galaxy clusters creates curved sources which are not well matched to long-slit spectra. IFU observations in galaxy clusters are uniquely powerful both for studying the cluster galaxies and the lenses. If the lensing model of the cluster is well determined, then the elongated lenses can be de-distorted to derive the true velocity field

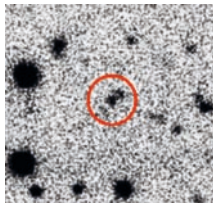
Figure 4: The faint halos of planetary nebulae profit from the power of IFUs to integrate over a large aperture (without degrading the spectral resolution). The spectrum of a single spaxel (spatial element – top) is compared to the spectrum obtained with the same area 16 × 16 spaxel binned (bottom) (taken from Martin Roth's presentation).

for background galaxies. A number of talks emphasised this approach (Mark Swinbank, Durham, and Marie Lemoine-Busserolle, Cambridge/Oxford); initial results in the cluster RCS0224-002 were reported by Swinbank et al. in the last issue of The Messenger (121, 33).

IFUs do not always have to have a large field: if they are targeted at a number of small objects within one field then multiple IFUs are a more efficient use of precious detector pixels. This mode is already available in FLAMES and observations of the velocity fields of z ~ 0.5 galaxies was described by François Hammer (Observatoire de Paris). The ability to build up samples of galaxies with resolved velocity fields at substantial redshift allows the evolution of the Tully-Fisher relation (rather the lack of evolution over the last ~ 4 Gyr) as also illustrated by near-IR IFU observations with CIRPASS by Andrew Bunker (Exeter). Future multiple IFU instruments for the VLT, such as KMOS, will explore this area in the infrared.

The nuclei of galaxies with a rich array of kinematic processes and strong gradients in surface spectra present ideal targets for IFUs. Reinhard Genzel (MPE) updated the participants on the continuing saga of the Milky Way Galactic Centre, where integral-field observations have played a fundamental role in discovery, of course in the IR on account of the high extinction. As well as providing the kinematics and stellar classifications of the luminous young stars orbiting the central black hole, IFU observations, most lately taken with SINFONI on the VLT, have





VVDS 02029855
z = 3.29

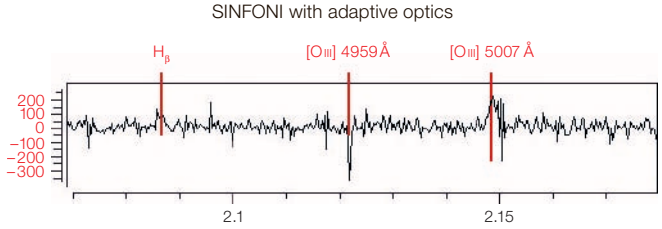


Figure 5: SINFONI study of the galaxy VVDS 02029855 at a redshift z = 3.29. The CFHT I-band image shows the faint object, for which SINFONI (assisted by adaptive optics in this case) obtained a spectrum. A velocity field was obtained from the detected [O III] 5007 Å line (taken from Marie Lemoine-Busserolle's presentation).

enabled the spectra of the central object Sag A* to be followed as it undergoes outbursts on a time scale of hours. It was salutory to see spectra of tens of stars in an area the size of a ground-based seeing disc! The "weather" around the nearby Seyfert nucleus of NGC 1068 was described by Gerald Cecil (University of North Carolina) with some fine animations. This environment has been systematically studied by IFUs and probes how shocks play an important role proximate to the active nucleus.

Emission-line nebulae were often considered the staple targets for 3D instruments providing well-resolved, kinematically complex targets. A number of talks described imaging spectroscopy studies of planetary nebulae (Martin Roth, AIP, using the PMAS instrument; Katrina Exter, IAC, using Integral) and H II regions such as the proplyds in Orion (Henri Plana, LATO, Brasil, using the Gemini GMOS IFU) and Herbig Haro objects (Rosário Lopez, Universidad de Barcelona). The ability to post-bin the IFU data enables the detection of very low surface brightness features, such as the faint emission-line haloes around planetary nebulae. Several talks described work done with the MPFS on the Russian 6-m telescope which has been collecting data for almost 15 years. Sergei Fabrika (Special Astrophysical Observatory, Russia) and Pavel Abolmasov (Moscow State University) discussed IFU observations of the shock nebulae associated with Ultra-luminous X-ray binaries (high luminosity cousins of SS433); here He II emission is an important diagnostic. The SNR around SN1987A is now large enough for AO corrected imaging spectroscopy and Karina Kjær (ESO) described VLT SINFONI observations.

Far from being restricted to large extended objects, IFUs are beginning to make an impact in high-redshift observations to which the entire last day was dedicated. The often complex, knotty appearance of high-redshift galaxies, which are probably interacting or merging, can be sampled in an unbiased way with an IFU. This can be important since the obvious nucleus may not be apparent and rotation curves can be derived for apparently rather chaotic objects and emission-line haloes, as shown for example by Montse Villar-Martin (Andalucia) and Richard Wilman (Durham). Deep surveys of blank sky, or regions around QSOs for indications of local overdensity of galaxies, are being conducted with Sauron and the VIMOS IFU, as shown in several talks (see Jarvis et al. in the last issue of The Messenger (121, 38)). Serendipitous discovery of emission-line objects which can be missed by photometric surveys was highlighted, although the number of such objects is small.

The conference summary was presented by Andreas Quirrenbach (Leiden). He said that October 14 was a historic day: it was the last day of the last conference devoted to the subject of 3D spectroscopy. The technique has come of age and can now enter the repertoire of standard observational tools employed by an astronomer. (Imagine a conference on long-slit spectroscopy!). The very wide range of topics covered at the conference to which imaging spectroscopy had been applied was indeed striking. There seemed to be little area of the parameter space of spatial coverage, spatial scale, spectral coverage and spectral resolution which had not been described at the meeting. The discussion following the summary concentrated on instrumental issues and possible developments, such as the ideal detector able to determine the position, wavelength and polarisation state of each incoming photon, currently imperfectly realised but the ultimate goal of 3D spectroscopy.

Report on the

Science Day in Honour of Alvio Renzini

Catherine Cesarsky, Bruno Leibundgut
(ESO)

The scientific legacy of Alvio Renzini was celebrated with a one-day workshop in Garching on October 19. Alvio retired as the VLT Programme Scientist in June this year and this conference was a way to look back at his many scientific achievements and his influence on ESO and the VLT project.

The programme of the day was only a partial reflection of Alvio's scientific work. There were no presentations of his early work, e.g. on stellar evolution. Instead the topics concentrated on research he is currently interested in and actively working. The programme was as varied as Alvio's work. The diversity was clear right from the start: Pascale Jablonka (Lausanne) described work on the bulge of M31, followed by a status report on white dwarfs in globular clusters given by Sabine Moehler (ESO). Gianpaolo Piotto (Padova) introduced globular cluster oddities and Markus Kissler-Patig (ESO) used globular clusters as template stellar populations. A topic that was hot when Alvio joined ESO were flares at the centre of elliptical galaxies, and Francesco Bertola (Padova) gave an update of this research. Moving into more cosmological topics Adriano Fontana (Rome) talked about the galaxy mass function at high redshifts and Claudia Maraston (Oxford) presented work inspired by Alvio on the importance of AGB stars in the interpretation of