

ESO@50 — The First 50 Years of ESO

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Jeremy Walsh¹
Eric Emsellem¹
Michael West¹

¹ ESO

In recognition of the 50th anniversary of the signing of the ESO Convention, a special science workshop was held at ESO Headquarters in Garching to focus on the main scientific topics where ESO has made important contributions, from Solar System astronomy to fundamental physics, and to provide a perspective for future scientific challenges. The workshop is summarised.

The five-day workshop ambitiously covered a vast range of topics in optical, infrared and millimetre/submillimetre astronomy on which ESO telescopes have concentrated over the last 50 years. Topics ranged from the planets and moons of the Solar System, extrasolar planets, stellar evolution, star clusters, the Galactic Centre, Galactic structure to nearby galaxies, dwarf and giant, to quasars and active galactic nuclei to galaxy surveys and the distant Universe. As well as focussed contributed talks (21) and poster papers (15), there were invited reviews (25) covering a broader range and five plenary talks putting ESO astronomy in the widest context. As befits the celebratory tone, there were many and diverse social activities, from a welcome reception at ESO on the evening of the first afternoon of the workshop, an informal dinner in a Biergarten in Munich, a more formal workshop dinner in a restaurant in Garching, “beer and brezen” in the auditorium on the penultimate evening and a farewell lunch on the Friday following the last session. A photograph of the participants is shown on p. 62.

The contributions are available (in PDF) on the conference website¹. For the first time at ESO the proceedings were webcast and the recordings of each presentation are also available on the website. We present a brief summary of the topics covered in the plenary and invited talks.

Young stars and planets

ESO's next major milestone, the Atacama Large Millimeter/submillimeter Array (ALMA) featured strongly in the first few talks. Some of the first Cycle 0 results in young stars and star-forming regions were presented by Leonardo Testi (ESO) where the high spatial resolution and sensitivity of ALMA will bring many advances. The field of astrochemistry was covered by Ewine van Dishoeck (Leiden), concentrating on very high spectral resolution, including some ALMA spectra from protoplanetary discs, demonstrating the potential for finding new species (up to 50% of lines are unidentified). High-mass star formation in clusters was presented by Guido Garay (Universidad de Chile) who highlighted the contributions of the Swedish ESO Submillimetre Telescope (SEST) and more recently the ATLASGAL survey with the Large Bolometer Camera (LABOCA) on the Atacama Pathfinder Experiment (APEX).

Two invited talks were devoted to the Solar System, one on the planets and moons by Bruno Sicardy (IAP) and one on small bodies by Pierre Vernazza (ESO). Occultations play an important role in determining the structure of Solar System bodies by exploiting fast read-out modes and also adaptive optics imaging with NACO. ESO telescopes have been instrumental in the detection and characterisation of small bodies — comets, asteroids and trans-Neptunian objects (TNOs).

Stephane Udry (Geneva) reported there were 777 extrasolar planet candidates at the time of the meeting, of which 715 had been detected by the radial velocity technique. The large HARPS allocation (100 nights/year over five years) has been crucial, with a variety of programmes targeting stars of different types (early- and late-type, giants and dwarfs, young and older stars). Francois Bouchy (IAP) followed with a talk on transiting planets; many detected with the CoRoT satellite have been followed up with ESO telescopes and instruments.

Transients

Steven Smartt (Belfast) summarised detection and follow-up surveys for bright transients which have recently begun at La Silla Observatory. The La Silla–QUEST survey (see Baltay et al., p. 34) produces transient alerts within days and these are followed up spectroscopically by the Public ESO Survey of Transient Objects (PESSTO) with EFOOSC on the New Technology Telescope (NTT).

The Very Large Telescope (VLT) was very well timed for the beginning of the era of observations of gamma-ray burst afterglows. The seminal object 1998bw, a supernova (SN) associated with a weak gamma-ray burst and extensively observed by ESO telescopes, began the exploration of the now fruitful SN–gamma-ray connection, as reported by Johan Fynbo (Niels Bohr Institute).

The Milky Way

The major role that ESO facilities have played in studies of the Milky Way was covered by Marina Rejkuba (ESO), ranging from large surveys with high resolution spectroscopy dating back to the 1980s to the current imaging surveys with the survey telescopes VISTA (VVV) and the VST (VPHAS+) and the Gaia–ESO spectroscopic survey. Pavel Kroupa (Bonn) covered the evidence for systematic variations of the stellar initial mass function, demonstrating that ESO facilities have made many essential contributions. Giampaolo Piotto (Padova) showed how the old paradigm of a globular cluster as a single population of co-eval stars has been overturned in favour of globular clusters as an assembly of multiple populations showing an Na–O (and Mg–Al) anticorrelation. FLAMES in its Medusa modes (130 simultaneous single-object spectra) has revolutionised the field and enabled chemical abundances in many clusters to be measured. Reinhard Genzel (MPE) described two decades of high precision infrared imaging and astrometry on the Galactic Centre. One of the highlights was the observation of a complete orbit for the star S2 from 1992–2012 as it travels around the central black hole,

encompassing many NTT and VLT astrometric measurements.

Nearby galaxies

Dwarf galaxies of the Milky Way and the Local Group were discussed by Eline Tolstoy (Groningen). GIRAFFE and UVES have provided important data on the chemical evolution timescales for these galaxies and detailed spectroscopy of more distant dwarf galaxies will be achievable with the European Extremely Large Telescope (E-ELT). The Magellanic Clouds have naturally proved a rich pasture for ESO telescopes and they have explored many of the objects that act as astrophysical probes in these, the nearest, and lower metallicity galaxies, as shown by Carme Gallart (IAC).

Francoise Combes (Observatoire de Paris) discussed observational approaches to understanding the triggering and regularisation of star formation in galaxies. Although H_2 is key for star formation it is very difficult to observe directly, so CO is the favoured tracer. ALMA is set to bring CO and other molecular tracers in normal galaxies at high redshift within the realm of study.

Distant galaxies and clusters

The great impact of the VLT on large-scale redshift surveys was summarised by Simon Lilly (ETH Zurich) who noted that of the $\sim 100\,000$ spectroscopic redshifts to $z > 1$ about two thirds are from the VLT. We are currently in a golden age for the exploration of the distant Universe. Linda Tacconi (MPE) showed how ESO is perfectly tuned to answer many of the big questions in cosmic star formation history and ALMA will open up the field of mapping the rotation curves of disc galaxies at $z \sim 1$. Active galactic nuclei (AGN) have been known from around the time of the signing of the ESO convention and, as Carlos de Breuck (ESO) showed, their increased numbers and luminosities at higher z made them ideal targets with which to investigate galaxies. Natascha Förster-Schreiber (MPE) described spatially resolved studies of the kinematics and structure of early galaxies. Integral field

spectroscopy (IFS) with SINFONI at the VLT with adaptive optics has enabled the kinematics and structure at 1–2 kpc scales of the star-forming regions to be studied. Many more targets will become accessible with KMOS, currently being commissioned on the VLT and in the longer term by E-ELT IFS instruments.

Yannick Mellier (IAP) provided an overview of gravitational lensing studies, noting that the first quadruple gravitationally lensed galaxy was detected by the MPG/ESO 2.2-metre telescope in 1988 and the redshift determination of the large arc in the galaxy cluster A370 with the 3.6-metre. From 1990–1997 ESO supported the EROS microlensing survey with the 1.0-metre MarLy telescope at La Silla and from 2002–2012 the PLANET consortium using the Danish 1.54-metre. Marijn Franx (Leiden) treated ESO's role in the study of galaxy evolution at high redshift, highlighting the early influential surveys COMBO-17, a 17-filter imaging programme with the MPG/ESO 2.2-metre telescope and the wide-field imager (WFI), and the K20 survey of extremely red objects with FORS on the VLT.

Cosmology

The talk by Mark Sullivan (Oxford) on supernova cosmology began with an historical overview of the first ESO surveys of SN Type Ia as cosmological distance probes, dating from the late 1980s. More recently VLT observations have contributed to refining the value of the cosmological equation of state parameter, w , whose value seems to be very close to -1 (Einstein's cosmological constant). Absorption lines arising in the diffuse intergalactic medium and dense interstellar medium along the line of sight to quasars were considered by Patrick Petitjean (IAP). The spectrum of the first quasar was obtained in 1962, but it was not until the commissioning of UVES on the VLT in 1998 that extensive surveys of quasar absorption lines took off at ESO. Michael Murphy (Swinburne) considered the astronomical evidence that the fundamental constants (in particular the fine structure constant α) are varying throughout the Universe. Based on high-resolution spectra with UVES (153 absorbers) and HIRES on Keck (142 absorbers)

of quasars using the many-multiplet method, the two datasets show evidence for a dipole in the sky distribution of $\Delta\alpha/\alpha$ at 4.1σ level.

Instrumentation

Guy Monnet (CRAL) presented a historical outline of ESO's contributions and innovations in instrumentation. Sandro D'Odorico (ESO) then went through the development of instrumentation at ESO, following his close involvement from 1981 to his emeritus appointment in 2010. The instrumentation plan for the VLT was defined with the community at an early stage and for the E-ELT the paradigm was significantly extended, with ESO coordinating 11 studies for instruments and adaptive optics modules, of which two concepts were accepted as first-light instruments (a diffraction-limited near-infrared imager and a single-field near-infrared wide-band integral-field spectrograph).

Plenary talks

Alvio Renzini (Padova) presented a personal view on ESO's important influence on astronomy in Europe, noting that approval of the VLT was seen as a turning point from small to big science. Large Guaranteed Time Observing (GTO) allocations to instrument consortia, Large Programmes and most recently Public Surveys, have led to progress on major problems and areas of astrophysics. These large programmes typically produce a larger impact per night, in terms of papers and citations, compared to small programmes.

Massimo Tarenghi (ESO) gave an enthusiastic talk on the history of the ESO observatories from the 3.6-metre to the NTT (for which he was Project Manager) at La Silla, to the VLT (where Massimo was the first Director) and onwards to ALMA (where he also served as Director).

Richard Ellis (Caltech) presented a talk on the global impact of ESO. In its formative years (1962–1986) ESO showed a strong diversity of high performance instrumentation including the infrared, pioneered by the late Alan Moorwood. The NTT era

(1986–1996) was based not only on the success of this innovative new telescope, but also planning of the VLT and expansion of instrumentation at La Silla including the SEST, which initiated ESO’s route into the submillimetre. For the VLT era (1998–present), he compared some of the science cases in 1997 with those achieved with the VLT and demonstrated that new telescopes achieve far more than their original science cases. He closed by looking forward to the Extremely Large Telescope era with the Giant Magellan Telescope (GMT), the Thirty Meter Telescope (TMT) and the E-ELT.

Bruno Leibundgut (ESO) examined the synergies between ground- and space-based observatories. Examples of the relative advantages of ground versus space measurements were made and the example of SN1987A was used to show how a multi-wavelength approach is essential to arrive at a fuller picture of the many features of the evolving supernova remnant. The presence of the Space Telescope European Co-ordinating Facility, which was hosted by ESO from 1984 to 2010, provided many synergistic benefits with Hubble Space Telescope practice and operations, such as operations models and the science archive. In addition, the link with the European Space Agency improved coordination of ground and space missions, such as ground-based support for the Rosetta and Gaia missions.

Roberto Gilmozzi presented a white paper, for discussion, on Paranal in the era of the E-ELT, seeking community input to the two questions:

- Is the VLT operations model suitable for the E-ELT?
- What is the future of the VLT in the next decade 2020–2030?

He sketched the facilities considered to be available circa 2025, the instruments still operating on the VLT and what the extant scientific questions might be. A range of tactical and strategic options were presented. The initial ideas have been presented to the ESO committees — the Scientific Technical Committee (STC) and Council — and internally to ESO astronomers. The aim is to incorporate feedback in a white paper to be subsequently iterated in the next six months, leading to a community-wide workshop



Figure 1. The Director General, Tim de Zeeuw, outlining future perspectives for ESO at the conference.

in 2013 with the aim to finalise the white paper by end of 2013.

Closing remarks

Tim de Zeeuw summarised ESO’s mission and accomplishments during the past half century in developing and operating world-class observing facilities for astronomical research and organising collaborations (see Figure 1). He then provided a perspective for the next 10–15 years:

- keep Paranal as a leading observatory with an integrated system of VLT, VLTI, VST and VISTA;
- maintain and upgrade instruments and replace them with second generation instruments;
- add the E-ELT into this system;
- further develop ALMA;
- continue the fruitful partnership with the community such as, for example, hosting experiments on La Silla, building instruments and providing studentships and fellowships.

The Director General tried to envision astronomy 50 years from now, emphasising that surely new questions will arise and paradigm shifts will occur in the way astronomy is done in the future, but most

likely the exoplanet field will continue to be a high priority one. Technology developments should be harnessed to improve and extend the capability of instruments. This assumes, of course, that society continues to be interested in scientific advancement; outreach has a role to play here. ESO operates within a world astronomical community and a degree of competition in the optical/infrared field is healthy for future progress.

Strategically some moderate further growth by the addition of new ESO Member States was advocated, and will bring added value without leading to over-dominance (ESO currently involves about 30% of the world astronomical community). ESO’s successful operational model should be retained with a mix of multi-purpose telescopes and experiments, in combination with strong national programmes and strong connections between the Observatory and the astronomers in the Member States (through community involvement and a mix of visitor/service observing modes). Around the end of the decade a new telescope project could be perhaps contemplated in close connection with space observatories and other ground-based astronomy developments.

Links

¹ ESO@50 workshop programme: <http://www.eso.org/sci/meetings/2012/ESOat50/program.html>