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Report on the ESO–INAF Workshop

VST in the Era of the Large Sky Surveys

held at INAF–Astronomical Observatory of Capodimonte, Naples, Italy, 5–8 June 2018

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This workshop focussed on science programmes carried out with the INAF–ESO VLT Survey Telescope (VST) several years into its operation. The aim of the conference was to review the latest results and ongoing programmes, and to look ahead to future science cases, as well as potential synergies and collaborations with other projects and facilities.

The VST is an INAF facility operated by ESO under a 10-year agreement. It was developed to enable optical imaging surveys from Paranal. Equipped with a 1 × 1 degree field of view, the VST provides one of the best quality optical wide-field imaging capabilities to date. After seven years of operation, there was a need to discuss the present successes and to start organising the future of the VST. The Science Organising Committee included ESO and INAF representatives, the Principal Investigators (PIs) of the three ESO Public Surveys — ATLAS, the Kilo-Degree Survey (KiDS), and the VST Photometric Hα Survey of the Southern Galactic Plane (VPHAS+) — along with other scientific experts. The Science Organising Committee welcomed talks on ESO Public Surveys, Guaranteed Time Observation (GTO) programmes from both the VST and OmegaCAM consortia, and programmes carried out in Chilean and ESO time. Talks from other facilities were also encouraged in order to explore synergies and new scientific ideas, as well as proposals for technical upgrades. The programme comprised 51 talks, the full details of which can be found via the conference web page[1].

The first part of the conference was dedicated to managerial and operational aspects, and reviewing the landscape of the current ESO Public Surveys. The domain covered by these ongoing surveys encompasses a range of research areas across multiple wavelengths and using different telescopes. The surveys have demonstrated an increasingly high level of scientific productivity and, as with large programmes, have generally had a high impact. The operational aspects underpinning these programmes were also discussed. The efforts of ESO's quality control group were presented, as well as the night and day operations at the telescope; these help to ensure stable operation with negligible technical downtime. There were also talks on the publication of science data products via the ESO Archive, in order to ensure that they can be used for further scientific analysis by the community at large.

ESO VST Public Surveys

The ATLAS survey, which covers 4700 square degrees, was presented and its legacy value discussed, in particular its use in X-ray surveys with the extended ROentgen Survey with an Imaging Telescope Array (eROSITA), and follow-up with the 4-metre Multi-Object Spectrograph Telescope (4MOST). The ATLAS survey focusses on a range of topics including: quasar redshift surveys in the redshift range $0.5 < z < 6.5$; quadruply lensed quasars; investigations of the enigmatic Cosmic Microwave Background (CMB) Cold Spot (a region that appears unusually cold relative to the background radiation levels of the CMB); the discovery of dwarf Milky Way satellite galaxies (including the Crater 2 dwarf galaxy); and new catalogues of thousands of white dwarf stars in the Milky Way. An extension to the ATLAS survey in the *u* band is being conducted in Chilean time and the latest results from these efforts were also presented.

The application of the galactic plane survey VST OmegaCAM Photometric Hα Survey (VPHAS+) in uncovering the fainter ($r > 13$) massive O and early-B type stars of the Milky Way disc was also described. One session was dedicated to contributions from the KiDS survey, which is designed to take the maximum possible advantage of the wide field and the outstanding image quality of VST and OmegaCAM. Its science focusses on weak gravitational lensing by galaxies, groups and large-scale structure. Recent results were presented that demonstrated how cosmological constraints can be derived from KiDS lensing measurements. The high image quality and deep photometry of KiDS are ideal for galaxy evolution studies and for hunting peculiar and rare objects, such as massive compact galaxies and gravitational lenses. Methods and techniques to find Quasi-Stellar Objects (QSO) and arcs were addressed, as were the first spectroscopic follow-ups and specific science cases (for example, the Fornax dwarf spheroidal galaxy). Synergies between KiDS and other projects (both current and future) were also discussed. Many aspects of the approach to data handling for the Astronomical Wide-field Imaging System for Europe (Astro-WISE) will also be applied to data processing from the ESA Euclid mission. The overlap with the Galaxy And Mass Assembly (GAMA) project galaxy spectra allows for the measurements of the central velocity dispersions. Synergies between the strong gravitational lensing studies with Herschel and the VST observations were explored. We also explored the incorporation of VST data into the HELP-IDIA Panchromatic PrOject (HIPPO); HELP is the Herschel Extragalactic Legacy Project and IDIA is the Inter University Institute for Data Intensive Astronomy. This combines multi-wavelength datasets and tools in a cloud infrastructure.

Galactic astronomy

After an introductory talk about how data from multiple instruments can be combined to enable pulsating stars to be used as stellar population tracers, several stellar programmes were presented, ranging from the STRucture and Evolution of the GAlaxy (STREGA), which aims to investigate the formation and evolution of the galactic halo, to the SMC in Time: Evolution of a Prototype interacting late-type dwarf galaxy (STEP); and the study "Yes, Magellanic Clouds Again" (YMCA) — this focusses on the Magellanic system stellar populations. Galactic globular-cluster studies were also discussed, including photometric and astrometric studies of Omega Centauri, and the tidal tails of a selected sample of clusters. Finally, there was a talk on a survey called Accretion

Figure 1. Workshop participants at the Capodimonte Astronomical Observatory; Mount Vesuvius is in the background.

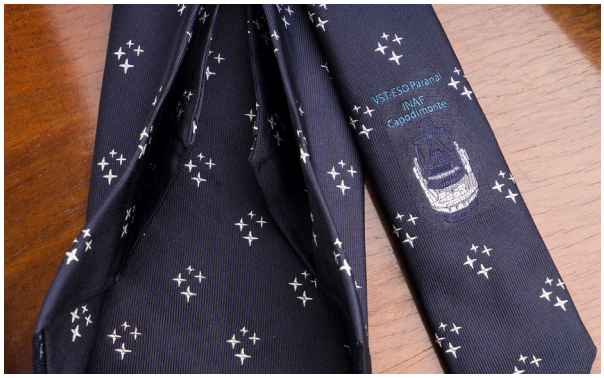

Figure 2. The conference tie: bringing together the ESO look with Italian style.

Discs in Hα with OmegaCAM (ADHOC), which studies the population of pre-main sequence (PMS) objects in close-by star forming regions (also see p. 17).

Extra-galactic astronomy

There were many contributions addressing extragalactic science. The KiDS ATLAS Bridging Survey (KABS) is characterising many objects in fields not targeted by ATLAS or KiDS and will build on the strengths of the two Public Surveys in preparation for follow up with eROSITA and 4MOST. The Shapley Supercluster Survey conducted with VST, the Visible and Infrared Survey Telescope for Astronomy (VISTA) and the Australian Astronomical Observatory spectrograph AAOmega has observed the transformations of galaxies in a stormy environment. The survey called Galaxy Assembly as a function of Mass and Environment (VST-GAME) targets massive galaxy clusters in order to understand how different cluster assembly processes can drive the evolution of galaxies as a function of mass and environment. It is part of a larger effort that also uses VISTA and VLT data.

The Wide-field Imaging Nearby Galaxy clusters Survey with OmegaCAM (WINGS and OmegaWINGS) studies nearby galaxy clusters. In another talk results were presented from the the GAs Stripping Phenomena in galaxies (GASP) programme, which is a follow-up study using the Multi Unit Spectroscopic Explorer (MUSE). A set of coordinated contributions were presented from the VST survey of Early-type GAlaxies in the Southern hemisphere (VEGAS) and the Fornax Deep Survey (FDS) teams in a dedicated session. A survey of early-type galaxies which is using a deep photometric analysis to study stellar halos and faint structures was presented. Globular clusters within the same fields are also being studied, as well as NGC 1533 in the Dorado group and the post-merger evolution of early-type galaxies. The evolution of dwarf galaxies was analysed using FDS data. Other FDS contributions concerned automated searches for low-surface-brightness galaxies and surface photometry of late type galaxies inside the virial radius of the Fornax cluster.

Time-domain astronomy

Several talks focussed on time-domain astronomy. These included the study of the evolution of the supernova rate with cosmic time with the SUpernova Diversity And Rate Evolution (SUDARE) project, which targets the Chandra Deep Field South (CDFS) and the Cosmic Evolution Survey (COSMOS) field in a joint effort, including Italian and Chilean time, and the programme VST Optical Imaging of the CDFS and ES1 fields (VOICE). In addition, the multi-epoch survey of the COSMOS field allowed optical variability to be used as a tool to identify Active Galactic Nuclei (AGN).

Talks and discussions addressed the nascent field of gravitational wave astronomy, and the fundamental role played by the VST in the GRAvitational Wave INAF TeAm (GRAWITA), which searches for electromagnetic counterparts of gravitational wave events in rapid response to LIGO–Virgo alerts. The discovery of the kilonova, the optical counterpart of the GW170817 event, was showcased during this discussion. Time-domain astronomy

and monitoring campaigns targeting variable phenomena are set to increase, thanks to the availability of science products in the ESO archive, the improved capabilities of the recently launched ESO Archive Science Portal[2], and the anticipated capability of the Large Synoptic Survey Telescope (LSST).

Synergies and future ideas

Building on the many synergies discussed by speakers between the VST and both ongoing and future facilities — including ongoing INAF projects in the optical and near-infrared — this conference began the necessary process of looking to the future. The astronomy landscape is continuously changing as new facilities start operating.

What is the VST’s place amongst these future developments? Several major facilities were described, including the ESA Gaia satellite, for which the VST Ground Based Optical Tracking (GBOT) campaign has been essential to improve the astrometric precision, and which has also discovered lots of new asteroids. In addition, there is the Cherenkov Telescope Array (CTA), whose southern site will be close to Paranal and which will require the identification of optical counterparts. The ESA Euclid mission already incorporates lessons learnt with the VST and will require complementary ground-based data; the NASA Wide Field InfraRed Survey Telescope (WFIRST) space observatory may require a future exoplanet ground-based microlensing survey; and the 4MOST project will have wide-field multi-object spectroscopic capabilities.

New ideas were presented for cosmology experiments over the next decade, such as high-cadence monitoring of strongly lensed quasars for time-delay cosmography and a slitless spectroscopic survey to provide accurate redshifts for the synergy between the LSST and the ESA Euclid mission. The latter requires the implementation of a slitless spectroscopy unit working in combination with the existing imaging camera. A proposal to upgrade the system to make the VST the first large survey telescope for optical polarimetry, retaining the camera, was also discussed. Scientific cases include mapping the Milky Way, Magellanic cloud magnetic fields, surveys of quasar polarisation, identification and variability of polarised brown dwarfs, etc.

After this intense four-day workshop, we can state that the VST user community is addressing a wide range of scientific topics. The telescope and camera are in their best shape, regularly delivering seeing-limited images of outstanding image quality across the one-square-degree field of view, with a technical downtime that was recently determined to be smaller than that of ESO’s VLT unit telescopes. The telescope is clearly delivering exciting science at the moment; the future is what we want to build! It is now important to define future science cases that are optimally designed to play a vital role in the astronomical developments of the next decade, with the participation of the INAF and ESO communities.

Proceedings based on the conference contributions are available through Zenodo[3]; they are fully searchable via the SAO/NASA Astrophysics Data System (ADS) and linked from the programme webpage.

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References

Capaccioli, M. & Schipani, P. 2011, The Messenger, 146, 2
Kuijken, K. 2011, The Messenger, 146, 8

Links

[1] Conference website: https://indico.ict.inaf.it/e/VST2018
[2] New data services offered by the ESO Science Archive Portal: http://www.eso.org/sci/publications/announcements/sciann17122.html
[3] Presentations from the conference are available via Zenodo: https://zenodo.org/communities/vst2018

This stunning VST image encompasses three star forming complexes. From left to right these are the Omega Nebula (Messier 17), the iconic Eagle Nebula (Messier 16) and Sharpless 2-54.