Highlights of Spanish Astrophysics VI, Proceedings of the IX Scientific Meeting of the Spanish Astronomical Society held on September 13 - 17, 2010, in Madrid, Spain. M. R. Zapatero Osorio et al. (eds.)

OTELO project: first results

J. Cepa[1,2], A. Bongiovanni[1], A.M. Pérez–García[1], E.J. Alfaro[3], H.O. Castañeda[4], A. Ederoclite[1], J.J. González[5], J.I. González–Serrano[6], M. Sánchez–Portal[7], J. Bland-Hawthorn[8], D. Heath Jones[9], J. Gallego[10], J. Acosta–Pulido[1], C. Esteban[1], and J.M. Rodríguez–Espinosa[1]

[1] Instituto de Astrofísica de Canarias, E–38200 La Laguna, Tenerife, Spain
[2] Departamento de Astrofísica, Universidad de La Laguna, E-38206 La Laguna, Tenerife, Spain
[3] Instituto de Astrofísica de Andalucía (CSIC), Apdo. 3004, E–18080, Granada, Spain
[4] Departamento de Física, Escuela Superior de Física y Matemática, IPN, México D.F., Mexico
[5] Instituto de Astronomía, Universidad Nacional Autónoma de México, Apdo Postal 70-264, Cd. Universitaria, 04510, Mexico
[6] Instituto de Física de Cantabria, CSIC-Universidad de Cantabria, Santander, Spain
[7] Herschel Science Centre, ESAC/INSA, P.O. Box 78, 28691 Villanueva de la Cañada, Madrid
[8] Sydney Institute for Astronomy, School of Physics, University of Sydney, NSW 2006, Australia
[9] Anglo-Australian Observatory, PO Box 296, Epping, NSW 1710, Australia
[10] Departamento de Astrofísica, Universidad Complutense de Madrid, 28040 Madrid, Spain

Abstract

The OTELO project is the extragalactic survey currently under way using the tunable filters of the instrument OSIRIS at the GTC. OTELO is providing the deepest emission line object survey of the universe up to a redshift 7. In this contribution, the first images will be shown together with some preliminary results.

1 Introduction

Extragalactic surveys are extremely useful and necessary tools for studying the cosmic evolution of galaxies. Broad-band multicolour photometry allows observing the faintest targets and deriving redshift estimations together with morphological parameters. Spectroscopic surveys allow obtaining accurated redshifts and more detailed spectral energy distributions for tackling a wide variety of scientific objectives. Narrow band imaging surveys, such as OTELO, are a powerful tool to detect and study the evolution of line emitter objects (see [6] and references therein). They allow, depending on the emission line observed according to the redshift of the source, deriving star formation rates (SFR), metallicities and its cosmic evolution. Since the selection procedure is specifically suited for this kind of objects, selection effects present in other techniques (broad band imaging or spectroscopy) are avoided. For example, multiple object spectroscopy (MOS) surveys, are biassed to bright continuum objects, i.e. could miss faint emission line emitters that could dominate the faint tail of star formation galaxies. Then narrow band surveys provide a complementary view of the universe at high redshift.

Within narrow band surveys, those using tunable filters, as CADIS (Calar Alto Deep Imaging Survey [7]), and the TTFFGS (Taurus Tunable Filter Faint Galaxy Survey [5]) detect one order of magnitude more objects (when normalizing for telescope size and exposure time) than conventional narrow band surveys as the Suprime-Cam of Subaru [4]. For this reason narrow band surveys with tunable filters in large telescopes constitute a deep sky probe with unprecedented sensitivity. Whereas there are other instruments using TFs in operation (the Kyoto 3D spectrograph) or in commissioning (the Prime Focus Imaging Spectrograph of the SALT Telescope[1]), OSIRIS [2] is an unique instrument, thanks to its larger FOV ($8.5' \times 8.5'$), spectral range (365–1000 nm) and telescope size (10.4 m). No other wide field TF in common user instruments for 8–10 m class telescopes is currently available. Then, OSIRIS provides GTC with unique capabilities compared with similar telescopes, and the OSIRIS Tunable Emission Line Object survey (OTELO) will supply a unique database in survey area, sensitivity and target discrimination, as shown in Table 1.

2 OTELO survey

OTELO is aimed at surveying emission line objects using OSIRIS tunable filters in selected atmospheric windows relatively free of sky emission lines. Different high latitude and low extinction sky regions with enough angular separations will be observed yielding a total area of 0.1 square degrees. A minimum detectable flux of 10^{-18} erg/cm^2/s will allow detecting objects of equivalent width (EW) of 3 Å or smaller, making OTELO the deepest emission line survey to date (Table 1). This lowest EW will allow detecting, for the first time in this kind of surveys, even faint spirals and blue compact dwarf galaxies at redshifts up to 1.5. OTELO is a deep space probe that will provide a representative sample of the Universe from $z = 0.4$ through 6.7. Given the observing procedure, OTELO will allow studying clearly defined volumes of Universe at a known flux limit.

To this aim, 108 dark hours of guaranteed observing time at a single pointing at the Extended Groth Strip (EGS) are planned for obtaining images of 36 contiguous wavelengths at a FWHM of 1.2 nm, scanning every 0.6 nm (i.e., half the FWHM) in the 907–928 nm window in the OH sky line forrest. Each wavelength will be observed 6600 seconds distributed in 6 exposures of 1100 seconds dithered 18 arcseconds.

Table 1: OTELO survey main characteristics

Parameter	Value
Limiting flux (3σ)	$1{\times}10^{-18}$ erg/cm^2/s
Minimum EW	3 Å
Area	0.1 sq.deg.
Redshift accuracy	10^{-4}
Cosmic statistics	Several fields
Deblend Hα from [NII]	Yes

3 First OTELO observations and data reduction

So far 18 hours have been observed corresponding to 6 contiguous wavelengths in the spectral range 925–928 nm. The mean seeing during the observations was of 0.8 ± 0.17 arcsec, as measured directly on the scientific images. The best seeing corresponds to 0.64 arcsec. The TF tuning during the observations was found stable at the nominal accuracy of 0.1 nm, as expected.

Data reduction was performed using standard IRAF routines. Bias was first subtracted, and the images were trimmed. Cosmic rays were removed, and flatfielding was achieved by fitting a 2D surface to the data, since sky flats were not available, and dome flats are not suitable due to illumination effects. Then, sky rings were subtracted using the TFRED IRAF package after iteratively masking objects at 3 σ level. A median combination of dithered images provide a fringe map that was subtracted to the data yielding (Fig. 1). For each image, astrometry was performed using stars of $z' < 23.0$ magnitudes of the CFHTLS[1], and the matched images of the same wavelength combined (Fig. 2). Finally the sources were extracted using SEXtractor and the centre to edge variation corrected based on the TF optical centre and the wavelength dependence given by the optical design. Flux calibration was achieved using the standard spectrophotometric star STIS HD126511.

4 Preliminary results

As expected, a minimum detectable flux of 10^{-18} erg/cm^2/s (3 σ) at each wavelength was achieved, with completitud at 3×10^{-18} erg/cm^2/s (3 σ) at each wavelength (Fig. 3). These figures are fully consistent with the OSIRIS ETC calculators provided in the OSIRIS www page. A total number of 1300 to 1500 objects per wavelength are detected in the images. An

[1]CFHTLS is based on observations obtained with MegaPrime/MegaCam, a joint project of CFHT and CEA/DAPNIA, at the Canada-France-Hawaii Telescope (CFHT) which is operated by the National Research Council (NRC) of Canada, the Institut National des Science de l'Univers of the Centre National de la Recherche Scientifique (CNRS) of France, and the University of Hawaii. This work is based in part on data products produced at TERAPIX and the Canadian Astronomy Data Centre as part of the Canada-France-Hawaii Telescope Legacy Survey, a collaborative project of NRC and CNRS.

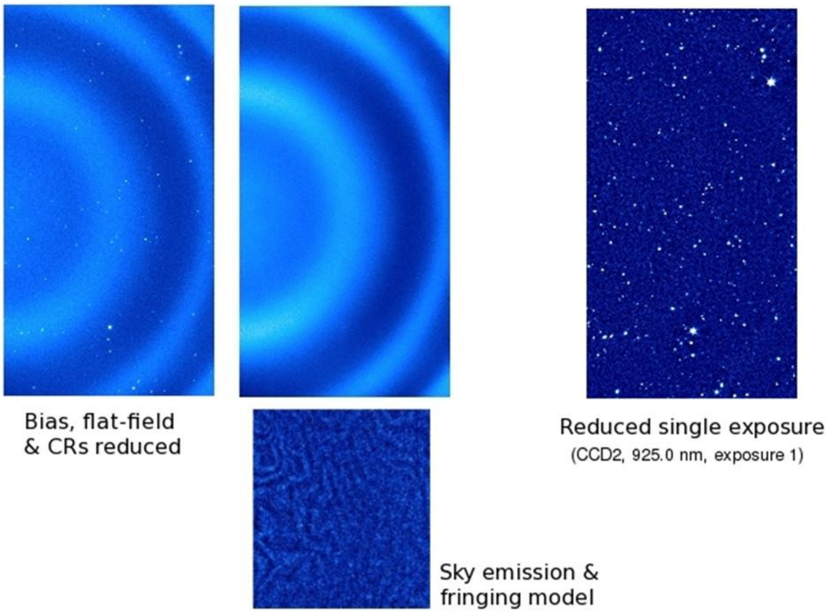

Figure 1: Steps of the OTELO data reduction process. From left to right and top to bottom: bias and flatfield corrected image, cosmic ray corrected, final image, and a detail of fringe pattern image.

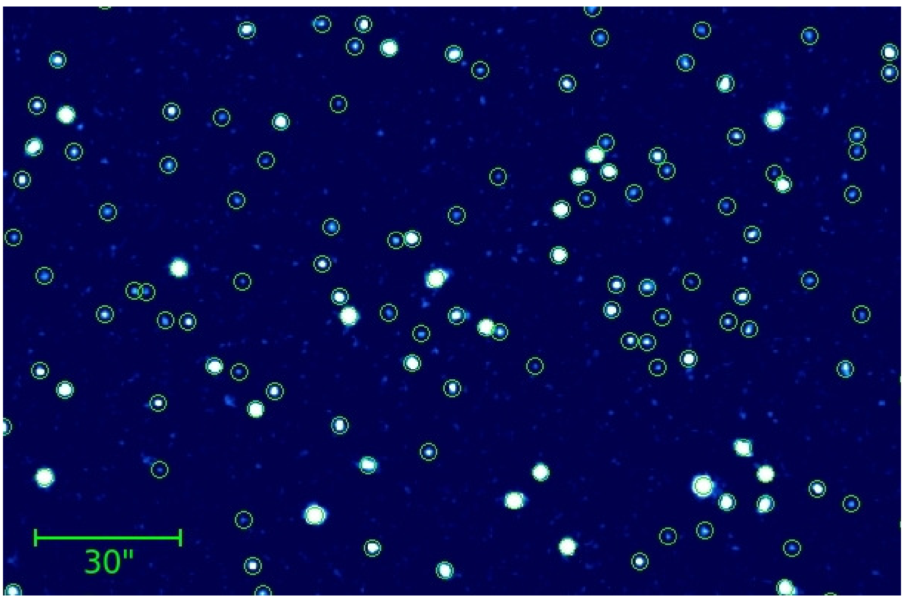

Figure 2: OTELO sources of a 3×2 arcmin^2 section (i.e. 1/8 of the total field) of the synthesized NB filter $\sim$925.9/3.0 nm, obtained adding together the four matched images from 925.0 through 926.8 nm, overimposed on the broad band I image of [3].

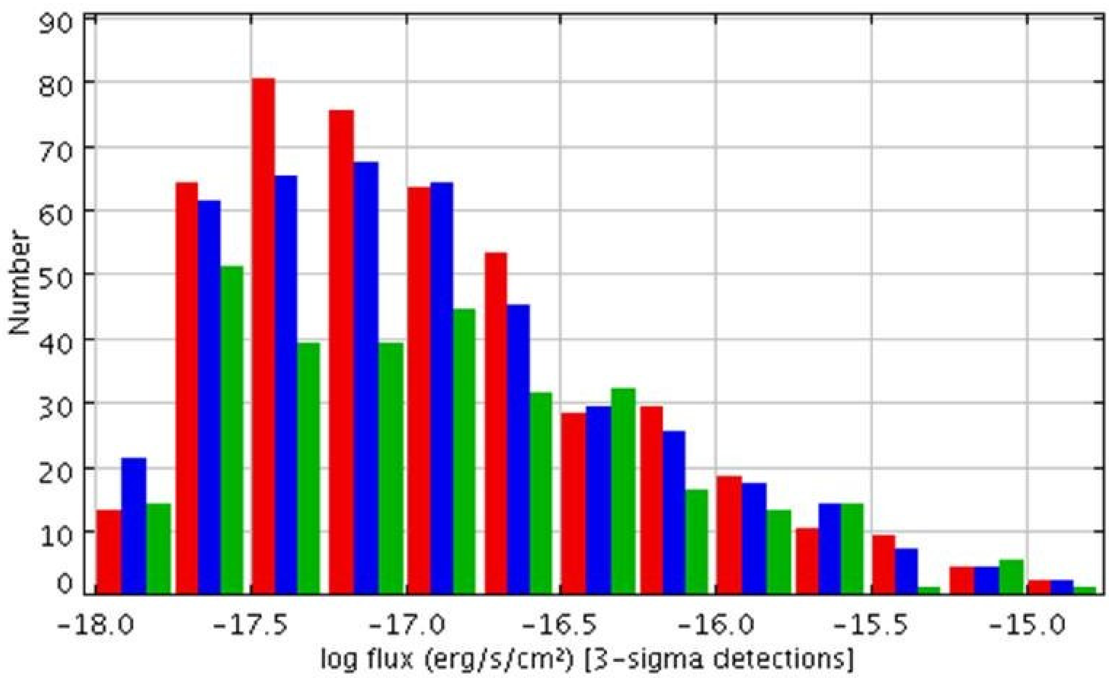

Figure 3: Histogram of the extracted sources of the final calibrated images at 925.0 (red), 926.2 (blue) and 928.0 nm (green).

educated guess yields 5000–6000 targets per OSIRIS pointing and the a total of about 40000 targets in 0.1 square degree survey.

A preliminary analysis shows a higher fraction of emitters at $m_I(\mathrm{AB}) > 24$ magnitudes, a *prima facie* indicator that current MOS surveys might be missing a substantial fraction of emitters at low luminosities

5 Summary

OTELO will be a unique survey in terms of minimum detectable flux and EW limit, that yields the deepest emission line survey to date. In this contribution the first data are analyzed, indicating that TF tuning accuracy and stability, and instrument transmission specifications are fulfilled, reaching the survey planned depth. The current data indicate that a total of about 40000 objects are expected for the full survey. Finally, the first preliminary results show evidence that a larger fraction of faint line emitters are missed by current spectroscopic surveys, likely due to the low EW limits of OTELO survey. Data gathering and analysis will continue during 2011 and 2012.

Acknowledgments

This work was supported by the Spanish Plan Nacional de Astronomía y Astrofísica under grant AYA2008–06311–C02–01. Based on observations made with the Gran Telescopio Canarias (GTC), installed in the Spanish Observatorio del Roque de los Muchachos of the Instituto de Astrofísica de Canarias, in the island of La Palma.

References

[1] Buckley, D.A.H, 2001, in *The New Era of Wide Field Astronomy*, ASP Conference Series, Vol. 232, eds. R. Clowes, A. Adamson, & G. Bromage, San Francisco

[2] Cepa, J., et al. 2005, Rev. Mex. Astron. Astrof., 24, 1

[3] Cepa, J., et al. 2008, A&A, 490, 1

[4] Fujita, S.S., et al. 2003, ApJ, 586, 115

[5] Jones, D.H., & Bland–Hawthorn, J. 2001, ApJ, 550, 593

[6] Steidel, C.C., et al. 2000, ApJ, 532, 170

[7] Thommes, E., et al. 1997, Reviews in Modern Astronomy, 10, 297