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Status of the OTELO project

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Abstract

The OTELO project is the extragalactic survey currently under way using the tunable filters of the OSIRIS instrument at the GTC. OTELO is already providing the deepest emission line object survey of the universe up to a redshift 7. In this contribution, the status of the survey and the first results obtained will be presented.

1 Introduction

The study of the evolution of galaxies and of high redshift objects has undergone a substantial advance in the last decade due to the deep multi–wavelength extragalactic surveys available. These surveys could be classified according to the spectral resolution. Low resolution broad–band multicolour photometry allows observing the faintest targets, and deriving redshift estimations together with morphological parameters. Mid–band multicolour surveys allow increasing redshift accuracy, and even detecting the brigthest line emitters, with penalty on depth. Higher resolution spectroscopic surveys allow obtaining accurate redshifts, and more detailed spectral energy distributions for tackling a wide variety of scientific objectives. Intermediate resolution narrow band imaging surveys, such as OTELO [2], are a powerful tool to detect and study the evolution of line emitter objects (see [9] 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, for every target in the field without previous selection. Then, narrow band surveys complement broad band surveys, that are more efficient in detecting continuum dominated and bright emission line targets, and complement spectroscopic surveys, whose targets are selected using broad band surveys. In summary, narrow band surveys provide a complementary view of the universe at high redshift.

Within narrow band surveys, those using tunable filters as OTELO, CADIS (Calar Alto Deep Imaging Survey, [10]), and the TTFFGS (Taurus Tunable Filter Faint Galaxy Survey [4]) detect one order of magnitude more objects (normalizing for telescope size and exposure time) than conventional narrow band surveys as the Suprime-Cam of Subaru [3]. For this reason narrow band surveys with Tunable Filters in large telescopes constitute a deep sky probe with unprecedented sensitivity. Moreover, since tunable filter surveys obtain a set of images of the same pointing at slightly different wavelengths, this technique can be rather considered narrow band 3D wide field spectroscopy than conventional narrow band imaging. They allow obtaining redshifts with an almost spectroscopic accuracy, while allowing a quite precise photometric calibration for deriving absolute SFRs.

For these reasons, 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, redshift accuracy and target discrimination, as shown in Table 1.

2 OTELO Survey

OTELO [2] 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 5×10^{-19} erg cm^{-2} s^{-1} will allow detecting objects of equivalent width (EW) of 3Å 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 7.0. 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) will be devoted for obtaining images of 36 contiguous wavelengths at a FWHM of 1.2nm, scanning every 0.6nm (i.e.: half the FWHM) in the 907–928nm win-

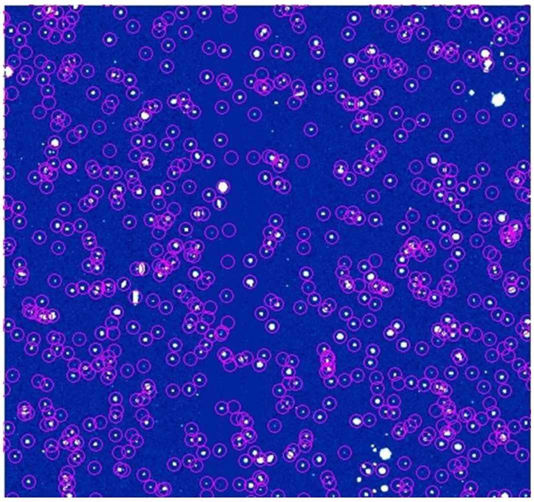

Figure 1: OTELO sources of a 7.4×7.1 arcmin^2 section of the synthesized NB filter ~924.4/8.4nm, obtained by the median of all matched images from 920.8 through 928.0nm. The sources marked with a circle are those identified in the shallower z′ survey of [7].

dow in the OH sky line forrest. Each wavelength will be observed 6600 seconds distributed in 6 exposures of 1100 seconds dithered 18 arcseconds in a cross–shaped pattern to fill out the gap between detectors.

Table 1: OTELO Survey main characteristics

Parameter	Value
Limiting flux (3σ)	5×10^{-19}erg cm^{-2} s^{-1}
Minimum EW	3Å
Area	0.1 sq.deg.
Redshift accuracy	10^{-4}
Cosmic statistics	Several fields
Deblend Hα from [NII]	Yes

Also, observations of a second pointing in the central part of Lockman Hole, with the same observational configuration but in grey time, will start next season.

3 OTELO observations and data reduction

So far 39 hours have been observed corresponding to 13 contiguous wavelengths in the spectral range 920.8–928.0nm from April 2010 through April 2012. The mean seeing during the observations was of 0.9±0.2 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

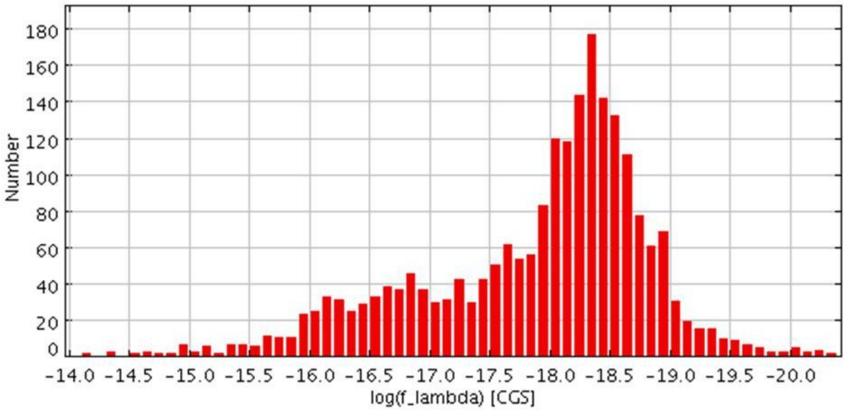

Figure 2: Histogram of the 2300 sources with counterparts in the [7] catalogue, detected in the image of the synthesized filter 924.4/8.4nm, with an exposure time equivalent to 85800s. A minimum detectable flux of 5×10^{-19} erg cm^{-2} s^{-1} at 3σ level is obtained.

at the nominal accuracy of 0.1nm, 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 useful due to illumination effects. Then, sky rings were subtracted using the TFRED IRAF package [5] after iteratively masking objects at 3σ level. A median combination of dithered images provide a fringe map that was subtracted to the data, providing fringe corrected images.

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 wavelength variation corrected based on the TF optical centre and the new wavelength dependence derived by the instrument team [6]. Flux calibration was achieved using two standard spectrophotometric stars within the same field.

4 Data quality

A median of the 78 OTELO images was obtained, synthesizing a filter 924.4/8.4nm. Then the extracted sources from this median image were cross matched with the catalogue of [7] obtained using the z' filter, reaching up to magnitude 23rd, shallower than achievable in

[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.

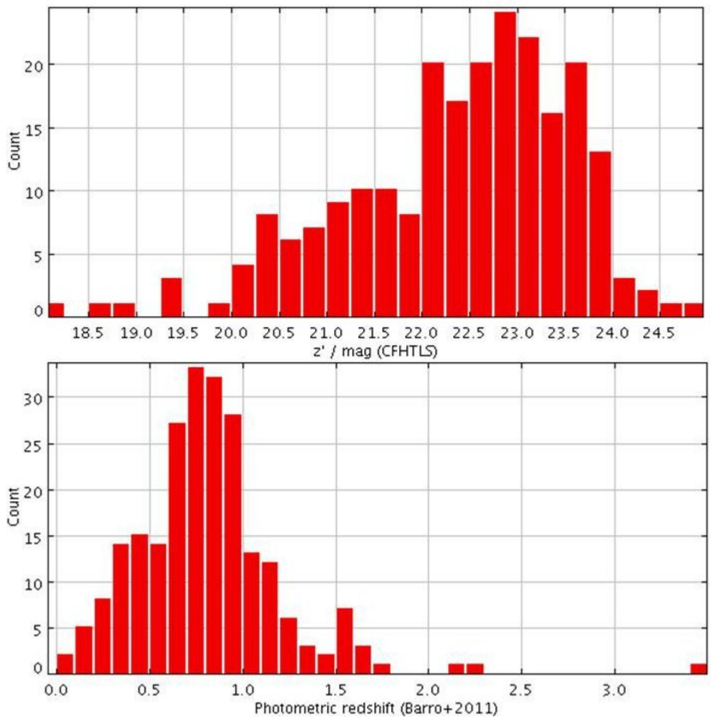

Figure 3: Histogram of the extracted sources with emission line signatures that are detected at all wavelenghts and with counterparts in [1]. *Upper panel:* the distribution of z′ magnitudes in the shallower survey of [7]. *Lower panel:* the photometric redshifts estimated by [1]. Peaks corresponding to the most conspicuous lines Hα, [OIII]λ500.7nm and [OII]$\lambda\lambda$372.7nm, can be seen at z $\sim$ 0.4, 0.8 and 1.5, respectively.

OTELO survey (Fig. 1). A total of more than 2300 sources were identified in this way.

As expected, a minimum detectable flux of 5×10^{-19} erg cm^{-2} s^{-1} (3σ) was achieved, with completitude at 1×10^{-18} erg cm^{-2} s^{-1} (3σ) (Fig. 2), two magnitudes deeper than the deepest narrow band survey so far available. These figures are fully consistent with the OSIRIS ETC calculators provided by the instrument team and available in the WWW.

5 Preliminary results

With one third of the first pointing complete, it is just possible to start deriving some scientific results. As a first step, only sources identified at all wavelengths and with emission line signatures were considered, resulting in a total of 237 emitters. From these, 222 show counterpart in [1]. In Fig. 3, the histograms of the distribution of z′ magnitudes from [7] and the distribution of the photometric redshifts derived by [1] are shown. Most emission line galaxies are detected between redshifts 0.5 and 1.0. As a consequence, the emission line detected is mostly [OIII]λ500.7nm, with Hα at redshifts z $<$ 0.4, and [OII]$\lambda\lambda$372.7nm at z

~1.5 also present. In fact, peaks can be distinguished at redshifts ∼ 0.4, 0.8, and 1.5 corresponding to these emission lines (Fig. 3). Further analysis of the pseudo–spectra of these sources will allow deriving precise redshifts and line fluxes.

The next step will be detecting targets present only in two contiguous wavelengths, or even in only one wavelength, corresponding to faint continuum emission line galaxies. For the Hα emitters at redshift z $\sim$ 0.4, the [NII] lines will be deblended thus obtaining SFR and a metalicity estimation for these objects [8]. Finally, matching surveys of the same field in the MIR, FIR and X-ray will allow studying different types of emission line targets. Follow–up optical spectroscopic observations are foreseen. In fact OSIRIS MOS observations of the Lockman Hole field using guaranteed time of the instrument team are already planned, and are expected to be executed as soon as this mode is available.

6 Summary

Once completed, OTELO will be a unique survey in terms of minimum detectable flux and EW limit, yielding the deepest emission line survey to date with spectroscopic redshift accuracy. In this contribution one third of data of the first pointing are analyzed. Data gathering and analysis will continue during 2013 for EGS and Lockman Hole fields.

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