X-shooter Science Verification Proposal

Title: Precise abundance determination of extremely metal poor HII galaxies

Investigators	Institute	EMAIL
Ángeles I. Díaz	UAM	angeles.diaz@uam.es
Roberto Terlevich	IoA/INAOE	rjt@ast.cam.ac.uk
Elena Terlevich	INAOE	eterlevi@inaoep.mx
Fabián Rosales	IoA	frosales@ast.cam.ac.uk
Guillermo Hägele	UAM	guille.hagele@uam.es

Abstract:

We propose to use X-shooter to obtain simultaneous UV-IR long-slit spectrophotometry to perform a precision abundance analysis of reported extremely low metallicity HII galaxies (XMPG). The large wavelength coverage of X-shooter at its moderate resolution will allow the detection and measurement of the faint temperature-sentitive emission lines needed to derive the ionization structure of the emitting nebulae. The near IR coverage will further add important constraints to the reddening determination, temperature fluctuation effects, importance of collisional effects and ionizing star temperature estimates.

Scientific Case:

During many years, the blue compact galaxy IZw18 with its derived metallicity of about 1/50 of the solar value has been considered the "lowest metallicity" galaxy known and therefore candidate to be close to a primeval object. Lately, and partly thanks to SDSS, more galaxies with very low derived abundances have been found and constitute now the class of objects referred to as "extremely metal poor galaxies" (XMPG; e.g. Kniazev et al 2003, ApJ 593, L73; Papaderos et al. 2008, A&A, 491, 113). In most cases, the oxygen abundances of these galaxies – $7.13 \leq 12+\log(O/H) \leq 7.70$ – have been determined by the so called "standard method" (Izotov et al. 2006, A&A, 448, 955) using the available emission lines in the blue spectral range (3500 - 5100 Å). While this is probably enough to characterize the overall metal content of these galaxies as traced by their oxygen abundance, a much more detailed work is needed in order to perform a comprehensive abundance analysis which is imperative to study their chemical evolution.

The precise derivation of elemental abundances however is not a straightforward matter. Firstly, accurate measurements of emission lines over a wide wavelength range are needed. Secondly, a certain knowledge of the ionisation structure of the emitting nebula is required in order to derive ionic abundances of the different elements and in some cases photoionisation models are needed to correct for unseen ionisation states. An accurate diagnosis requires the measurement of faint auroral lines covering a wide spectral range and their accurate (better than 5%) ratios to Balmer recombination lines. These faint lines are usually about 1% of the Hβ intensity. The spectral range must include from the UV [OII] λ 3727 Å doublet, to the near IR [SIII] $\lambda\lambda$ 9069,9532 Å lines. This allows the derivation of the different line temperatures: T_e([OII]), T_e([SII]), T_e([OIII]), T_e([SIII]), T_e([NII]), needed in order to study the temperature and ionisation structure of each HII galaxy considered as a multizone ionised region.

In the last years we have undertaken the task of obtaining a data base of HII galaxies with accurately derived abundances and a realistic precision using double arm spectrographs (Hägele et al. 2006, MNRAS, 372, 293; 2008, MNRAS, 383, 209). It is important to realise that the combination of accurate spectrophotometry and wide spectral coverage cannot be achieved using single arm spectrographs where, in order to reach the necessary spectral resolution, the wavelength range must be split into several independent observations. In those cases, the quality of the spectrophotometry is at best doubtful mainly because the different spectral ranges are not observed simultaneously. This problem applies to both objects and calibrators.

Our analysis shows that, in fact, most temperatures and abundances derived from SDSS data can only be taken as broad estimates and challenges the methodology used by different authors in the derivation of abundances for HII galaxies.

X-shooter is probably the ideal instrument to perform the task. To the 300-1000nm spectral range required for the detailed abundance analysis, the near-IR spectral range will add: a better reddening determination, through the use of Brackett lines; a further constraint on the effects of temperature fluctuations though the combined measurement of Balmer, Paschen and Brackett discontinuities; the quantification of the importance of collisional processes from the measuremts of H_2 lines; a better determination of the He abundance due to the relatively small collisional effects on the strongest IR lines (1.70, 2.06, 2.11μm); a better indicator for the temperature of ionizing stars trough the HeI 1.7μm /Br10 ratio etc. Furthermore, the CO bands together with the CaT lines in the far red can provide important information about the properties of the stellar populations in these very low metallicity objects.

Here we propose to obtain long-slit observations of a sample of very low metallicity objects which have already been observed in the blue-visible part of the spectrum and whose oxygen abundances have been derived by the "direct stantard method". Our higher prority objects are the two brightest objects (F(Hβ) between 1.6 and 4.5 $\times$ 10^{-14} erg $s^{-1}cm^{-2}$): SBS0335-052 and J2230-0006, both observable during the month of August. The first is considered by some authors as the most metal-deficient emission-line galaxy known and is reported to present oxygen abundance gradients on scales of 1 Kpc (Papaderos et al. 2006, A&A, 454, 119). It has also been observed in the near IR with SOFI at the NTT by Vanzi et al. (2000, A&A, 363, 493). The second is included in the works of Rosales (2006, MSc Thesis, INAOE) and Papaderos et al. (2008). The latter derives an oxygen abundance of 12+log(O/H)= 7.641 $\pm$ 0.017 based on the "standard method" of Izotov et al (2006).

Calibration strategy:

All the investigators have experience with double beam spectrographs at medium size telescopes.

Wavelength and spatial scale are going to be calibrated simultaneously using the mask of 9 equidistant pinholes present in each slit unit in combination with the ThAr lamp. Besides, we are going to use the full slit ThAr spectra to correct the slight displacement between the 9-pinhole masks an deach slit.

The objects in our sample are compact enough to perform the sky substraction using the ends of the longslit data. To perform the telluric absorption correction we are going to observe the telluric standard soon after or soon before the science observation at the same airmass. Since we are interested in the hydrogen and helium lines we also need to observe a late type star, and use it to correct for the helium and hydrogen absorption in the spectrum of the hot star. We will submit the specific spectral type in calibration OBs.

To obtain the absolute efficiency of the instrument and derive an absolute flux calibration of the data we will use the spectrophotometric standard stars calibrated from 300 to 2500 nm to this purpose through an ESO Observatory Programme.

Targets and number of visibility measurements

Target	**RA**	**DEC**	**F(Hβ)** 10^{-16} erg/s/cm^2	Exp. Time (s)	**Mode** (slit/IFU)	**Remarks** (priority)
SDSS J013352.56+134209.4	01 33 53	+13 42 09	78.4[a]	2400	slit	Second
SBS 0335-052	03 37 44	-05 02 40	450.0[b]	900	slit	First
g0405204-364859	04 05 20	-36 48 59	17.0[c]	3600	slit	Second
SDSS J115247.51-004007.6	11 52 48	-00 40 08	130.0[d]	1200	slit	Second
SDSS J120122.31+021108.3	12 01 22	+02 11 08	89.9[a]	2400	slit	Second
SDSS J223036.79-000636.9	22 30 37	-00 06 37	160.0[d]	1200	slit	First

Fluxes from: [a]Kniazev et al. (2003); [b]Papaderos et al. (2006); [c]Papaderos et al. (2008); [d]Rosales (2006)

Time Justification:

We have used the line intensities published in the literature and the "X-SHOOTER Exposure Time Calculator" to estimate the exposure time needed to achieve the necessary signal-to-noise ratio to measure the emission lines with the required accuracy.