FIRST OB-STARS IN THE IRON-POOR LOCAL GROUP GALAXY SEXTANS A

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BACKGROUND

Massive stars, and their strong radiation-driven winds, play an important role in the chemical and dynamic evolution of the Universe. The first population of stars, which may have begun the reionization of the Universe, were massive and extremely metal-poor (Bromm et al., 2001). It becomes important, therefore, to understand the properties and behavior of the massive stars and their winds in very metal-deficient environments.

Several studies developed in the past few years showed that massive stars in metal-poor galaxies (based on oxygen measurements) may have stronger winds than predicted by theory (Herrero et al. 2010 and Tramper et al. 2011). This contradicts the mass loss dependence on metallicity expected from theory (Vink et al. 2001) and confirmed by observations down to the metallicity of the Small Magellanic Cloud (Mokiem et al. 2007): $\dot{M} \propto Z^{0.72\pm0.15}$

If the strong winds at low metallicity were confirmed, the evolution and feedback of the first massive stars could need drastic revision. However, the independent works of Garcia et al. (2014) and Hosek et al. (2014) have found indication that the Fe abundance in those galaxies may be higher than simply scaled from oxygen. As Fe is the main driver of mass-loss, this mismatch could explain the strong winds problem.

Sextans A is a metal-poor irregular galaxy in the outer part of the Local Group and has been confirmed to have low Fe abundance (see Fig. 2). For this reason, Sextans A offers the unique opportunity to study massive stars in a really metal-poor environment. The goal of this project is to search and confirm candidate OB-stars in this galaxy, to subsequently study their wind behavior.

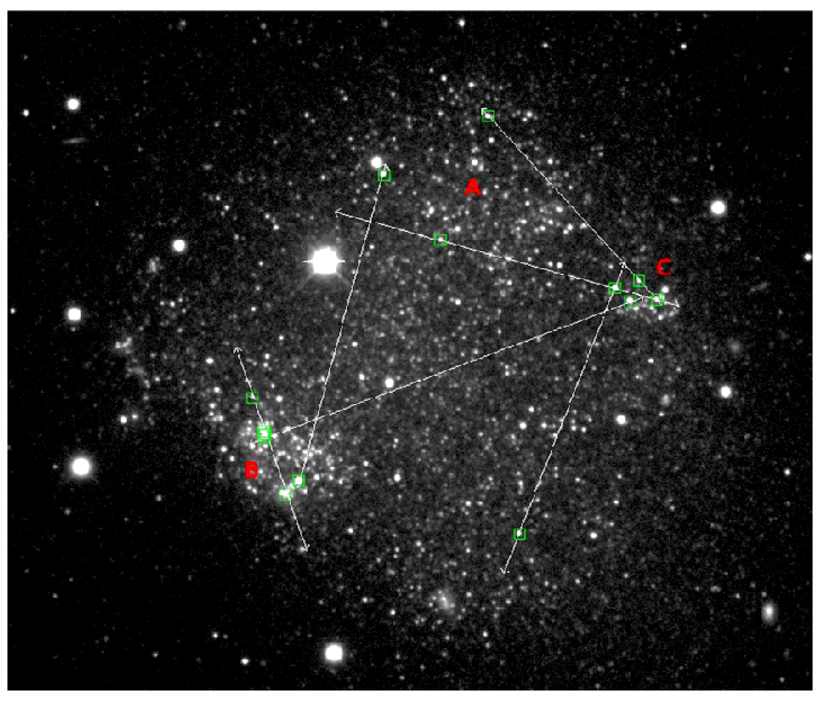

Fig. 1- V filter image of Sextans A. North is up and east to the left. The positions of the program stars are marked with green squares

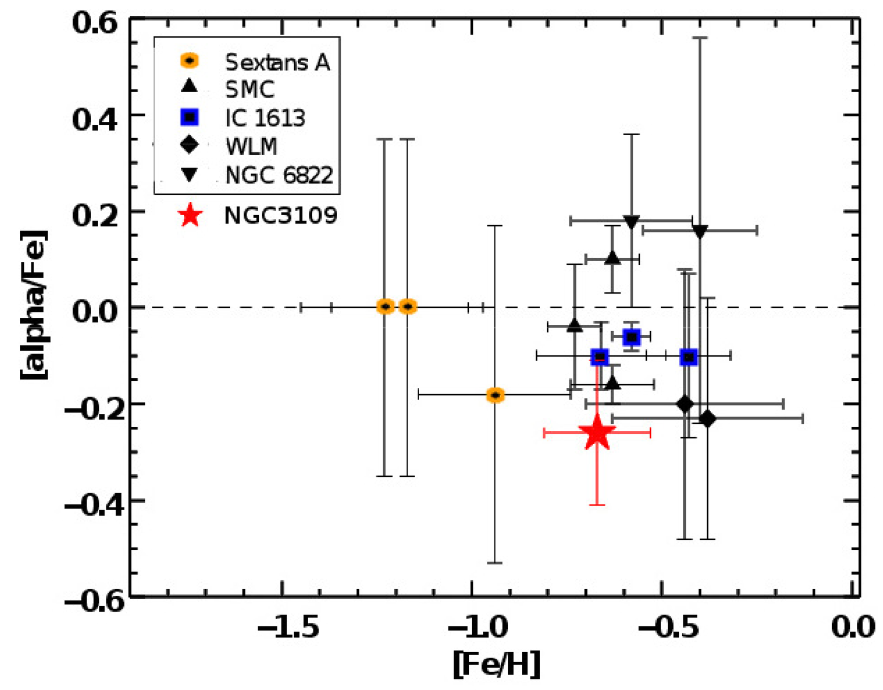

Fig. 2- [α/Fe] vs [Fe/H] derived from supergiants for different dwarf irregular galaxies. Sextans A shows lower Fe than other Irregular galaxies in the Local Group. Adapted from Hosek et al. (2014)

TARGET SELECTION

O and late-B type stars have similar colors, and their identification cannot be based in optical photometry only but requires other criteria and confirmation with spectroscopy.

Garcia et al. (2009) have shown that OB stars in the metal poor galaxy IC1613 (Z ~ 0.04 to 0.2 $Z_{\odot}$, see references in Garcia et al. (2009)) are located in a particular region of the (U-B) vs Q diagram (see Fig.3), where Q is a reddening-free pseudo-color parameter defined as:

$$Q = (U-B) - 0.72 * (B-V)$$

To separate O from B stars, Garcia et al. (2013) used a limiting value of Q < -0.8, and complemented it with UV GALEX imaging.

We adopt the same main criterion to find OB stars in the Sextans A galaxy, aiming at candidates that can be observed in 1 hour long observing blocks (V < 19.6). We also included those with strong UV emission even if they do not obey the main Q<-0.8 criterion, as O stars are strong sources in this wavelength range.

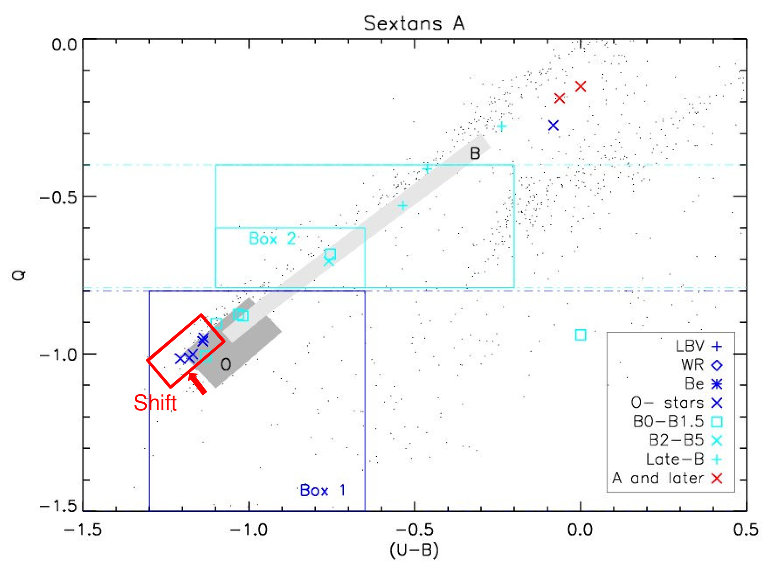

Fig. 3- Sextans A Q vs U-B diagram from Camacho et al. (2014) . Black dots mark catalogue stars from Massey et al. (2007). Other colors and symbols show the position of the sample of studied stars. Shaded boxes point out the location of O and B stars in IC1613. The O-type stars of Sextans A do not overlap with IC1613's counterparts, but their position is shifted as shown in the figure

OBSERVATIONS

The spectroscopic follow up was carried out using OSIRIS on the GTC.

The spectra covered the optical range 4000-5000 Å with a resolving power of R~1000. The 1.2" width long slits were orientated to specific angles in order to include at least two targets per slit (see Fig. 1)

We obtained good SNR for 11 candidate stars (with SNR of ~ 30) plus seven additional stars that fell in the slits.

FIRST RESULTS

We found six O-type and seven early-B stars (see Camacho et al. 2014 for details on spectral classification). These constitute the first atlas of OB-type stars in Sextans A.

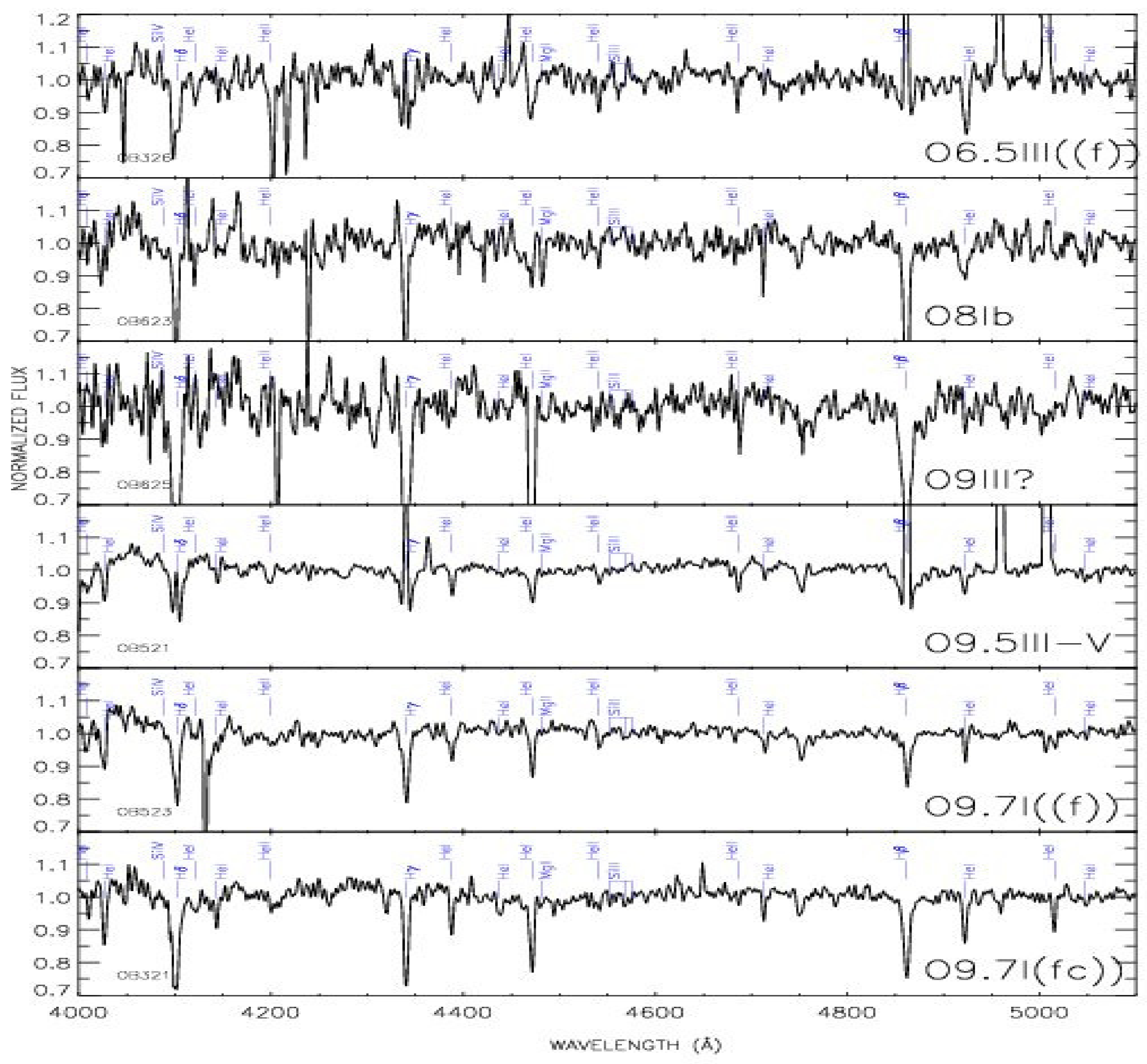

Fig. 4 - O-type stars in Sextans A unveiled by our program

The location of the OB supergiant stars in the HR diagram is shown in Fig. 5. Most of the stars are located as expected: O stars are young and closer to ZAMS, while most of the B stars are located in the post main-sequence region.

OB star masses derived from evolutionary tracks are between 20 and 40 $M_{\odot}$. O stars have ages between 4 and 6 Myr, while early B supergiant ages cluster around 8 Myr.

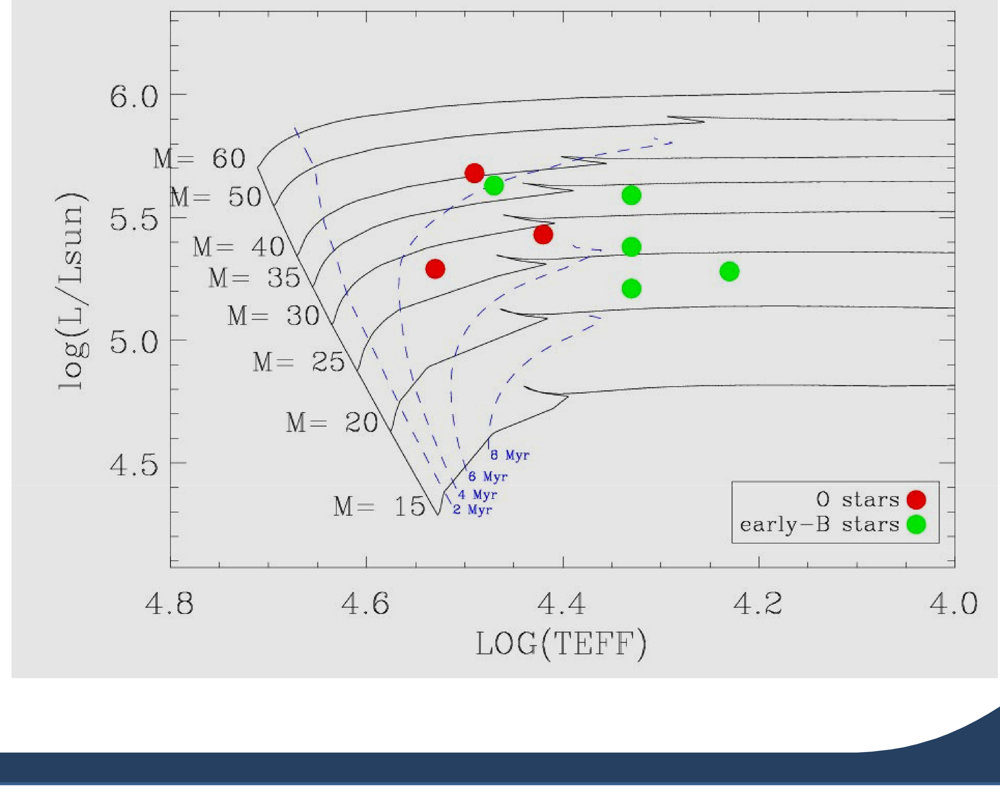

Fig. 5 - The location of the O and early-B supergiant stars of Sextans A in the HR diagram (giants have been excluded). Low-rotating evolutionary tracks and isochrones have been taken from Brott et al. (2011).
The temperature of the O-stars was estimated in Camacho et al. (2014) from a quantitative spectroscopic analysis with FASTWIND. The effective temperatures of B-supergiants were adopted from the calibrations of Crowther et al. (2006)

NEXT STEP: OPTIMIZED TARGET SELECTION CRITERIA

The target selection criteria for IC1613 do not work well for Sextans A. We found that only the 50% of the OB candidates are O or early-B type stars, in contrast with the 70% success rate we had in IC1613. Fig. 3 shows the position of the whole sample of studied stars in the (U-B) vs Q diagram, where the shift of O-stars into bluer zones is clear. The different properties of the internal reddening, and metallicity in both galaxies may be causing this shift of the stars in the diagrams. Hence, refined criteria are needed.

We defined five regions with different priorities (see Fig. 6, where Z1 is the most prioritary zone) to achieve higher percentage of O-type stars in Sextans A. Attending to the different distance and extinction of both galaxies (Sextans A is 0.6 Mpc farther than IC1613), we expect blue massive stars to be 1.5 magnitudes fainter in the V-band.

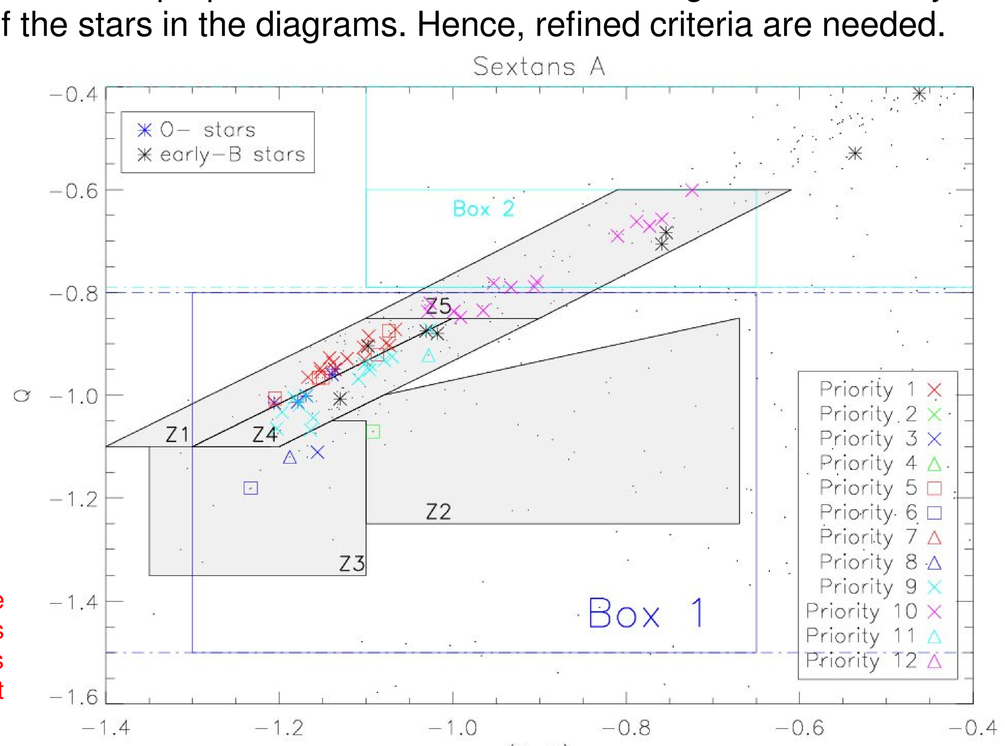

Fig. 6- Sextans A Q vs U-B diagram. The shaded boxes show the new refined zones defined to look for O-type stars in Sextans A. New candidate stars with different priorities are shown

To test the optimized selection criteria and unveil the new, precious O stars, we submitted a Guaranteed Time proposal to observe Sextans A with OSIRIS in multi-object spectroscopic mode (MOS), currently being carried out.

These are among the first MOS observations delivered by GTC.

Fig. 7 - Planned OSIRIS-MOS observations of Sextans A. East up and north to the right. The Field of view of OSIRIS-MOS covers the entire galaxy. White boxes and circles represent the selected slits and fiduciary stars, respectively, and the green shaded zones the spectral distribution

FUTURE WORK

We have already identified 13 O and early-B type stars in Sextans A, and we expect to find 16 additional stars with the MOS-GTC observations of our optimized candidates.

This constitutes a large sample of confirmed OB-stars in Sextans A, potentially the most Fe poor known massive stars of the Local Group. Our ultimate goal is to constrain their wind properties in order to better understand the role of Fe-content and metallicity in radiation driven winds.

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