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# GTC AND OSIRIS: EXPANDING THE METALLICITY HORIZON OF MASSIVE STARS KNOWLEDGE

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RESUMEN

Las estellas masivas son motores fundamentales del Universo en cada fase de su vida y también en su muerte. Sin embargo, su impacto sobre el medio interestelar y la galaxia que las acoge depende de su formación, vientos y evolución, cuestiones todas ellas relacionadas con la composición química. OSIRIS en el GTC es una máquina excelente para estudios cuantitativos de estrellas masivas azules en galaxias del Grupo Local, donde podemos estudiar entornos de diferente metalicidad. Presentamos aquí nuestro análisis de espectros de estrellas masivas azules obtenidos con OSIRIS en IC 1613, una galaxia pobre en metales ($\sim$0.05–0.1 $Z_\odot$ según regiones HII). GTC-OSIRIS nos permite desvelar nuevas estrellas-O en IC 1613 y realizar su estudio cuantitativo, lo que proporcionará nuevas perspectivas para nuestros modelos de vientos y evolución de estrellas masivas y las respuestas que necesitamos para evaluar su impacto en condiciones similares a las del Universo temprano.

ABSTRACT

Massive stars are fundamental drivers of the Universe because of their injection of energy, momentum, and nuclear-processed material in every stage of their life and death. Their feedback depends on their formation, winds and evolution, and these in turn depend on chemical composition. The GTC-OSIRIS combination is an excellent machine for quantitative studies of blue massive stars in Local Group galaxies, where different metallicity environments can be probed. We present our analyses of OSIRIS spectra of blue massive stars in IC 1613, where metallicity ranges from $\sim$0.05 to 0.1 $Z_\odot$ according to HII regions.GTC-OSIRIS unveils unknown O-type stars in IC 1613,whose quantitative analysis willprovide new insight for our models of massive star winds and evolution and will serve as proxy for studies of the early Universe.

*Key Words:* galaxies: individual (IC 1613) — stars: early-type — stars: spectroscopy



## 1. INTRODUCTION

Massive stars are crucial to understand the Universe because of their input in many astrophysics fields. Mighty stellar winds and ionizing radiation fields, and a tragic end as supernova, disrupt their surrounding medium and contaminate it with the products of the nuclear reactions that feed these titans. One of the most important ingredients of our paradigm of massive stars is their stellar winds because they regulate the duration of the evolutionary stages, ultimately deciding the end of the star and the remnant left.

The winds of massive stars are radiation-driven and metallicity dependent: the outflow of matter is propelled by the absorption of photons in numerous UV transitions of metallic ions. Hence theory predicts a correlation between the luminosity of the star and the momentum carried by the wind: the wind-momentum luminosity relation (WLR, see Figure 1). This relation has been proved empirically, and its metallicity dependence empirically characterized from the Milky Way (MW) down to the metallicity of the Small Magellanic Cloud (SMC) (Mokiem et al. 2007).

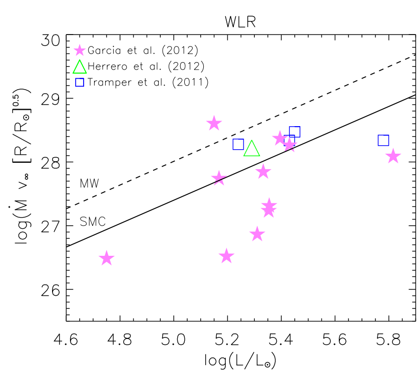


Fig. 1. WLR in IC 1613, compared to Mokiem et al. (2007)'s WLR for the MW (dashed) and SMC (solid). Colors represent different samples, see legend.

While our models of massive star winds work well on a general level, there are still puzzling ques-

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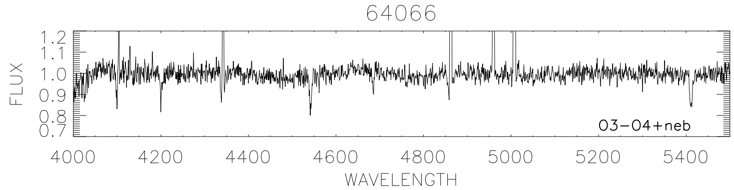


Fig. 2. GTC-OSIRIS spectrum of an early-O star in IC 1613. The spectrum, smoothed for clarity, is severely contaminated by nebular emission most prominent in the [O III]4959,5007 and Balmer lines. However He II lines (e.g. 4541 Å and 5411 Å), the footprint of hot massive stars, are clearly seen. This is the first spectrum ever taken for # 64066; its spectral type confirms it is a massive star, as our target selection criterion (based on Q-color and GALEX detection) indicated.

tions regarding the WLR. We expect that metal-poor SMC stars experience weaker winds than MW stars, but some low luminosity SMC stars lie much lower than the theoretical SMC prediction and similar outliers exist in the MW (Martins et al. 2004, 2005).

Understanding the winds of massive stars in general, and the metal-poor regime in particular, is crucial to quantify the feedback of these objects throughout cosmic ages, and to understand the first stars of the Universe.

## 2. BLUE MASSIVE STARS IN IC 1613

We have undertaken the study of the population of blue massive stars in IC 1613, a dwarf irregular galaxy of the Local Group with metallicity about 0.1 $Z_\odot$ (see references within Garcia et al. (2009), hereafter GHV09). Contrary to our expectations, we found an LBV candidate in this galaxy (Herrero et al. 2010), and our preliminary analysis of an Of star revealed its wind-momentum above the WLR (Herrero et al. 2011). Tramper et al. (2011) also obtained stronger winds than predicted by the theory for four stars in this galaxy. These results, compiled in Figure 1, suggest that the wind of metal poor massive stars may be stronger than predicted by the theory. However, our detailed analysis of the Of star (Herrero et al. 2012) and an extended VLT-VIMOS sample of IC 1613 (Garcia et al. 2012, in prep.) show no evidence for super-WLR stars (see Figure 1). We obviously need better data to clarify whether we have spotted a problem with the theory of radiation-driven winds, and if so to try to solve it.

In sight of Figure 1 we also need to extend IC 1613's WLR to the high luminosity $\log L/L_\odot \gtrsim 6$ regime, corresponding to early-O supergiants. However, these objects which are instrinsically the most luminous of the family of massive stars are paradoxically the faintest stars since they are usually obscured by gas and dust. GTC and OSIRIS can play a very important role to first unveil the O stars in IC 1613 and then provide high SNR mid-resolution spectra, whose analysis will yield new clues on the winds of very metal poor massive stars.

We submitted a low-budget proposal (5 h granted) to look for new O-stars in IC 1613. Candidate stars, chosen from their reddening-free $Q$ color ($Q = U - B - 0.72 * (B - V)$), GALEX detection and evolutionary mass, must be first confirmed with spectral classification prior to investing previous telescope time to obtain good quality spectra apt for quantitative analysis. Our proposal was designed to obtain low resolution spectra (R2000B, 1.2″ slit) of 2 candidates at once per slit per hour in order to obtain spectral types and identify the most interesting candidates for subsequent follow-up.

Figure 2 shows the observed spectrum of star #64066 (from GHV09's catalog). Despite severe nebular contamination, the data show clear Balmer lines and He I and He II lines that render the star an O-type. We would like to remark that only 1 hour observing time was required to get the spectrum of this $V = 19.03$ star. From our initial discovery expectation of 10 O-type stars, we have found 10 new O-stars, 7 early-B stars and provided a similar type for a formerly known early-O star. The run was very successful and even exceeded our expectations: some of the spectra can be studied quantitatively. We are currently using GTC-OSIRIS as a discovery machine of O-type stars in even lower metallicity galaxies.

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