Red Supergiant Stars with the European Extremely Large Telescope

Dr Lee R. Patrick, Dr Miriam García García, Dr Javier Piqueras López
Centro de Astrobiología (CAB), CSIC-INTA
Contact: lrpatrick@cab.inta-csic.es

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Introduction

Massive stars are the drivers of the elemental and kinematic evolution of galaxies. Such stars pollute their surrounding environments with nuclear processed material via intense stellar winds and as they explode as Type II supernova. The final phase of evolution of the majority of massive stars before supernova explosion is the red supergiant (RSG) phase. RSGs are accurate probes of stellar elemental abundances (e.g. Davies et al. 2015). Because these stars are at the peak of the luminosity function in star forming galaxies, they can be exploited at large distances. With current facilities this is possible out to several Mpc (Davies et al. 2017). Using VLT-KMOS we have previously demonstrated that using the integrated light of clusters of RSGs at near-IR wavelengths provides an accurate measure of the metal abundances of the individual stars (e.g. Patrick et al. 2016).

Studying star formation and evolution beyond the Local Group of galaxies is a key science driver of the European Extremely Large Telescope (E-ELT) and studies of RSGs are an important part of this effort. In the Massive Star group at the CAB we are involved in the science teams of both HARMONI and MOSAIC.

MOSAIC

MOSAIC is a multi-object spectrograph with a multiplex of 80-100 in the visible and near-IR range. This instrument has a wavelength coverage of 0.8–1.8 µm with resolving powers of R~5000 and 20,000. Such a setup makes this instrument ideal to study RSGs in resolved stellar populations beyond the Local Group.

HARMONI

HARMONI is a first-generation workhorse instrument on the E-ELT that exploits an integral field unit (IFU) to provide spectroscopic observations of whole the field of view (FoV) at various spatial scales. The near-IR spectrograph reaches the J-, H- and K-bands and the combination between a configurable FoV and various resolving powers make HARMONI ideal to study extragalactic environments in unprecedented detail, allowing circumstellar structures to be resolved and detailed abundance studies to be performed.

The HARMONI simulator v3 performs realistic simulations of observations that allow science case feasibility to be tested. Using these simulations, we demonstrate the feasibility of HARMONI to perform detailed abundance studies of individual RSGs in galaxies far beyond the Local Group. The high-resolution mode in the near-IR allows individual abundances of key alpha and iron group elements (e.g. Si, Ti, Fe) to be determined in spectral regions that are relatively free of contamination from telluric absorption.

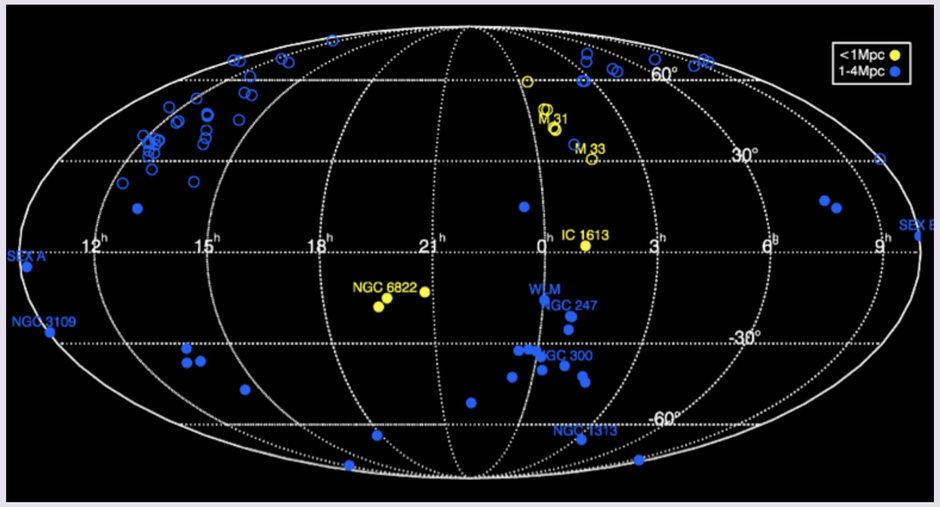
HARMONI details:

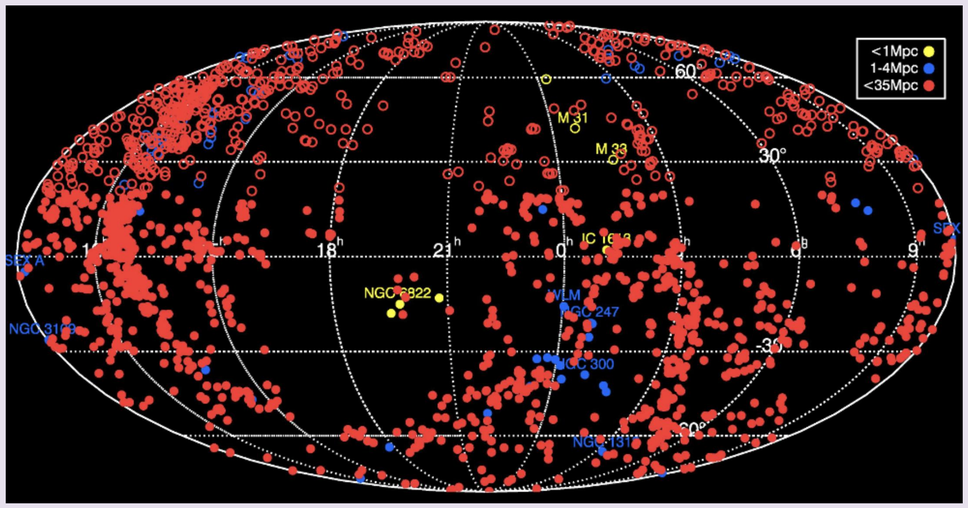
Wavelength	Spectral resolution (R)		Spatial Scales (“)
	NIR	VIS	
0.47—2.45 µm	~3,500, 7,500, 18,000	~3,500	9x6 3x4 1.5x2 0.61x0.82

Advancements over current instrumentation

The current generation of multi-object spectrographs on ground-based telescopes provides observations that allow stellar metallicities to be determined in Local Group galaxies out to distances of roughly 4Mpc. E-ELT HARMONI and MOSAIC allows similar studies to be performed on galaxies out to roughly 30 Mpc, which provides hundreds of potential targets for HARMONI and MOSAIC.

Fig. 1 shows a graphical representation of the galaxies that are potential targets for the E-ELT. where the solid points in both panels are the star forming galaxies that are observable from Cerro Amazones. Such galaxies will be ideal candidates for abundances studies with RSGs. Figure from the ELT-MOS White Paper (Evans et al. 2015).





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