Chapter 1

KMOS Observations in NGC 6822

1.1 Introduction

A promising new method to directly probe chemical abundances in external galaxies is with J-band spectroscopy of red supergiant (RSG) stars. With their peak flux at $\sim$1 μm and luminosities in excess of $10^4\,L_{\odot}$, RSGs are extremely bright in the near-IR, making them potentially useful tracers of the chemical abundances of star-forming galaxies out to large distances. To realise this goal, Davies, Kudritzki & Figer (2010) outlined a technique to derive metallicities of RSGs at moderate spectral resolving power (R $\sim$3000). This technique has recently been refined using observations of RSGs in the Magellanic Clouds (Davies et al., 2015) and Perseus OB-1 (Gazak et al., 2014b). Using absorption lines in the J-band from iron, silicon and titanium, one can estimate metallicity ($[Z] = \log Z/Z_{\odot}$) as well as other stellar parameters (effective temperature, surface gravity and microturbulence) by fitting synthetic spectra to the observations. Owing to their intrinsic brightness, RSGs are ideal candidates for studies of extragalactic environments in the near-IR.

To make full use of the potential of RSGs for this science, multi-object spectrographs operating in the near-IR on 8-m class telescopes are essential. These instruments allow us to observe a large sample of RSGs in a given galaxy, at a wavelength where RSGs are brightest. In this context, the K-band Multi-Object Spectrograph (KMOS; Sharples et al., 2013) at the Very Large Telescope (VLT), Chile, is a powerful facility. KMOS will enable determination of stellar abundances for RSGs out to distances of $\sim$10 Mpc. Further ahead, a near-IR multi-object spectrograph on a 40-m class telescope, combined with the excellent image quality from adaptive optics, will enable abundance estimates for individual stars in galaxies out to tens of Mpc, a significant volume of the local universe containing entire galaxy clusters (Evans et al., 2011).

Here we present KMOS observations of RSGs in the dwarf irregular galaxy NGC 6822, at a distance of $\sim$0.46 Mpc (McConnachie, 2012, and references therein). Chemical abundances have been determined for its old stellar population (e.g. Tolstoy et al., 2001; Kirby et al., 2013), but knowledge of its recent chemical evolution and present-day abundances is somewhat limited. Observations of two A-type supergiants by Venn et al. (2001) provided a first estimate of stellar abundances, finding $\log(\mathrm{Fe/H})+12 = 7.01 \pm 0.22$ and $\log(\mathrm{O/H})+12 = 8.36 \pm 0.19$, based on line-formation calculations for these elements assuming local thermodynamic equilibrium (LTE). A detailed non-LTE study for one of these objects confirmed the results finding 6.96 ± 0.09 for iron and 8.30 ± 0.02 for oxygen (Przybilla, 2002). Compared to solar values of 7.50 and 8.69, respectively (Asplund et al., 2009), this indicates abundances that are approximately one third solar in NGC 6822. A study of oxygen abundances in HII regions (Lee, Skillman & Venn, 2006) found a value of 8.11 ± 0.1, confirming the low metallicity.

NGC 6822 is a relatively isolated Local Group galaxy, which does not seem to be associated with either M31 or the Milky Way. It appears to have a large extended stellar halo (Letarte et al., 2002; Hwang et al., 2014) as well as an extended HI disk containing tidal arms and a possible HI companion (de Blok & Walter, 2000). The HI disk is orientated perpendicular to the distribution of old halo stars and has an associated population of blue stars (de Blok & Walter, 2003; Komiyama et al., 2003). This led Demers, Battinelli & Kunkel (2006) to label the system as a 'polar ring galaxy'. A population of remote star clusters aligned with the elongated old stellar halo have been discovered (Hwang et al., 2011; Huxor et al., 2013). In summary, the extended structures of NGC 6822 suggest some form of recent interaction.

In addition, there is evidence for a relatively constant star-formation history within the central 5 kpc (Weisz et al., 2014) with multiple stellar populations (Battinelli, Demers & Kunkel, 2006; Sibbons et al., 2012). This includes evidence for recent star formation in the form of a known population of massive stars, as well as a number of HII regions (Venn et al., 2001; de Blok & Walter, 2006; Hernández-Martínez et al., 2009; Levesque & Massey, 2012).