Stellar Populations as Building Blocks of Galaxies
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A First Study of Giant Stars in the Galactic Bulge based on Crires spectra

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Abstract. We present our on-going work on the determination of elemental abundances of giants in the Galactic Bulge by means of infrared spectroscopy. We show a preliminarily reduced spectrum and a synthetic spectrum fit of the Bulge giant Arp 4203 recorded with the near-infrared, high-resolution Crires spectrograph mounted on the VLT during its science verification run in August 2006. Abundances derived from this spectrum are discussed.

Keywords. stars: abundances, stars: individual (Arp 4203), Galaxy: bulge, infrared: stars

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Bulges are very important building blocks of galaxies and an exploration of them provides vital clues towards the understanding of galaxy formation and evolution. We are involved in a project with the goal to constrain the formation history, age, and chemical evolution of the Milky Way Bulge and its stellar populations. We will study the precise chemical compositions of giant stars in the Bulge, by means of near-infrared, high-resolution spectroscopy. This is now possible with the Phoenix and Crires spectrometers mounted on the Gemini South and VLT telescopes, respectively. Here, we present our first results of the Bulge giant Arp 4203 observed with Phoenix in July and Crires in August 2006. The full analysis will be presented later (Ryde *et al.* 2007, in preparation).

High-resolution, near infrared spectra of the $15530 - 15590$ Å (the Phoenix spectrum) and the $15310 - 15700$ Å (the new Crires spectra) regions are recorded. The resolving powers are $R \sim 60,000$. The advantage of observing in the near-infrared is the lower dust obscuration towards different bulge fields. Furthermore, infrared spectra are easier to analyse than optical spectra for metal-rich and cool stars (see for example Ryde *et al.* 2005). Molecular features are ubiquitous and are useful tools in the analysis. A draw-back with an analysis in the near-infrared only, is the difficulty in determining the stellar parameters spectroscopically. We are investigating different methods to determine these parameters.

We have modelled our observed spectra with synthetic spectra based on spherical MARCS model atmospheres. The stellar parameters of the star are $T_{\rm eff} = 3900$ K, $\log g = 0.5$, $M = 0.8\,{\rm M}_{\odot}$, [Fe/H] $= -1.25$, and $\xi_{\rm micro} = 2.0$ km s^{-1} (based on the analysis of Fulbright *et al.* 2006). The analysis of this rather metal-poor giant is made relative to Arcturus. As an example we show one of our 4 Crires spectra of the metal-poor bulge giant Arp 4203 in Figure 1, together with a preliminary synthetic spectrum. Crires has four detector frames which are recorded simultaneously and provides 4 times more wavelength coverage and is more sensitive than the Phoenix spectrograph.

In Table 1 we provide our preliminary derived elemental abundances for Arp 4203. The giant is depleted in C and enriched in N, whereas the abundances of O has not changed much, which are signs that matter exposed to the CN cycle (which conserves the sum of C and N nuclei) has been dredged up to the stellar surface. The sum of the abundances of C, N, and O is close to that expected from a non-processed star. We find

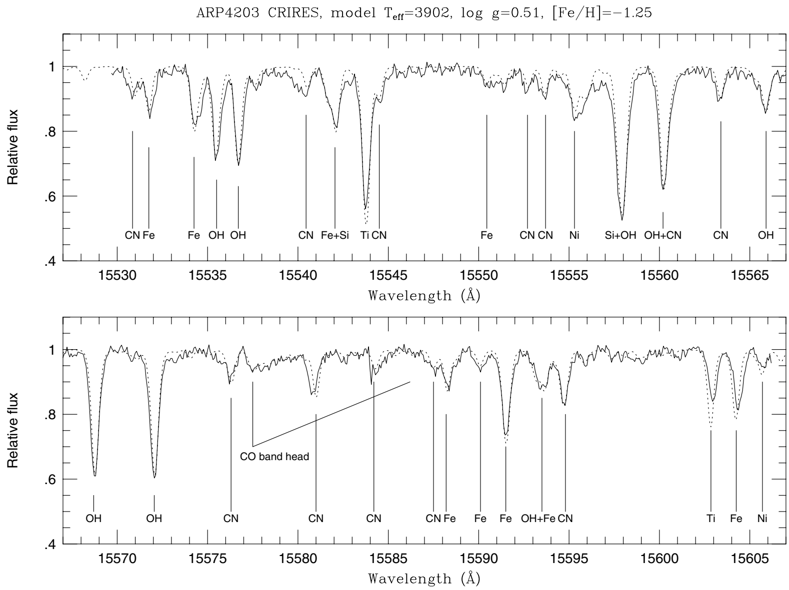

Figure 1. The third frame of our Crires spectrum of ARP4203 (full line). Several molecular lines from CN($v = 0-1$ & $1-2$) and OH($v = 3-1$ & $2-0$), and the band head of the second overtone of CO($v = 3-0$) are modelled, as well as lines from Fe, Ni, Si, and Ti (dashed line).

Table 1. Preliminary stellar abundances derived for Arp 4203. Uncertainties are of the order of 0.1 dex. The standard solar abundances are taken from Grevesse & Sauval 1998, apart from the C, N, & O abundances which are taken from Asplund *et al.* 2003.

Element	ARP 4203 (this study)		ARP 4203 (Fulbright *et al.* 2006)		Arcturus (α Boo)		Solar abundnace
	$\log\varepsilon$	$\Delta\log\varepsilon^{\ddagger}$	$\log\varepsilon$	$\Delta\log\varepsilon^{\ddagger}$	$\log\varepsilon$	$\Delta\log\varepsilon^{\ddagger}$	$\log\varepsilon$
C	6.65	−0.51	–	–	8.02	+0.11	8.41
N	7.75	+1.20	–	–	7.59	+0.29	7.80
O	7.75	−0.06	7.69	−0.12	8.67	+0.31	8.66
C+N+O	8.07	+0.15	–	–	8.79	+0.27	8.89
Si	6.70	±0.00	6.87	+0.17	7.25		7.55
Ca	5.51	±0.00	5.45	−0.06	6.06		6.36
Ti	4.17	±0.00	4.05	−0.12	4.72		5.02
Fe	6.30	+0.05	6.22	−0.03	6.96		7.50
Ni	5.17	+0.17	–	–	5.73		6.25

‡ The abundance compared to the scaled solar one, accounting for the α-element enhancement, $[\alpha/\mathrm{Fe}] = 0.4$.

the abundances of the α-elements Si, Ca, and Ti to be $[\alpha/\mathrm{Fe}] = 0.4$, at the expected levels for an α-enhanced metal-poor star. The nickel abundance is slightly higher than the overall metallicity. Our measurements lie close to those of Fulbright *et al.* (2006) for the elements we have in common. A full analysis and discussion will be presented in Ryde *et al.* 2007 (in preparation).

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