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The Italian contribution to FLAMES: technology and science ⋆

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Abstract. We present a brief description of the multi-object spectrographic facility FLAMES (ESO-VLT2) and of the Italian contribution to its completion. Preliminary results from Science Verification data aiming at detecting the presence of chromospheres and mass loss in red giant stars in the globular cluster NGC 2808 are presented and briefly discussed.

Key words. spectroscopy – globular cluster – red giant stars

1. Introduction

FLAMES (Fibre Large Array Multi-Element Spectrograph) is a multi-object spectrographic facility recently built by ESO and other Consortia. It is mounted at the Nasmyth focus A of VLT UT2/Kueyen and is available for routine observing since April 2003. Detailed information can be found at the ESO website *http://http.hq.eso.org/instruments/flames/*.

The Italian astronomical community has contributed to the completion of this instrument through the Ital-FLAMES Consortium, composed of four Observatories that have invested resources for the following tasks:

TRIESTE: Observing Control Software for UVES in fibre mode (P. Molaro, P. Santin);

BOLOGNA: Management, Templates (C. Cacciari (PI), E. Rossetti, F.R. Ferraro);

CAGLIARI: Data Reduction Software for UVES in fibre mode (I. Porceddu, G. Mulas, F. Buffa);

PALERMO: Data Reduction Software for UVES in fibre mode (R. Pallavicini, F. Damiani).

In return, the Consortium has been granted 11 nights of Guaranteed Time Observations (GTO) that will be shared among the following scientific programs:

1. Understanding the chemical enrichment history of massive globular clusters: Omega Centauri and M 22 (F.R. Ferraro)
2. A central black-hole in the core-collapsed cluster NGC 6752? (F.R. Ferraro)

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⋆ Based on observations collected at the European Southern Observatory, Chile, during FLAMES Science Verification

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3. The interstellar diffuse medium: 3-D structure and its reconstruction (I. Porceddu)
4. Multiobject spectroscopy of galactic open clusters of different ages and metallicity (R. Pallavicini)
5. Chemical composition and dynamics of dwarf spheroidals in the Local Group (P. Bonifacio)
6. The globular cluster NGC 6397: dynamics and its Li dispersion (S. Zaggia)
7. The metallicity distribution of the outer halo from the Chandra Deep Field South (L. Girardi)

The first GT observations are scheduled to be taken at the end of May 2003. At the moment only Science Verification data are available, a small part of which are discussed in Sect. 3.

2. FLAMES technical characteristics

FLAMES is made of several components:

A Nasmyth Corrector, that gives a corrected field of view of 25 arcmin diameter.

A Fibre Positioner (OzPoz), i.e. a system of fibres attached to ferromagnetic plates via magnetic buttons. FLAMES has 2 such plates, that can each be prepared while the other is observing, with a deadtime of less than 15 min for the changeover. The fibre positioning accuracy is < 0.1 arcsec (+ astrometric error), and the minimum object separation due to the physical size of the fibre is 10.5 arcsec.

A link to UVES (Red Arm only): 8 fibres (1 arcsec diameter on the sky), R=45000, 3 setups centered at 520, 580 and 860 nm and about 200 nm wide.

GIRAFFE: wavelength range 370-900 nm. There are three types of feeding fibre systems:
MEDUSA with 132 single fibres of 1.2 arcsec diameter, R$\sim$15000 and R$\sim$7000
IFU with 15 + 15 (sky) fibre bundles, each covering $\sim$ 2x2 arcsec with a space sampling of $\sim$0.52 arcsec, R$\sim$22000 and R$\sim$9000;
ARGUS with one rectangular array, 22 by 14 microlenses, sampling 0.52 or 0.3 arcsec, R$\sim$22000 and R$\sim$9000.

The expected performance of FLAMES has been verified and confirmed during Commissioning and Science Verification (SV) observations: in 1-hr exposure time UVES can reach S/N$\sim$15 (10 in the reddest setup at 860nm) for a A0V star with V=17, and GIRAFFE can reach S/N=10 at V$\sim$21.

The combination of multiplex capability, wide field of view, high spectral resolution and sensitivity contribute to make FLAMES a unique instrument, and particularly suitable and attractive for accurate spectroscopic work in relatively dense stellar fields.

3. First scientific results from SV data

FLAMES SV observations were taken during the period Jan 24 - Feb 02, 2003. Among the several programs accepted for these observations, one – "Mass Loss in Globular Cluster Red Giant Stars" proposed by C. Cacciari and A. Bragaglia – observed 137 stars along the Red Giant Branch (RGB) of the globular cluster NGC 2808, to search for evidence of mass motions (hence possibly mass loss) in the atmospheres of these stars, using three visual diagnostics, i.e. the Ca II H & K, Na D and Hα lines. Astrometry and visual photometry for the target stars were provided by Piotto et al. (2003), who also had a SV program approved on NGC 2808 for radial velocity determinations. 20 stars were observed at high resolution (R=47,000) with UVES, and the others were observed at lower resolution (R=19,000-29,000) with GIRAFFE in MEDUSA mode, monitoring $\sim$ 3 mag down from the RGB tip. This is by far the largest and most complete collection of such data in globular cluster giants,

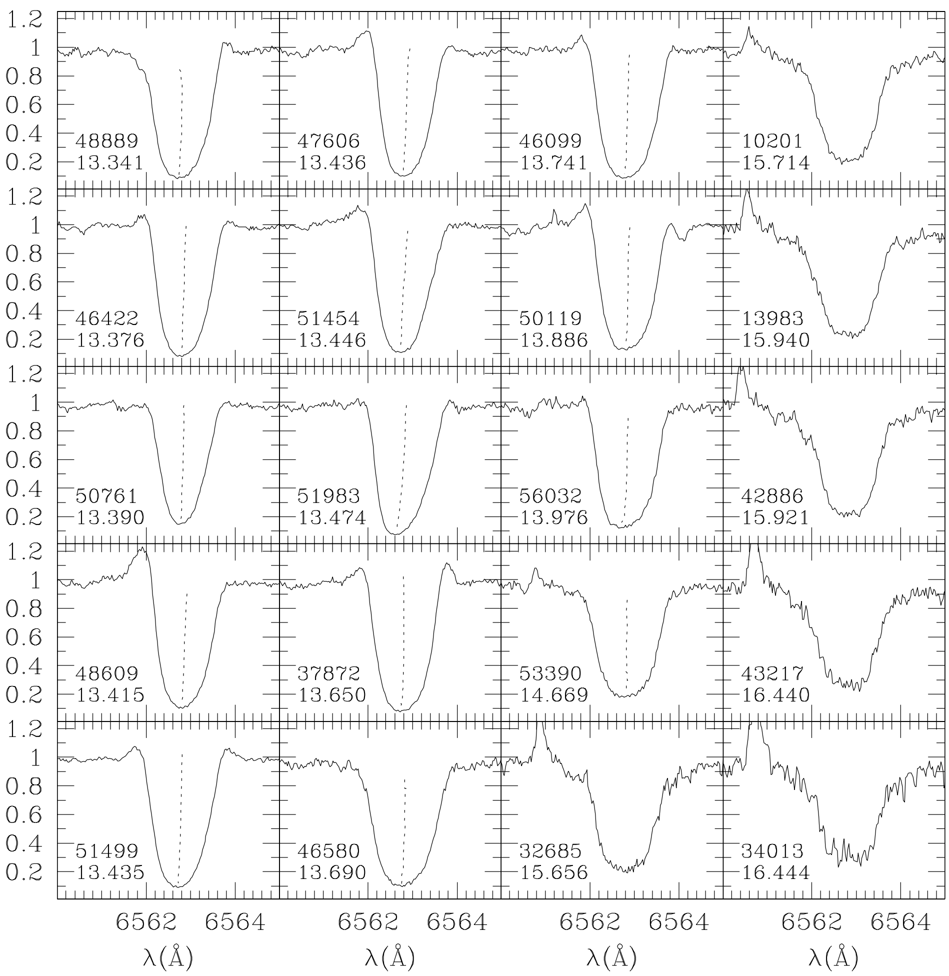

Fig. 1. Normalised parts of spectra containing the Hα line for the 20 stars observed with UVES. The line bisectors indicate a tendency for blueshifted cores in several cases.

both for the number of stars observed within one cluster, and for monitoring all the most important optical diagnostics of chromospheric activity/mass motions.

Hα: we have detected Hα emission wings in ~70% of the stars brighter than $\log L/L_{\odot}$ ~2.5. Some of the Hα profiles from the UVES spectra are shown in Fig. 1. The nature of this emission is most likely due to the presence of chromospheres, although some contribution from an extended atmosphere cannot be excluded. Outward mass motions are suggested by asymmetry (blue coreshifts) in the Hα absorption profile.

Na I D: Na D_1 and D_2 lines were observed for 20 stars with UVES and 82 stars with GIRAFFE. Significant negative Na

D_2 coreshifts have been detected in stars brighter than $\log L/L_\odot \sim 2.9$, suggesting outward motions in the atmospheric layers where the line forms.
Equivalent widths of the Na I D lines have been derived for all stars, and used by Carretta et al. (2003a,b; see also Carretta's contribution to the present conference) to perform a detailed abundance analysis: large variations of Na abundance are found at all positions along the RGB (see also Bonifacio et al., this conference, for independent abundance and radial velocity determinations using several hundred stars of NGC 2808 from the FLAMES SV program coordinated by G. Piotto).

Ca II K line: 22 among the brightest stars ($\log L/L_\odot \geq 2.8$) show the central emission and reversal features that suggest the presence of a chromosphere (see Fig. 2). The mostly negative coreshifts of the K_3 component again indicate the presence of outward motions.

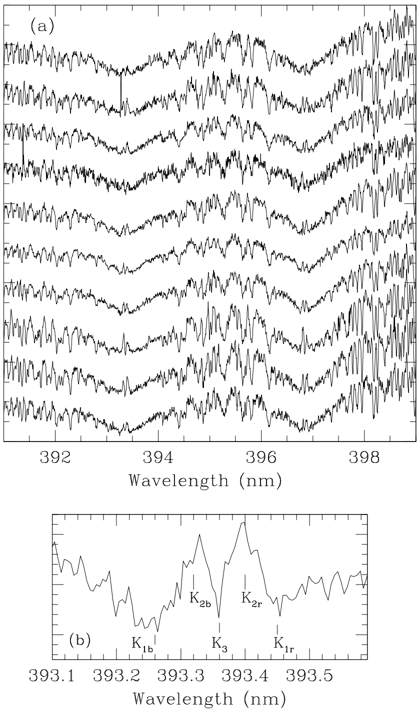

Fig. 2. Parts of spectra containing the Ca II H and K lines, for some of the brightest stars we have observed. The insert shows the zoomed part of the K line for star #51499.

4. Conclusions

Our survey of RGB stars in NGC 2808 searching for mass motion diagnostics in their atmospheres has been able to reach fainter luminosity thresholds and monitor in much more detail along the RGB than any previous study in a given globular cluster. This is due to the FLAMES ability of reaching faint magnitudes with good S/N and good spectral resolution for a large number of stars simultaneously.

Although some of our diagnostics (e.g. Hα emission) may not provide an unambiguous interpretation, other diagnostics give clear indications of the presence of both chromospheres and mass outflows in the atmospheres of these stars.

Final results based on these data will be presented in forthcoming papers (Carretta et al. 2003a,b; Cacciari et al. 2003).

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