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ABSORPTION LINE MAPPING WITH OSIRIS TUNABLE FILTERS: A PILOT STUDY

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RESUMEN

En este trabajo demostramos que es posible obtener espectros de líneas de absorción para cualquier tipo de sistema estelar utilizando los Filtros Sintonizables de GTC/OSIRIS y una técnica de observación novedosa que permite la reconstrucción de los perfiles de las líneas. El método se ha probado con éxito para el sistema de cúmulos globulares de VCC1261, una enana elíptica del cúmulo de Virgo.

ABSTRACT

We demonstrate in this work that it is possible to derive spectra of integrated absorption lines for any type stellar system using the GTC/OSIRIS Tunable Filters and a novel observing technique which allows for a reconstruction of the line profiles. The method has been successfully proven for the globular cluster system of VCC1261, a dwarf elliptical in the Virgo Cluster.

Key Words: techniques: radial velocities — techniques: spectroscopic — galaxies: kinematics and dynamics

1. INTRODUCTION

In this paper we present the very first results of a novel observing technique based on the use of the GTC/OSIRIS Red Tunable Filter (RTF) to determine radial velocities of integrated stellar spectra by scanning in wavelength strong absorption lines. For this purpose we developed and calibrated a sensitive RTF-based radial velocity indicator for the second line of the near-IR calcium triplet at 8542 Å (hereafter CaT2).

Originally, the technique was designed for a GTC observing proposal devoted to study the kinematics of luminous dwarf ellipticals (dEs) in the Virgo cluster and of their globular clusters (GCs), with direct implications in understanding the origin of dEs and their dark matter content. The dE sample for this proposal was selected to host a large number (>30) of GCs with V<24 on the basis of HST/ACS imaging (Strader et al. 2006), to construct 2D kinematical maps of the dE starlight out to $4R_{\rm eff}$ and, simultaneously, to determine the GC kinematics out to $\sim$10 $R_{\rm eff}$. Since our approach is based in direct imaging with the RTF, we estimate that our approach is $\sim$8 times more efficient –in terms of number of spectra per exposure time unit– than classical multi-object spectroscopy techniques in other 10 m-class telescopes.

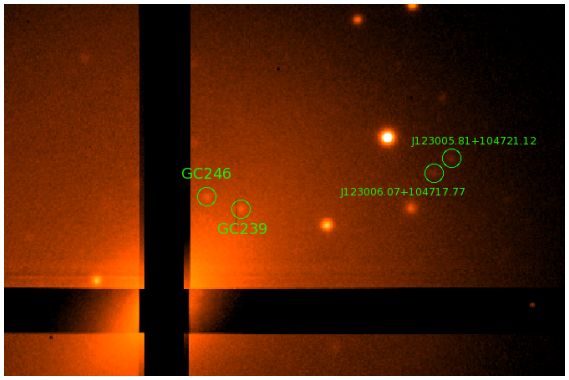

Fig. 1. Coadded RTF images of VCC1261 and its GC system. Green circles indicate the four GCs for which data is presented in this work.

The data that we present here correspond to a pilot study of the technique performed on the Virgo dE VCC1261, with a radial velocity (RV) of 1871 km s^{-1}.

2. OBSERVATIONS AND DATA REDUCTION

VCC1261 was placed in the centre of the OSIRIS FOV and observed with the RTF in a sequence in wavelength for mapping the CaT2 line between 8575 and 8643 Å, using a filter width of 12 Å and a scanning step of 4 Å. The RTF observations were alternated with shorter exposures with an order-sorter filter (8582/581 Å) to account for the continuum. With the order-sorter being used as a continuum fil-

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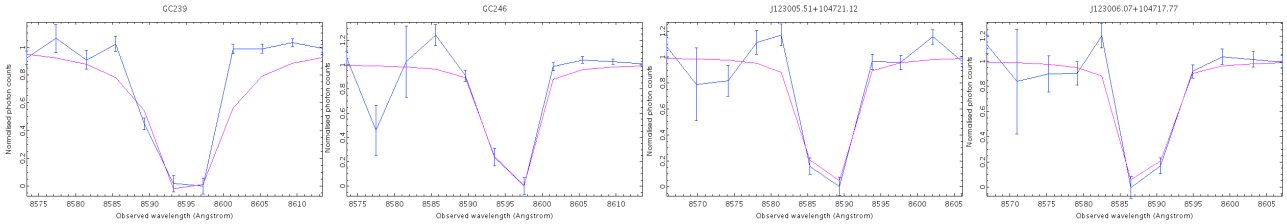

Fig. 2. The profiles of the CaT2 absorption lines of four GC candidates in VCC1261, reconstructed using the OSIRIS RTF scanning technique. In magenta, the best fit to a Lorentzian profile.

ter, the RTF integrations at fixed positions along wavelength allow to reconstruct the CaT2 profile, which is in fact a convolution of the intrinsic line profile and the RTF response. In this approach, RVs and the galaxy velocity dispersion can be accurately derived from the reconstructed CaT2 centroid and width.

Rather than scanning the RTF sequentially in wavelength, we applied a non-consecutive wavelength sequence for the RTF exposures to take advantage of the phase effect typical of interference filters –by which the outer regions of the image correspond to bluer wavelengths– to remove the sky of the previous RTF exposure. This is not so critical for point-like sources like GCs, but it makes a difference for a proper sky subtraction in VCC1261. Hence, by defining appropriately the order in wavelengths of the RTF sequence to sample the line, the outer regions of most RTF observations can be used to compute the airglow contribution in the central regions (i.e. in the galaxy) of the preceding one, with a negligible variation in the observing conditions.

The original observing plan consisted in sampling twice the CaT2 line to increase the S/N. Unfortunately, only the first half of the requested observations were performed, limiting the study to just the brightest GCs around VCC1261 .

Raw observations were subjected to the standard reduction procedure (bias subtraction, flat-fielding and trimming) using `IRAF` tasks. Cosmic-rays were removed using the Laplacian Cosmic Ray Identification algorithm (van Dokkum 2001). Line and continuum science frames were then astrometrically calibrated (RMS=0.1 arcsec) and registered using WCS. We identified up to 15 GC candidates in the coadded RTF images (see Figure 1). Aperture photometry of the GC candidates was obtained using `IRAF apphot` tasks. The effective wavelength for each photometric measure was estimated using the prescription given in González et al. (in preparation) prior measurement of source angular distance to the optical center. With this information we determined the radii to the optical centre for the estimation of the sky contribution in the corresponding frames. The sky brightness for each wavelength and source comes from the average of the raw counts in squares of 2×2 pixels in three different points at the same radius. The final reduction of the photometry was carried out adopting the procedure described in Barth et al. (1994), but customized for the case of absorption line systems. Finally, the reduced data was sorted and reassembled.

3. CONCLUSIONS AND FUTURE WORK

Using the GTC/OSIRIS RTF and the novel observing technique here described, we have obtained for the first time pseudo-spectra of the CaT2 absorption line for more than 15 GC candidates around VCC1261. Figure 2 illustrates four of the derived pseudo-spectra, two of them (GC239 and GC246) already catalogued in Beasley et al. (2009). The next step consists in measuring the CaT2 profile for all the GC candidates to estimate their RVs and obtain a more complete GC velocity field than those provided by classical multi-object spectroscopy. We devised three different approaches to reach this aim: (i) a standard minimization of a CaT2 synthesis grid (RVs, age & metallicity) by using the index scanning technique, (ii) a dual-profile (Voigt) fitting of pseudo-spectra, and (iii) a deconvolution of the observed profile by the instrumental one prior to the Gaussian fitting of normalized, resulting spectral profile.

It is clear from Figure 2 that the designed technique works successfully in reconstructing the CaT2 profile and that accurate RVs can be recovered after applying post-processing techniques. This result opens a new and unexplored window to study absorption-line systems using the OSIRIS tunable filters with the appropriate scanning strategy.

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