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Visual and Near-Infrared Photometry of Nearby Dwarf Spheroidals

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Abstract. This paper is based on photometry from two different observational approaches. Both are of an explorative character and act as feasibility studies. For the future we plan to use these methods to study Asymptotic Giant Branch (AGB) stars in nearby galaxies.

First, we present results on broad-band photometry in Bessell V and I, as well as narrow-band measurements in the Wing 778 nm and 812 nm filters of a galactic globular cluster using the new Austrian Oe-FOSC (Oesterreich Faint Object Spectrograph and Camera), a copy of the ESO Instrument EFOSC mounted on our 1.5 m-telescope.

The second part of the contribution deals with the possibilities of using Gunn I, J and K_S measurements originating from the DENIS (DEep Near Infrared Survey of the Southern Sky) project on similar objects. A few southern dwarf spheroidals already observed within DENIS (covering now some 40% of the southern hemisphere) are selected.

1. Visual Narrow Band Photometry

AGB stars play an important role in studies of stellar evolution and galactic structure and contribute significantly to the enrichment of the interstellar medium. Both their intrinsically high red and infrared luminosity, and their well-defined evolutionary stage, make them important constituents of extragalactic systems. Due to their age they define highly relaxed subsystems.

On the other hand the extragalactic studies are important for our understanding of AGB-evolution itself. The AGB is the final evolutionary stage for more than 95% of all stars that leave the main sequence in a Hubble time! Two of the most interesting questions are the formation of carbon-stars (lower and upper MS mass limits) and the interrelation of pulsation, mass loss, and metallicity. By observing populations of different metallicity, some contributions to answer these and other questions can be expected.

Consequently, the efficient detection and characterisation of such objects is essential. Since survey spectroscopy is not feasible in external systems, photometry plays an important part in the course of statistical studies and preselection for spectroscopic follow-up programmes. Unfortunately, typically fewer than

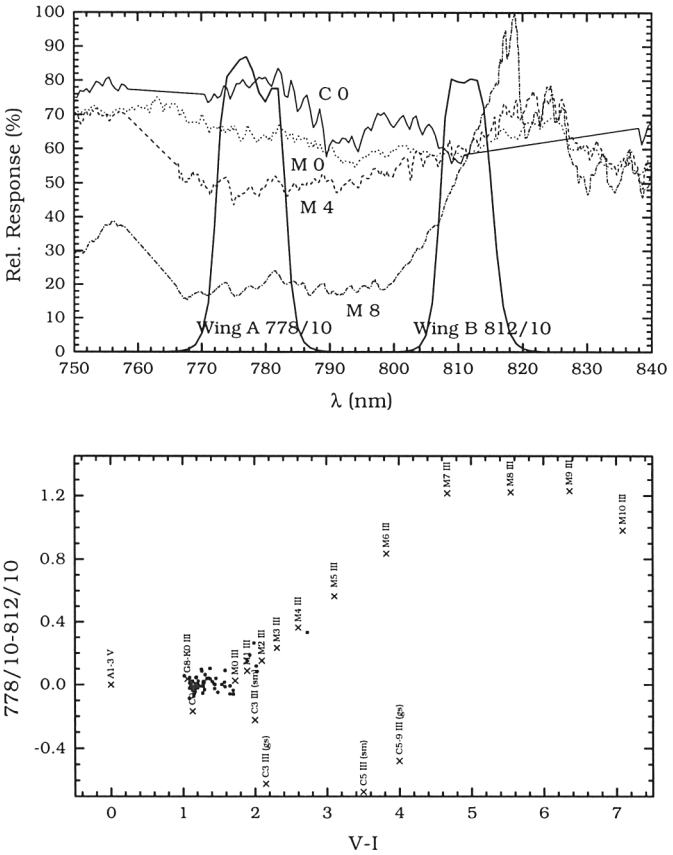

Figure 1. Upper panel: Response curves of the narrow-band filters able to detect O- and C-rich late type giants. Typical spectra of giants are plotted for illustration. Lower panel: Observed and synthetic colours of standard stars (x) overlaid with a "short exposure" of the globular cluster M15 (dots).

10 AGB-Carbon stars are known in each of even the nearest galactic satellite galaxies (Groenewegen 1998). Only the LMC and the SMC can be called "well studied" in this respect. Also in M31 less than 250 Carbon stars have been identified. Hence a large group of objects, being in one of the most important phases of stellar evolution, is not studied in the appropriate way.

Dating back to the early 1970s a system described, e.g. in Palmer & Wing (1982) has been quite successful in identifying O-rich as well as C-rich AGB stars.

The system works as follows. Whereas conventional filters like Bessell V and I are used as temperature indicators, two narrow band filters at 778 nm and 812 nm measure TiO or CN band strengths in the case of O-rich or C-rich AGB stars, respectively. Spectra of such objects with the filter response curves overlaid are shown in the upper panel of Fig. 1.

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By such means these objects can be identified quite easily as demonstrated in the lower panel of Fig. 1, where we have plotted a mixture of synthetic and observed colour indices together with a "short exposure" of only one minute of the northern globular cluster M15. Even with a very low S/N ($\sigma \approx 0.1$ mag in the narrow band filters) it is easy to see the deviation of its M-stars from the 0.0 level in 778−812, where all stars without features in those filters are found (essentially all stars earlier that about M0).

Up to now we only have a few observations of some selected nearby objects using the new Austrian Faint Object Spectrograph and Camera mounted on our Austrian 1.5 m-telescope. Some first tests on M31 using the Nordic Optical Telescope have been carried out in recent weeks. For the future we plan to use these filters for a survey of a larger sample of Local Group galaxies of different star formation history and metallicity. In this way the interrelation of chemical history, main sequence mass and mass loss as a function of the stellar environment can be studied. Our surveyed galaxies will cover a wide range of environmental properties. Moreover, the observation of more fields per galaxy will allow us to probe for different stellar populations (bulge, disk, ...) and to derive properties as a function of galactocentric distance.

2. DENIS Observations

Large near-infrared surveys like 2MASS (Skrutskie et al. 1997) and DENIS (Epchtein 1997) lead to an enormous gain of knowledge about cool, reddened and other "infrared" constituents of our galaxy. Keeping in mind their limits both in magnitude and spatial resolution, they can also be used to study individual objects in very nearby galaxies like the LMC or SMC (Cioni et al. 1998).

It turns out that with DENIS limiting magnitudes of about 18.5, 16.5, and 14.0 in I, J, and K_S, respectively, AGB stars situated in the nearest southern dwarf spheroidals like Sextans, Sculptor, Carina and Fornax with distance moduli between 19 and 21 are just within the limits of this survey. At such small distances, confusion because of the low spatial resolution of DENIS plays a minor role, too.

Since no dedicated observations were available, we tried to detect these galaxies using already available, pipeline reduced DENIS material. As an example, Fig. 2 shows the available DENIS-strips passing close to the dwarf spheroidal in Fornax. In all objects, fields on and off the galaxies were selected for further investigation.

The right panel in Fig. 2 tries to illustrate the detection abilities using DENIS I-photometry. In the case of the two Fornax strips the galaxy turned out to be quite prominent. Notice the different histograms of the two strips passing Fornax. Their heights and δ-positions are due to the different radial distances and the inclination of the major axis of Fornax!

Finally, from colour-magnitude and two colour diagrams not shown here, it turns out that we mainly pick AGB-stars from the dwarf spheroidals. The distributions of on- and off-fields differ only in the reddest parts, where mass-losing AGB-stars are expected.

For the near future we plan a re-reduction of the pipeline processed data-sets which should improve our limiting magnitudes by typically 1.5 mag. Moreover,

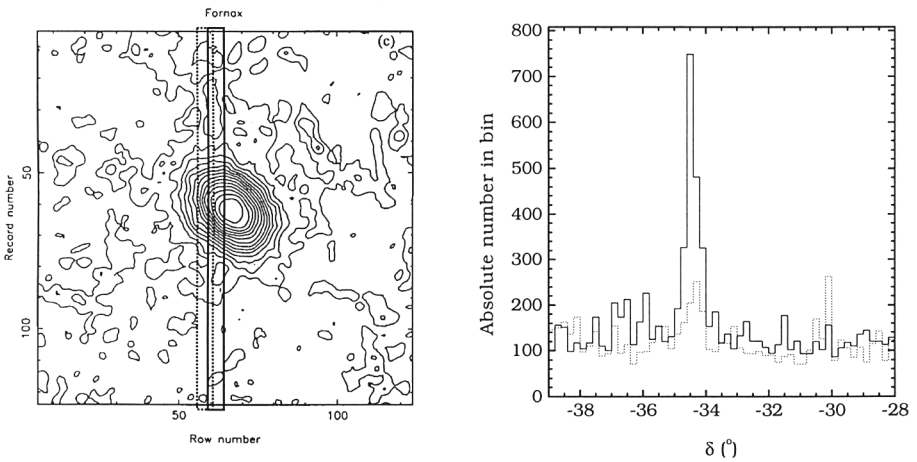

Figure 2. Left panel: Isopleth map of Fornax taken from Irwin & Hatzidimitriou (1995). Two DENIS-strips are indicated. Right panel: Histograms of the number of extracted I-sources for Fornax in the two strips, as a function of declination.

more DENIS-strips at different radial distances from the centres of the galaxies will allow us to derive NIR-density profiles.

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