Ten Times More Halo Dwarfs Now Within the Reach of the CAT

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Introduction

The determination of detailed elemental abundances in the atmosphere of stars is interesting for many branches of Astrophysics. The huge amount of information obtained with high resolution spectroscopy is useful, for example, to test the model of nucleosynthesis in the stars during their life as well as the final stages of nucleosynthesis of the elements in stars. This last case does not seem to be directly linked with abundance determination in stars. Still, at the end of their life, the massive stars expelled processed material into the interstellar medium. Then, the atmosphere of stars which will be formed from the interstellar matter will contain the signature of the matter expelled by the stars. The analysis of stars of different age will give some hints for the understanding of these last stages and for the chemical evolution of the Galaxy. The differential study of dwarf stars relative to the sun gives very accurate results. Moreover, the study of halo dwarfs can give clues on the early evolution of the Galaxy. However, halo dwarfs are faint and the limiting magnitude of the instrument is crucial for such studies. At ESO, high resolution spectroscopy was possible only with the 1.4 m CAT + CES. The detector was a RETICON array of 1,870 photodiodes (15 μm × 700 μm). The limiting visual magnitude was about 7. It was, in principle, possible to obtain fainter stars by long exposures but the so-called "cosmic rays" made the choice hazardous. Multiple exposures of the same object could also be done but the time needed to obtain good spectra for a large sample of stars was quite long and prohibitive. Thus, this instrumentation was typically used for disk dwarfs. The resolving power was of the order of 100,000. Only the brightest halo dwarfs were then observable.

In January 1986, a new camera was installed at the CES. At the same time, a new CCD receptor was available. It is a double density RCA CCD (ESO CCD 8, 640 × 1,024 pixels, 15 μm square). Details on the technical and optical properties are given in No. 43 of the *Messenger* by Dekker et al. (1986). Allocation time has been allocated with this instrumentation for the period 36. The purpose of this paper is to show that halo dwarf stars can now be easily studied with the 1.4 m CAT of ESO. About ten times more halo dwarfs are now within the reach of the CAT.

Observations and Analysis

4 nights we allocated for the observation of halo dwarfs: it was the first regular run for visiting astronomers with this instrumentation (28 May to 1 June 1986). During the first night, the sky was cloudy. For the last three nights, we have been able to take spectra of 6 halo dwarfs, the magnitude of which were ranging from 8.1 to 9.07. For each star, we have obtained spectra in different regions of wavelength in order to derive the abundances of several light metals in the halo dwarfs. In this paper, we would like to present the analysis of the star HD 160617 (m_v = 8.74). For this star, we have obtained three spectra (table 1). A part of one of these spectra is shown in Fig. 1. The resolving power is about 50,000. Flat-field exposures were taken after each exposure, using the tungsten lamp. The reduction of the data was carried out with the reduction chain of programmes ASTERIX on the VAX computer of Paris Observatory at Meudon. The determination of the elemental abundance, based on the comparison of the line profiles with synthetic profiles, have been done following the same procedure as in François (1986a). For the main parameters of the atmosphere of HD 160617, we followed Perrin (1986) and adopted θ_{eff} = 0.86 log g = 3.5 and [Fe/H] = −1.60. We have also taken the microturbulent velocity v_t = 1 km/s as in Perrin (1986).

$\bar{\lambda}$	Date	Exposure	S/N
6700	29/30 May 86	2 H 00	250
6160	30/31 May 86	2 H 00	250
4730	31 May/1 Jun 86	2 H 00	150

Table 1: *Spectrograms of HD 160617*

Results

Aluminium lines at λ 6696.032 and 6698.3 were not observable in this star because they were too faint (less than 2 mÅ). However, Sodium, Magnesium and Silicon abundances have been obtained. Results are presented in table 2. The ratios [Mg/Fe] and [Si/Fe] found in HD 160617 confirm the overabundance of α-elements (O, Mg, Si, Ca) in halo dwarf stars found with larger telescopes. The value of the [Na/Mg] ratio is in agreement with the ratio found by François (1986b) where a constant ratio in halo dwarfs was suggested.

Magnesium and Silicon are built mainly in massive stars and the overabundance of these elements in old stars which are halo stars seems to show that SNII (whose progenitors are massive stars) have mainly contributed to the enrichment of the halo (Matteucci et al. 1986, Cayrel 1986).

However, only few determinations of elemental abundances in halo dwarfs exist up to now, and new observations

[Fe/H]	= −2.00
[Mg/Fe]	= +0.50
[Na/Fe]	= −0.03
[Si/Fe]	= +0.35

Table 2: *Relative abundances*

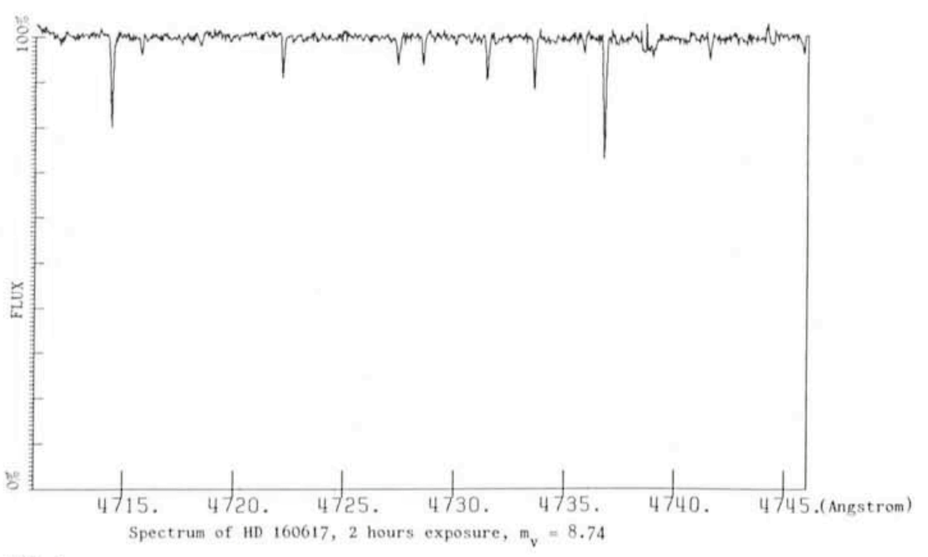

Fig. 1.

are important for understanding the chemical evolution of our Galaxy. The 1.4 m CAT + CES equipped with the short camera + CCD is now, as we have tried to show, suited for this study.

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Bierce and Astronomy

Ambrose Bierce, the famous American satirist, was born in 1842 and is believed to have died in 1913, during the revolution in Mexico. A man of many trades, he spent part of his life in San Francisco as a journalist. He apparently made the first entries to "The Devil's Dictionary" around 1876, but it was only after 1881 that regular instalments began to appear in the "Wasp" under Bierce's chief editorship.

Although Bierce apparently showed no particular animosity against astronomers, he did include some references in the "Dictionary". Here are some (slightly abbreviated) examples of his wit, written more than one century ago:

Astrology, n. The science of making the dupe see the stars. Astrology is by some held in high respect as the precursor of astronomy (. . .).

Comet, n. An excuse for being out late at night (. . .).

Dawn, n. The time when men of reason go to bed (. . .). The reason we find only robust persons doing this thing is that it has killed all the others who have tried it.

Electricity, n. The power that causes all natural phenomena not known to be caused by something else. It is the same thing as lightning and its famous attempt to strike Dr. Franklin is one of the most picturesque incidents in that great and good man's career. (. . .) The question of its economical application to some purposes is still unsettled, but experiment has already proved that it will propel a street car better than a gas jet and give more light than a horse.

Gravitation, n. The tendency of all bodies to approach one another with a strength proportioned to the quantity of matter they contain – the quantity of matter they contain being ascertained by the strength of their tendency to approach another. (. . .)

Morning, n. The end of night and dawn of dejection. The morning was discovered by a Chaldean astronomer, who, finding his observation of the stars unaccountedly interrupted, diligently sought the cause and found it. After several centuries of disputation, morning was generally accepted by the scientific as a reasonable cause of the interruption and a constantly recurrent natural phenomenon.

Newtonian, adj. Pertaining to a philosophy of the universe, invented by Newton, who discovered that an apple will fall to the ground, but was unable to say why. His successors and disciples have advanced so far as to be able to say when.

Observatory, n. A place where astronomers conjecture away the guesses of their predecessors.

Telescope, n. A device having a relation to the eye similar to that of the telephone to the ear, enabling distant objects to plague us with a multitude of needless details. Luckily it is unprovided with a bell summoning us to the sacrifice.

Zenith, n. A point in the heavens directly overhead to a standing man or a growing cabbage. A man in bed or a cabbage in the pot is not considered as having a zenith, though from this view of the matter there was once a considerable dissent among the learned, some holding that the posture of the body was immaterial (. . .).

List of ESO Preprints

September–November 1986

465. F. Murtagh and A. Heck: An Annotated Bibliographical Catalogue of Multivariate Statistical Methods and of their Astronomical Applications (Magnetic Tape). *Astronomy and Astrophysics Suppl.* September 1986.
466. D. Baade: Be Stars as Nonradial Pulsators. Invited review presented at IAU Coll. 92 "Physics of Be Stars", Boulder, 18–22 August 1986. September 1986.
467. C. Motch et al.: The Optical Light Curve of the Low Mass X-Ray Binary XB 1254-690. *Astrophysical Journal.* September 1986.
468. M. Rosa and J.S. Mathis: On the Chemical Homogeneity of the 30 Doradus H II Region and a Local Enrichment by Wolf-Rayet Stars. *Astrophysical Journal.* September 1986.
469. M. Heydari-Malayeri, V.S. Niemela and G. Testor: The LMC H II Regions N 11 C and E and their Stellar Contents. *Astronomy and Astrophysics.* September 1986.
470. A. Lauberts: UBVRI Photoelectric Photometry of 48 Southern Galaxies. *Astronomy and Astrophysics.* October 1986.
471. F. Murtagh and A. Lauberts: A Curve Matching Problem in Astronomy. *Pattern Recognition Letters.* October 1986.
472. T. Gehren and D. Ponz: Echelle Background Correction. *Astronomy and Astrophysics.* November 1986.
473. E. Giraud: Malmquist Bias, Type Effect and Dispersion in the Tully-Fisher Relation. *Astronomy and Astrophysics.* November 1986.
474. R. Gathier: Properties of Planetary Nebulae I. Nebular Parameters and Distance Scale. *Astronomy and Astrophysics.* November 1986.
475. M.H. Ulrich: Observations of Active Galactic Nuclei with IUE and Comparison with X-Ray Data. Review paper given at the NASA/ESA/SERC Conference held in London, 14–16 July 1986: "New Insights in Astrophysics: 8 Years of UV Astronomy with IUE". November 1986.

A Workshop organized by ESO on

STELLAR EVOLUTION AND DYNAMICS IN THE OUTER HALO OF THE GALAXY

will be held at ESO, Garching, **April 7–9, 1987.**

Topics of this 3-day workshop will include observational and theoretical aspects concerning chemical evolution and dynamics of field stars, globular clusters and planetary nebulae in the halo of our Galaxy and in halo systems – Magellanic Clouds and Dwarf Spheroidals.

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