Paper nº I.1.

HIGH RESOLUTION SPECTROSCOPY WITH THE E.S.O. COUDE ECHELLE SPECTROMETER (*)

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I. INTRODUCTION

Various applications of high resolution spectroscopy with the E.S.O. Coudé Echelle Spectrometer (CES) are discussed. The aim of this paper is not to present a complete survey of the CES capabilities, but to illustrate some possible applications, with emphasis on rather unusual aspects. In all the observations presented here, the CES has been used with the new short camera and a CCD detector (high resolution RCA SID 503, 640 x 1024 pixels, 15 x 15 μm each). Compared to the long camera and Reticon detector, this new combination represents an increase of efficiency of 2 to 3 magnitudes, with only a moderate loss of resolving power.

II. OBSERVATIONS

1. Comets

The use of a CCD detector adds a spatial dimension to the recorded data, which allows to investigate the spatial variation of the spectra of extended objects, such as comets. Although at the Coudé focus, the position angle of the slit on the sky changes continuously, useful information may be obtained from relatively short exposures. As an illustration, we present in Fig. 1 a spectrum of Comet Wilson around the CH band at 4300 Å obtained on April 7, in 70 min exposure.

(*) Based on observations collected at E.S.O. (La Silla).

The resolving power was set to 50000. The extended molecular emissions are easily distinguished from the much narrower continuous spectrum. The spatial extension is of the order of 2 arc minutes while the spectrum covers some 35 Å. The high resolution spectroscopic study of Comet Wilson was made in collaboration with C. Arpigny, F. Dossin, R. Haefner and J. Manfroid.

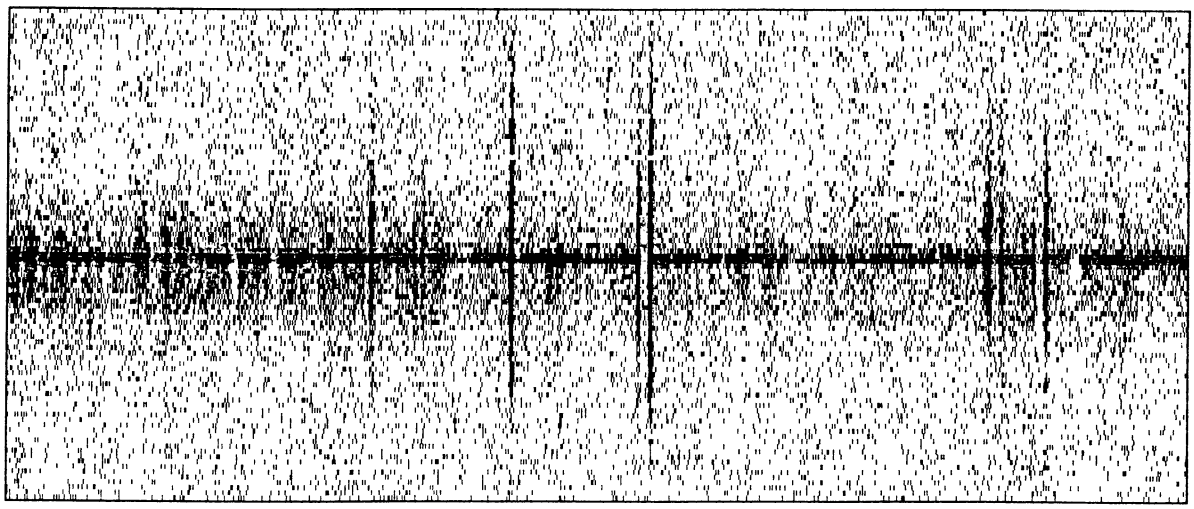

Fig. 1. Spectrum of Comet Wilson around the CH band at 4300 Å.

2. Wolf - Rayet variability

The gain in efficiency, which allows high S/N spectra to be recorded in a rather short time for relatively faint objects, facilitates the study of rapid spectral variations. The CES has been used in early April to monitor a number of Wolf - Rayet stars in a search for spectral variations with periods of a few hours. Fig. 2 presents the spectrum of the WN 7 star HD 151932 around the 4471 Å He I line obtained on four different nights. Variations in the absorption component of the P Cygni profile are clearly seen. An exposure time of 35 min allowed to reach a S/N of 350 for this 6.6 mag star at a resolving power of 50000, despite the fact that this

wavelength range is rather far from the peak sensitivity of the instrument. This study is a collaboration with D. Baade, J. Manfroid, O. Stahl and J.- M. Vreux.

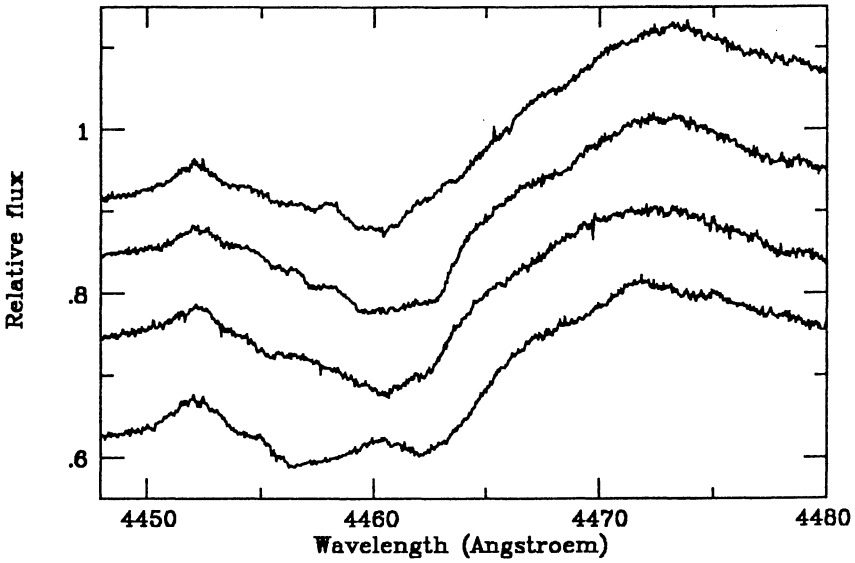

Fig. 2. Spectra of the 4471 Å He I line in HD 151932 on four different nights.

3. Day-time observations of Be stars

Intensive monitoring of stars which vary on time scales of months ideally requires observations to be made during the full year. The possibility of making day-time observations is thus very interesting, not only because the star may then be followed over a much larger fraction of the year, but also due to the fact that the telescope is much more easily available during day-time. Thanks to the kind cooperation of visiting astronomers, some test observations were carried out on a few bright Be stars. Fig. 3 shows the H_α profile of δ Cen = HR 4621, observed on January 7. The exposure sequence was star-sky-star, which allowed a very good sky correction. The total exposure time was 80 sec for this 2.6 mag star. This program is a collaboration with D. Baade.

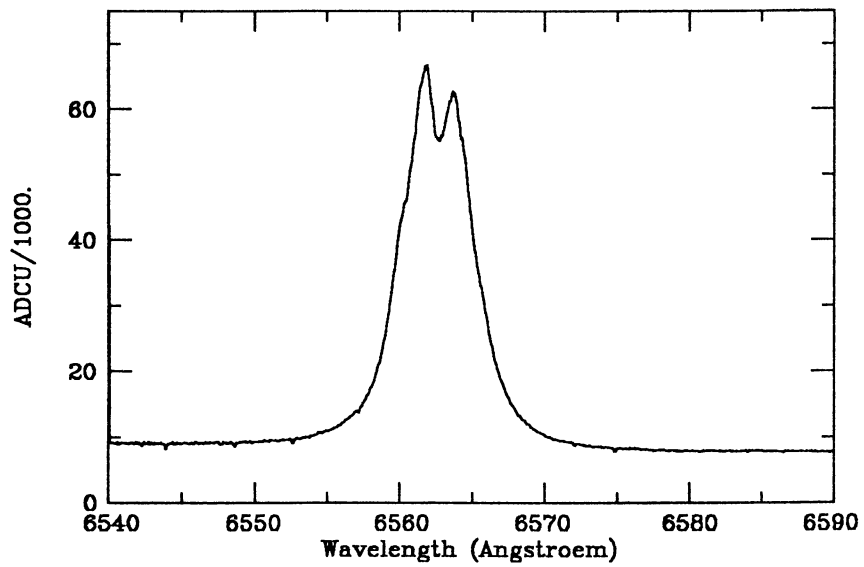

Fig. 3. Day-time spectrum of the H_α line in δ Cen.

4. The age of the field halo stars

The age of the globular clusters can be determined from the comparison of their Hertzprung-Russell diagram with theoretical isochrones. But, up to now, that method could not be used to obtain the age of the field halo stars with useful accuracy. The main reason for this is the lack of accurate parallaxes. A way around this problem is to obtain accurate surface gravities by spectroscopic means. However, the standard method, which uses ionization equilibria, does not provide the requested accuracy and is subject to systematic errors, due to eventual departures from local thermodynamic equilibrium (LTE). A potentially much more accurate method is to compare the wings of strong lines with weak lines originating from the same atomic level. However, in these metal-poor stars, few suitable strong lines can be found, so this method requires high resolution and high S/N to allow an accurate surface gravity to be deduced from a single moderately strong line. Since the brightest of these metal-poor stars are typically of 8th magnitude, the short

camera with the CCD is needed. Fig. 4 shows the observed profile of the 4383 Å Fe I line in HD 194598, compared with the predictions of models having surface gravities log(g) = 3.5 and 4.0. A value of 3.9 is deduced for this star, with an accuracy which should be better than 0.1 dex. (The discrepancy of the computed and observed line cores may be due to non-LTE effects in the outer layers, and does not affect the result, which is based on the line wings). The exposure time for this 8.4 mag object was about 2 hours, at a resolving power of 80000.

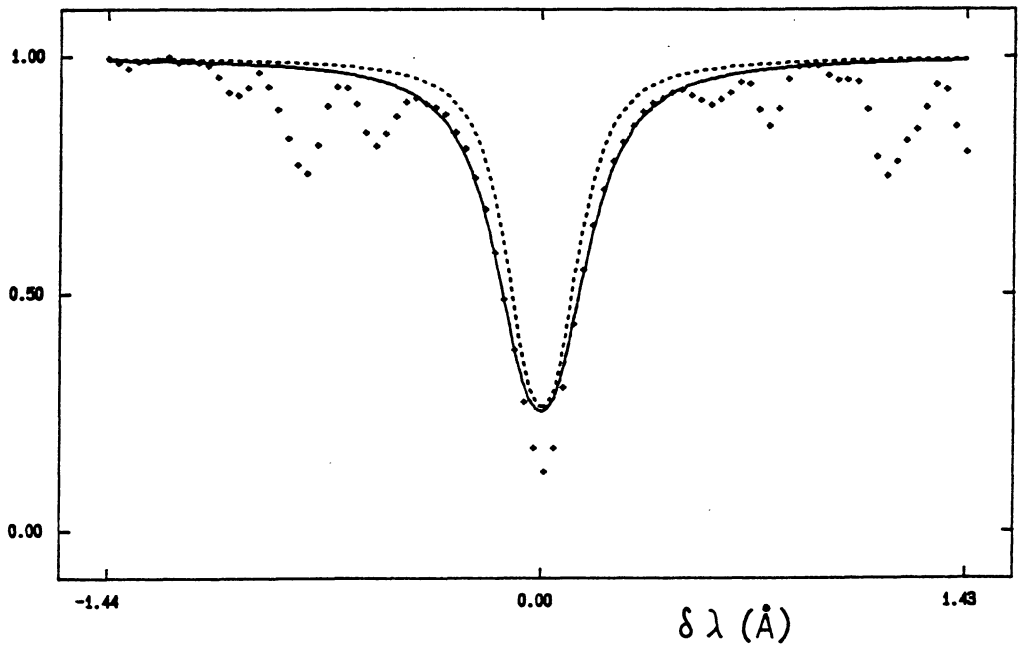

Fig. 4. The 4383 Å Fe I line in HD 194598 compared to predictions of models with log(g)=3.5 (dashed line) and log(g)=4.0 (continuous line).

DISCUSSION (Paper I.1)

VOGT : Why does CCD feature lower resolution than Reticon ?

MAGAIN : Its' behind a faster camera ... image scale is different.

FORREST : Why did continuum of comet disappear between the two strong emission lines ?

MAGAIN : This is because of the presence of an absorption line in the reflected solar spectrum.