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The Analysis of Digitised Objective Prism Spectra

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Abstract. A method for a fully automatic reduction of digitised objective prism spectra is developed. It leads to positions and radial velocities, magnitudes and intensities of spectral lines. The latter then can be used for classification purposes. The system is tested with plates taken with a specific telescope-prism-filter combination.

It has long been known that objective prism plates can serve for the determination of stellar positions and radial velocities. Digitising objective-prism plates, as proposed by Rose (1984) and by Rose & Agostinho (1991), opened the field for a quantitative classification of spectral types, luminosities, and metallicities. Subsequently, methods were developed by the author to derive the positions and radial velocities directly from the digitised spectra. Finally a system of programs was developed which goes in a fully automatic manner all the way from locating the spectra on the plates to coadding the spectra from several plates, locating spectral lines in the spectra and determining their intensities, to the positions, radial velocities, and spectral indices. It is the purpose of this presentation to give an overview of the processes involved. A detailed description of the method will be published elsewhere.

The first step, naturally, is the scanning of the plates with a scanning microdensitometer such as a PDS or a GALAXY machine. An adequate size of the analyzing beam as well as of the steps in both the dispersion and perpendicular directions have to be chosen previously. Likewise the size of the window to be scanned around each spectrum has to be determined before the sanning can be started.

The next step is to produce an input list. The Guide Star Catalogue proves to be an excellent source for the preselection of stars to be scanned. Its positions are accurate enough for the purpose, and its magnitudes permit the definition of a uniform limiting magnitude for the scanning list. Furthermore it can serve to eliminate, ahead of time, those stars which would show overlapping spectra.

To facilitate the following discussion we define a rectangular coordinate system such that the Y-direction coincides with the dispersion direction. The X-direction is perpendicular to the dispersion and is occasionally referred to as the transversal coordinate. The origin of both coordinates should coincide with the plate center.

Once a plate is scanned the following steps have to be taken:

1. Find the tilt of the spectra.

2. Determine the width of the spectra in the direction of the X-axis.

3. Determine the coefficients of a polynomial describing the width of the spectra as a function of the rectangular coordinates X and Y and the photographic density.

4. Determine spectrum by spectrum whether it has the proper tilt and width.

5. Determine the background reading.

6. Co-add the spectra in the transversal direction.

7. Co-add spectra from different plates with identical directions of the dispersion.

8. Produce a standard list of spectral lines which may be found in the spectra and their exact relative positions.

9. Locate all absorption lines in every spectrum.

10. Identify the lines found by matching them with the standard list.

11. Steps 9 and 10 are applied separately to the coadded righthand and lefthand spectra.

12. Determination of the Y-coordinate.

13. Combining righthand and lefthand spectra, using procedures explained elsewhere (Stock 1984) positions and radial velocities can be obtained.

From this point on we deal with the procedure leading to spectral indices.

14. Co-add righthand and lefthand spectra by cross correlation.

15. Calculate mean density for spectra for which magnitudes are available and find their relation.

16. Convert densities to intensities.

17. Locate line by line a pseudo-continuum.

18. Determine the line depth and width using the pseudo-continuum.

The entire system outlined above in 18 steps has been applied to spectra which were taken with the Schmidt Telescope on Cerro Tololo, equipped with a 10-degree prism, and an interference filtere of 150Å width centered approximately at Hδ. A spectrum coadded from six plates is shown in Fig. 1. A total of twelve lines was found with sufficent frequency in the spectra. These include the lines used by Rose (1984) and by Rose & Agostinho (1991). Fig. 2 shows an example of an empirical calibration using mean densities and intensities observed with a CCD.

Fig. 3 shows the relation which was found between two of the Fe-lines which are evidently well correlated. The Sr-line at 4077Å is known to be a luminosity indicator. Fig. 4 shows its relation with respect to a combination of Fe-lines.

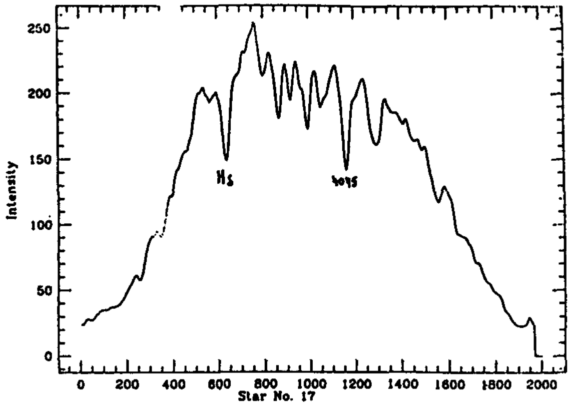

Figure 1. A sample spectrum of a late-type star taken in a spectral window of width 150 Å.

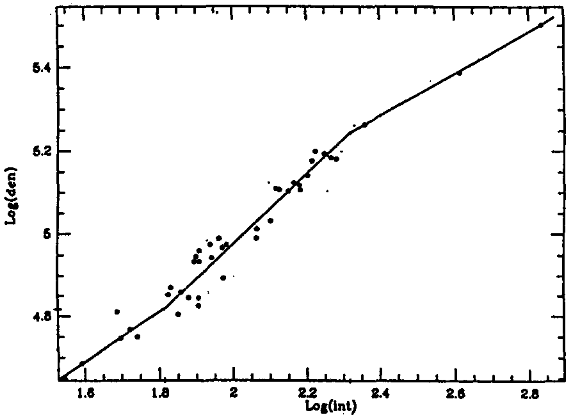

Figure 2. Example of an empirical calibration using mean densities and intensities observed with a CCD.

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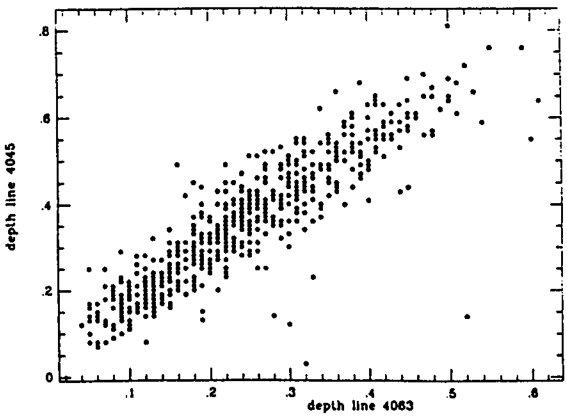

Figure 3. Empirical relation between the pseudo-depths of two Fe lines.

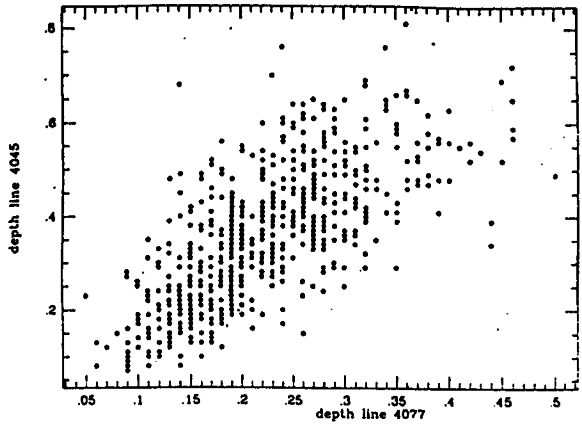

Figure 4. Empirical relation between the pseudo-depths of Fe-lines and that of a Sr line.

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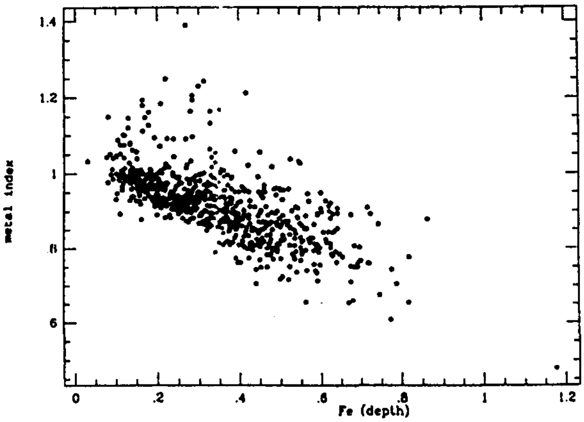

Figure 5. Empirical relation between the pseudo-depths of Fe-lines and a metallicity index.

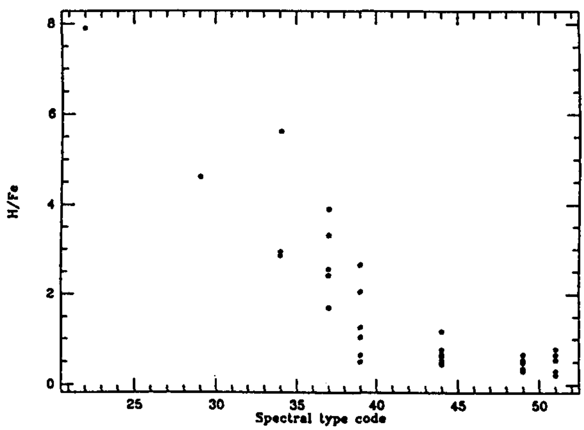

Figure 6. Relation between the spectral types by N. Houk and the spectral index H/Fe. The spectral type are coded such that F0 = 30, G0 = 40.

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There is evidently some correlation which is to be expected since both lines are temperature sensitive, but it is also clear that at least one additional stellar physical parameter is involved. Rose (1984) found that the apparent intensity maxima at three well defined wavelengths can be used to test the metallicity of the objects. Fig. 5 shows how the respective index is correlated with the intensity of Fe-lines.

It is not our purpose to reproduce the MK-system by an automated method of classification. Spectral types and luminosities derived in a numerical manner as above will define its own system and will have to be calibrated with the help of stars for which the numerical values of physical parameters are known. Even so a comparison with MK data is in place. Fig. 6 shows a comparison of the measured ratio $H\delta$/Fe with spectral types by N. Houk (1975). Rose uses basically the same ratio for the determination of his spectral type index, but he makes use of the central intensities at the bottom of the lines, while here we use the depth relative to the pseudo-continuum.

References

Rose J. A., 1984, AJ, 89,1238

Rose J. A. & Agostinho R., 1991,AJ, 101, 950