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MORPHOLOGY OF LOW-RESOLUTION SPECTRA OF LATE-TYPE STARS IN THE NEAR-INFRARED

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RESUMEN. Se presentan resultados preliminares sobre la aplicación de técnicas de procesamiento digital de imágenes para la caracterización del espectro de estrellas M y carbono en placas prisma-objetivo. Se utilizaron placas obtenidas con los telescopios Schmidt de CTIO y CIDA, ambos equipados con prismas de cuatro grados. Se fotografiaron diversos campos en la Vía Láctea, utilizando emulsión Kodak IV-N (hipersensibilizada con AgNO3) en combinación con un filtro Schott RG-695, obteniéndose espectros en el rango de 6800- 8800Å con dispersión de 1700Å /mm (CIDA).

Se digitalizaron imágenes de espectros de estrellas M y C, en estas placas, utilizando los microdensitómetros PDS 1010 del Centro Científico IBM de Venezuela y Joyce-Loebl de la Universidad de Los Andes.

El sistema interactivo de procesamiento digital de imágenes, HACIENDA, del mismo Centro, se utilizó para estudiar los espectros resultantes. Se aplicaron a las imágenes rutinas de procesamiento para elevar contrastes y codificar en color falso. Las imágenes resultantes se caracterizaron, desde un punto de vista morfológico, utilizando el contenido de pixels de densidades especificadas y la definición de índices de color virtuales. Se discute la aplicación de este procedimiento para la obtención de datos espectroscópicos, fotométricos y astrométricos con métodos automatizados.

ABSTRACT. Preliminary results on a procedure intended to characterize the low-dispersion spectra of M and carbon stars using image-processing techniques is presented. Objective-prism plates were obtained with Schmidt-type telescopes at CTIO and CIDA, each equipped with a four-degree prism. Several fields in the Milky Way were photographed using Kodak IV-N emulsion (hypersensitized in AgNO3) and a RG-695 Schott filter. This procedure yielded spectra in the range 6800-8800Å , with a dispersion of 1700 Å /mm (CIDA).

Density tracings from the spectra of M and C stars, on the plates, were obtained using the PDS 1010 microdensitometer, at the IBM Scientific Center, in Caracas, and the Joyce-Loebl microdensitometer at the Universidad de Los Andes, Mérida.

The IBM interactive image-processing system HACIENDA was used to study the resulting images. Contrast-enhancing and color-coding routines were applied to the spectral images. They were characterized applying morphological criteria based on pixel-density distribution plots and the definition of virtual color indices. Practical procedures for obtaining spectroscopic, photometric and astrometric data from Schmidt plates using automated methods are discussed.

Key Words: Carbon stars: spectra. M stars: spectra. Image-processing.

I. INTRODUCTION

Over the years, low-resolution spectroscopy has proved to be a very useful technique in studying the stellar content of our Galaxy and other star systems. Schmidt-type telescopes and astrographs, equipped with objective prisms, are continously being used to survey large areas in the sky. Lately, large reflecting telescopes, with Grisms and Grens devices located at their prime foci, have been used to resolve the spectra of individual objects in some nearby external galaxies. An excellent summary of the fundamental studies in the field has recently been given by McCarthy (1984).

There has recently been renewed interest in studying the surface and space distribution of late-type objects such as M, carbon (C) and S stars in the Galaxy and in some nearby dwarf galaxies. Results derived from near-infrared surveys suggest a significant correlation between the population ratio of C and M stars (C/M) and the metallicity of the star system where they are found (Blanco, Blanco and McCarthy 1978). These studies also suggest that the carbon star population is related to the chemical evolution and the star formation history of the given systems (Richer 1981).

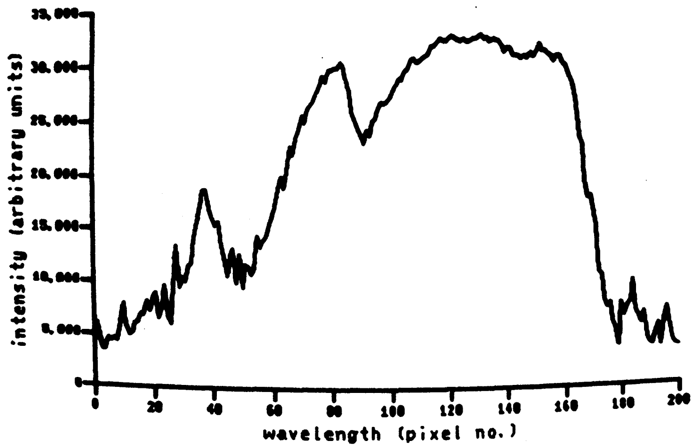

Figure 1. Intensity tracing of the spectrum of a late M star as seen on a monitor screen.

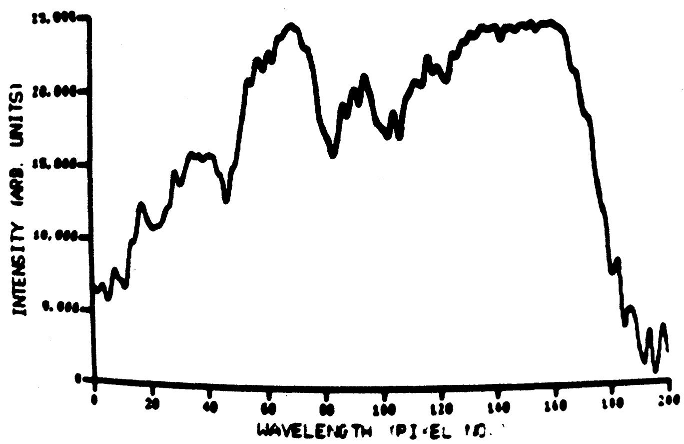

Figure 2. Intensity tracing of the spectrum of a C star as seen on a monitor screen.

Carbon star surveys are usually carried out applying objective-prism techniques in the bue, red and near-infrared spectral ranges. The samples of carbon stars collected in the same sky region, but using different spectral ranges, are not necessarily identical. Blue surveys often pick out the hotter stars, while the redder and cooler carbon stars are selected by the red and near-infrared surveys. Whichever technique is applied to look for carbon stars, among the few hundred or thousand of star spectra on a Schmidt plate, a painstaking and tedious labor is often involved. Cataloguing stars identified on an objective-prism plate also requires the brightness estimation and accurate position determination. Efforts have been made everywhere in order to ease this task.

In this work we report on an attempt to apply image-processing techniques to identify the spectra and to measure the brightness and position of carbon and M stars on objective-prism plates. The plate material is described in Sec. II, and the image-processing technique is presented in Sec. III.

II. THE PLATE MATERIAL

The 61/91 cm Curtiss Schmidt telescope at Cerro Tololo InterAmerican Observatory, and the 100/150 cm CIDA Schmidt in Venezuela, each equipped with a 4-degree prism, were used to secure a set of near-infrared plates taken in several fields of the Milky Way. Kodak IV-N emulsion (hypersensitized in a 0.01 molar AgNO3 solution) were exposed through a 3-mm Schott RC-695 filter. This emulsion-filter combination yields a band-pass between λ 6800 Å and λ 8800Å , with a reciprocal dispersion of 1700 Å/mm (CTIO) and 2100 Å/mm (CIDA) at the telluric A band. All exposures were guided and the spectra unwidened. CTIO plates were exposed during 45 min. and the CIDA plates 30 min.

Several good-quality spectral plates were selected and examined with a binocular microscope. M and C stars ere identified using the usual criteria given in Nassau and Velghe (1964). Brightness was estimated by eye using veral star references on the same plate. Accurate positions, with a mean error of 1 arc sec, were measured in a Zeiss ;K-2 machine. A list of the M and C stars found during this survey is given elsewhere (Fuenmayor 1985).

I. THE IMAGE-PROCESSING TECHNIQUE

The Perkin-Elmer PDS 1010 microdensitometer at the Centro Científico IBM, in Caracas, was used to gitize several representative specimens of M and C stars found on the plates. Due to the small size of the images on the ate (about 1.5 mm long), a spatial resolution of 5 microns and a low scanning speed were required. Several runs in ansmission mode, 200 pixels long and 50 pixels wide, were carried out covering the spectral image and the surround-g plate background. The photographic image is converted, in this way, into a matrix of pixels each containing 12 bits information. Due to hardware limitation this information is truncated to 8 bits without significant losses.

Once the digitation was performed, the original picture was visualized using a high-resolution color monitor tached to an image-processing equipment called HACIENDA developed by IBM (Franchi et al. 1983). The picture ıd to be first magnified by a factor of four using an algorithm of cubic convolution. The images appeared with a fair nount of noise (as in the case of a few dense spectra), and therefore had to be further processed using a low-pass filter hich generated a smoother image. Using equalization techniques it was possible to expand the range of gray levels side the spectrum, resulting in an image of better contrast. Finally, each group of pixels was codified a with different ›lor, obtaining therefore a supervised classification of the complete image. The different zones of absorption by olecular bands appear clearly on the final image allowing accurate photointerpretation. Furthermore, each spectrum as carefully histogrammed giving us the relative amount of pixels. By adding in each class the amount of pixels ›tained, we were able to draw the relationship between the absorption bands. In Figures 1 and 2, intensity tracings of ıe spectra of a late M star and of a C star are respectively shown as they appear on the monitor screen.

The final analysis was performed with a PL/I program, allowing us to draw intensity tracings based on the ocessed images. The data was then plotted and visualized using an IBM 3279 terminal..

/. CONCLUSIONS

Preliminary results on the application of PDS microdensitometry and image-processing techniques on objec-ve-prism images are promising. The spectra identification, brightness and position determination can be carried out ırough image manipulation. Software routines have been applied to improve image contrast and to reduce noise in eak images. We intend to develop a routine to process a whole Schmidt plate in order to help speeding up cataloguing ocedure.

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EFERENCES

lanco, B.M., Blanco, V.M., Ana McCarthy, M.F.: 1978, Nature, 217, 638

ranchi, P. González, J. Montey, P. Parolo, A. and Simmons, J.: 1983, IBM Journal of Research and Development, 27, 116.

uenmayor, F.J.: 1985 in preparation.

lcCarthy, M.F.: 1984, in "Astronomy with Schmidt type Telescopes", ed. M. Capaccioli, (Dordrecht: Reidel), p.37

assau, J., and Velghe, 1964, Astrophys. J., 139, 190

.icher, H.: 1981, Astrophys. J., 243, 744

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