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LOW-RESOLUTION SPECTROSCOPY AND *uvby*-β PHOTOMETRY OF SELECTED STARS IN HAFFNER 18[1]

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RESUMEN

Se reporta la clasificación espectral en el sistema MK de una muestra selecta de estrellas asociadas con el cúmulo galáctico Haffner 18, localizado en la Constelación de la Popa. Los espectros correspondientes tienen una resolución de $\lambda/\Delta\lambda = 1720$ alrededor de $H\alpha$, resultando de nuestra espectroscopía, que 1/4 de los 50 miembros estimados de este cúmulo son estrellas O y B tempranas. Algunas de ellas también fueron estudiadas fotométricamente en el sistema *uvby*-β. Además de dar los tipos espectrales MK y discutir a algunas estrellas individualmente, se hace una reinspección de los parámetros físicos del cúmulo sobre la base de nuestros resultados y de los de otros autores, ya publicados.

ABSTRACT

We present MK spectral types of a sample of selected (bright) stars associated with the galactic cluster Haffner 18 in Puppis. They were obtained from low-resolution ($\lambda/\Delta\lambda = 1720$) spectra by H$\alpha$ slit spectroscopy. Some of the selected stars were also observed photoelectrically in the *uvby*-β system. Our spectroscopic data show that over 1/4 of the estimated 50 star members of the cluster are O and early B stars. We give MK spectral types and discuss the individual stars observed. Finally, based on these spectroscopic results, on our photometry, and on published data we briefly reinspect the physical parameters of the cluster.

Key Words: **OPEN CLUSTERS: PHYSICAL PARAMETERS — STARS: O AND EARLY B STARS — STARS: OPEN CLUSTERS (HAFFNER 18)**

1. INTRODUCTION

The galactic cluster Haffner 18 (Haffner 1957), elongated parallel to the galactic plane, is in the direction of the Puppis Constellation (cf. Figure 1). Its galactic coordinates are $l^{II} = 243°$ and $b^{II} = 0\overset{\circ}{.}5$ and its star members brighter than $V = 17^{\rm m}$ are estimated to be about 50 (Moitinho 2000; Labhardt, Spaenhauer, & Schwengeler 1992; Munari, Carraro, & Barbon 1998, MCB98 hereafter). The cluster has been scarcely observed in the past, in spite of the interesting fact that some of its members interact with gas associated to it. In particular, star FM3060a (designation after Fitzgerald & Moffat 1974, hereafter FM74) is surrounded by a small knot of gas that is clearly present in a monochromatic Hα image taken by Pişmiş & Moreno (1976, PM76 hereafter; see also Figures 3 and 4 of this work). This small knot closely resembles the Hα knots observed in other clusters such as S155, Haffner 19 and NGC 2175 (cf. Moreno-Corral et al. 1993; Moreno-Corral, Chavarría-K, & de Lara 2002; Chavarría-K, de Lara, & Hasse 1987, respectively). The Hα knots are signposts of youth. Because Haffner 18 is apparently close to the clusters NGC 2467 and Haffner 19, it has been associated with these star-forming regions. On the other hand, there is a window of low interstellar absorption towards the Puppis Constellation that allows us to observe very distant objects in that direction. Confusions due to this are very likely and this situation explains, at least partially, the large scatter in the distance estimates of Haffner 18. The distance values given in the literature vary be-

[1] Based on observations collected at the Observatorio Astronómico Nacional in Sierra San Pedro Mártir, Baja California (México), operated by the Instituto de Astronomía of the Universidad Nacional Autónoma de México.

tween 4.5 kpc and 8.1 kpc. Consequently, there is also a large discrepancy regarding the cluster's age, of the order of a factor of 10. Moreover, only six stars apparently associated with Haffner 18 have MK spectral types, but only three are OB stars. In view of the above discussion, we decided to do low resolution ($\lambda/\Delta\lambda = 1720$ by Hα) spectroscopy of the brightest stars in the field of the cluster, in an attempt to confirm their cluster membership and to establish the physical parameters of Haffner 18 more accurately. As a backup of the spectroscopy, we also made photoelectric photometry in the *uvby*-β photometric system of some of the selected stars. Here we report the observations and our results.

2. OBSERVATIONS AND DATA REDUCTION

2.1. *Low-Resolution Spectroscopy*

Low-resolution slit spectroscopy in the spectral range 5200 Å $\leq \lambda \leq$ 7320 Å (dispersion = 2.07 Å/pixel) of selected bright stars in the direction of Haffner 18 was secured at the Sierra San Pedro Mártir National Astronomical Observatory, Baja California (México), SPMO hereafter, with the Italian Boller and Chivens spectrograph attached to the Cassegrain f/7.5 focus of the 2.1 m telescope on two epochs, February 1997 and January 2000. On both epochs, the CCD-TEK detector of SPMO, a Metachrome II coated and thinned 1024×1024 pixel^2 Tektronix (TK1024 AB) CCD with pixel sizes of 24×24 μm^2, was used with a gain factor of 4 (= 1.22 e$^-$/ADU). The detector has a read-out noise of 3.0 e^- RMS and a linearity of 0.02%. Its potential well depth is of $3.2 \times 10^5\,e^-$ and it has a dark current of $0.76\,e^-$/hr (no-MPP mode). A diffraction grating with a 600 l/mm ruling and blazed at 13° was used in the first order for the observations, with an inclination angle of $11°45'$, giving a central wavelength of $\lambda = 6260$ Å. An effective slit width of 100 μm (= $1\overset{''}{.}3$ sky-projected) and a mask that limited the field of view perpendicular to the dispersion axis to $2\overset{'}{.}9$ were also used here. From the (FWHM) line widths of the He-Ar comparison spectra and night sky lines, a resolution of $\lambda/\Delta\lambda = 1720$ by Hα was estimated. Twelve spectrograms of an equal number of selected bright stars in the field of Haffner 18 were selected for this work, but a few stars were observed more than once. The average exposure time of a spectrogram was of $\approx$ 30 minutes. With the help of IRAF[2], the spectrograms were corrected for cosmic rays and with a mean bias for each run were then wavelength-calibrated with a He-Ar comparison spectrum. Normalized tracings of the resulting spectrograms of the O-stars found here are shown in Figure 2. Finally, each star was classified in the MK system by identifying the photospheric lines present in its spectrogram using Moore's multiplet table (Moore 1945) and by comparison with the SPMO and Jacoby, Hunter, & Christian (1984) libraries of MK stellar spectra. Jacoby et al. spectrograms have a dispersion and resolution similar to ours. Because of the long-slit orientation in the east-west direction, on several exposures additional spectrograms of cluster and field stars with enough signal-to-noise ratio for classification purposes were also gained for this work; they were reduced and classified spectroscopically in the same manner as the bright main targets described above, but some of the spectrograms were too noisy, making the classification difficult.

The resulting spectral types of a total of 30 stars are reported in Table 1. In the first column of the table we give their identification numbers taken from FM74. A cluster membership qualifier by FM74 is also shown in Column 2, where m stands for cluster members, m? for probable cluster members, n? for probable non members and n for non members. FM74's membership was assigned considering the location of the stars in the clustering as determined from star counts and from their locations in the color-color and magnitude-color diagrams. In Column 3 we give the MK spectral types determined here. Columns 4 and 5 contain the MK spectral types reported by FM74 and by MCB98, respectively. The lower case spectral types of Column 4 were determined from the UBV photoelectric photometry by FM74. Note that several stars of Table 1 were considered field stars by FM74 but, because of the long-slit used here, they fell into the field of view of the spectrograph and were also classified spectroscopically by us.

2.2. *CCD-Imagery in Selected Nebular Lines*

To better understand the environment of Haffner 18, during the nights of 23 through 26 January 1997 we took images of Haffner 18 with the f/13.5 *Harold L. Johnson* 1.5 m telescope of SPMO through a set of narrow-band filters centered in the nebular lines of Hα, Hα + [N II], [S II] and in the red-continuum by λ6650 Å, as well as in the Johnson-Cousins $(\mathrm{UBV})_J(\mathrm{RI})_C$ photometric system. In particular, the night of 25 January was photometric, with seeing improving as the observations progressed. The set of images we discuss here was obtained on that night. The log-sheet of observations

[2]IRAF is the Image Reduction and Analysis Facility made available to the astronomical community by NOAO, operated by AURA, Inc., under contract with the US National Science Foundation.

TABLE 1

SPECTROSCOPY OF SELECTED STARS

FM Nr	Member Qualifier	This Work	FM74	MCB98
		— Spectral Types —		
2057	n	B6 V	b5	
2058	n	G7 V		
3051	n	late A		
3057*	m	B6 V	b5	
3058*	m?	B2 V	(b8)	
3059*	n	B8 V		A2
3060	n	K0 II/III		
3060a*	m	O9.5 V	B1.5 Vk, b0	B0.5 III
3063	n	G8 II		
3064	n	F5 III		
3066*	m	B1 V	b1	
3067*	m	O8 V	O9 IV:k	
3070*	m	O9.5 V	b0.5	
3072a	m	B1 V	b2	
3074*	n?	B9/A1 V		A0 II/III
3077*	n	K3 III		
3078	m	B2 V:	b2.5	
3079	m?	B3 V:		
3081*	m	O7 V	O7:k, o7	O6
3082	m?	B1 V:		
3084*	n	G7 V	G8 V	
3085*	n	G0-1 V		
3088	n	F5 V:		
3091	n	A4 V		
4092a	n	G5 V:		
4094	n	F5 V		
4095	n	B4 V	b2	
4096	n	F7 III		
4099	n	G7 V		
4102	n	G0 III		

* Pointing star of the spectrograph. Spectral types with the suffix " : " have an uncertainty of ±2 subclasses and ±1 otherwise.

TABLE 2

LOG-SHEET OF THE DIRECT IMAGES[a]

Image	Filter	λ_o Å	$\Delta\lambda$ Å	Texp sec	Size arcsec
obj2013	Hα + [N II]	6570	80	60	1.58
obj2016	I	8040	1660	30	1.72
obj2021	V	5750	1400	15	1.19
obj2025	Hα	6563	10	600	0.97
obj2027	[S II]	6717	10	600	1.03
obj2028	cont-red	6650	80	600	1.20

[a]Images obtained the night of 25/01/97 with the 1.5 m telescope of SPMO.

is presented in Table 2. They were taken with the CCD-TEK detector of SPMO with a gain of 4.88 e^-/ADU (RMS noise = 1.5 e^-). The field scale of the telescope is $10.52''$/mm (or $0.25''$/pixel) and the size of an exposure was 4.26 × 4.26 arcmin^2. See Moreno-Corral et al. (2002) for more specifications of the equipment. In Figure 3 we show a Hα monochromatic image and in Figure 4 we display a mosaic of selected images at the different nebular wavelengths. The images were bias- and cosmic ray-corrected with IRAF. Note that the binary star FM3067 is clearly resolved in our images, in particular, in the $H\alpha$ frame, with guided (FWHM) stellar profiles of 0.97 arcsec, enabling us to measure the angular separation between FM3067 and LSS28 (= 2.3 arcsec at ∠ 348°).

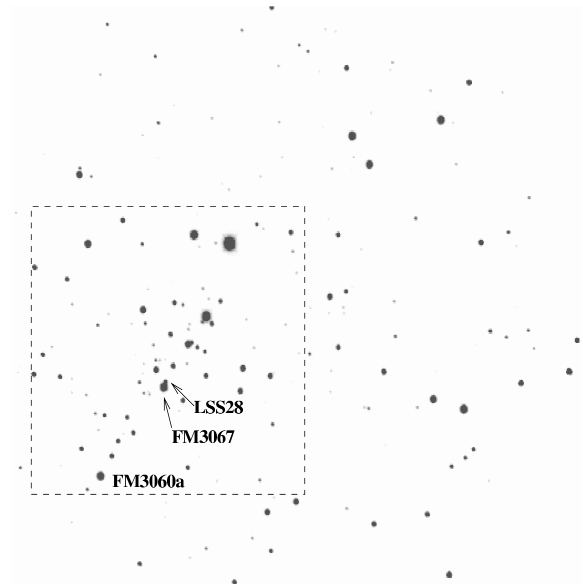

Fig. 1. A 4.26 × 4.26 arcmin^2 image of the region of interest in Johnson's V filter containing the galactic cluster, taken with the 1.5 m *Harold L. Johnson* telescope of SPMO. Haffner 18 is shown framed with a discontinous line. As usual, north is at the top and east to the left.

2.3. *uvby-β Photoelectric Photometry*

With *uvby-β* photometry one can achieve results similar to those of low-resolution spectroscopy of stars but with less effort in the reduction and analysis of the data. This photometric system has been carefully calibrated empirically and with models of stellar atmospheres (see Neri, Chavarría-K, & de Lara 1993; Terranegra et al. 1994 and the work cited therein), particularly with stellar temperatures, gravities (i.e., luminosities) and (relative) metal abundances. Thus, as a back-up of our spectroscopic observations, we also gathered *uvby-β* photometry of the brightest stars in the field of Haffner 18 with the 1.5 m *Harold L. Johnson* telescope of SPMO and the Danish *uvby-β* photometer (cf. Moreno-Corral et al. 2002 and Terranegra et al.

1994 for more details on the instrument). Haffner 18 was included within a broader photometric program of other galactic clusters to be reported elsewhere. The identification of the stars at the telescope was easily done with the supporting electronic gear of the off-set guider and adquisition system (Gutiérrez et al. 2003) of the newly refurbished Danish photometer. The observations were carried out during the nights of 13, 14, and 15 January 2004 under fair to good sky conditions (see standard deviations cited in Table 3). The photometry was reduced nightly following a usual procedure (e.g., Mitchell 1960) with the *RainBow.v01* reduction package (Chavarría, de Lara, & Chavarría-K 2000). Our photometric system satisfactorily reproduces the $uvby-\beta$ systems of Crawford & Barnes (1970), Crawford & Mander (1966), Crawford, Barnes, & Golson (1971), Crawford et al. 1973) and Olsen (1983; 1984). A 14 arcsec diameter diaphragm was used throughout the observations and the background was usually measured 14 arcsec east of the star, but being careful to leave out unwanted (weaker) stars. The resulting photometry is given in Table 3. The nightly standard deviations 1σ displayed in the last three rows of Table 3 comprise the observational errors and the uncertainties of the transformation from the natural to the standard or catalogue system, and were estimated from the reference or catalogue stars. The errors of the program stars with $V \leq 12\overset{\mathrm{m}}{.}5$ are expected to be similar to those of the standard stars, and thrice as large for stars fainter than $13\overset{\mathrm{m}}{.}5$, mainly in the $c1$ color, because of the low sensitivity of the u photomultiplier that made integration times prohibitively long for weaker and later type stars (see Gutiérrez et al. 2003).

For eleven stars observed photoelectrically in common between FM74 and us, we find for the V magnitude a linear relation with slope 0.987 and zero point −0.06 between the two data sets (scatter $1\sigma_V = 0.11$, correlation factor $r^2 = 0.996$). and a linear relation between the $(b-y)_{US}$ and the $(B-V)_{FM}$ with slope 0.642 and zero point −0.12 (scatter $1\sigma = 0.10$, correlation factor $r^2 = 0.971$). The latter relation's coefficient is in agreement with that found by Terranegra et al. (1994), considering the errors involved, but the zero-point correction is more negative making the colors bluer. Anyhow, the relation was used to estimate the $(B-V)$ colors from our photometry of the stars in common with FM74, as well as that of stars FM3084, 3085, 3091, 4095, and 4096 observed by us to double check these stars with the (less accurate) FM74's photographic UBV photometry. The systematic shift in V is similar to that found by other authors, in the sense that the V estimates of FM74 are brighter than those found by others (e.g., Munari et al. 1998; Munari & Carraro 1996, and references therein). The resulting computed $(B-V)$ colors compare well with those of FM74, but are bluer than the $(B-V)$ estimates given in the literature (e.g., MCB98, Munari & Carraro 1996, and references therein). (Note that the 1σ values refer to the expected standard deviation of any given star from the mean).

Considering that we observed the target stars in Haffner 18 only once and the observational errors involved, the comparison of our photometry with that of FM74 (photoelectric and photographic) is good, particularly for the stars observed photoelectrically by both.

3. RESULTS

3.1. *Low-Resolution Spectroscopy*

An important result is that Haffner 18 is rich in early type stars. In Fig. 2 we show the normalized spectra of the four O-type stars found in the cluster. One of the principal reasons for doing this work was to study more carefully the star FM3060a and its associated small, dense H II nebulosity. From the two spectrograms of the star used by us, which were taken three years apart, we infer the presence of a shell surrounding the star. On the other hand, PM76 suggest, from their Fabry-Perot Hα interferograms, that the Hα knot is expanding at a velocity of about 20 km s^{-1}. In order to better understand the nature of this Hα knot, we took a spectrogram at about 8.5 arcsec south from the exciting star FM3060a in February 1997. In Table 4 we list the most prominent emission lines in the spectral range observed by us. We also detected other nebular lines such as [O I]$\lambda\lambda$ 5577, 6300 Å and [N I]λ 5197 Å, but they were not listed in Table 4 since we were unable to disentangle them from the SPMO dark-sky lines also present in the spectrograms. We can affirm that, effectively, the knot that surrounds star FM3060a is an emission nebulosity. From a simple visual inspection of its spectrum, the nebular lines [S II]$\lambda\lambda$6717, 6730 Å and [N II]$\lambda\lambda$ 6546, 6584 Å seem broad but the spectral resolution of our data does not allow us to determine the expansion velocity.

3.2. *Monochromatic Imagery of Haffner 18 in Selected Nebular Lines*

The images taken at the wavelengths of the nebular lines Hα, Hα + [N II], as well as [S II] clearly show the small knot surrounding its exciting star, FM3060a (cf. Fig. 4). From these images, its diameter is $18\overset{''}{.}5 \pm 0\overset{''}{.}5$. If it expands with 20 km s^{-1}

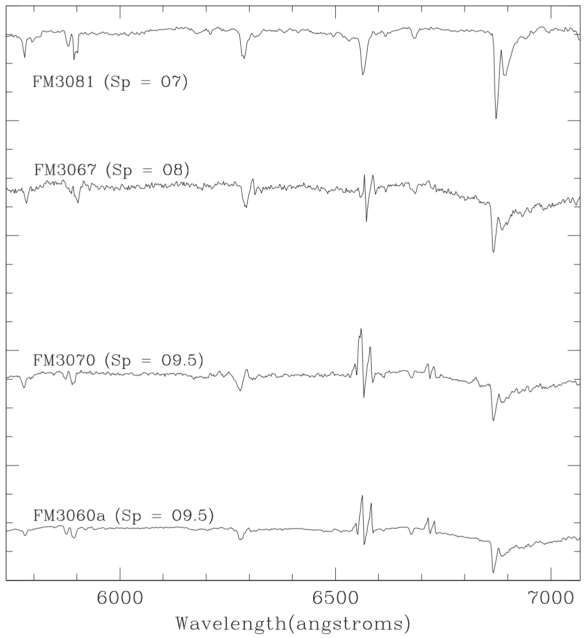

Fig. 2. Normalized spectra of the four O-stars in Haffner 18 identified by us here. The spectrograms are ordered, from top to bottom, in decreasing effective temperature, and vertically shifted by an arbitrary amount for clarity.

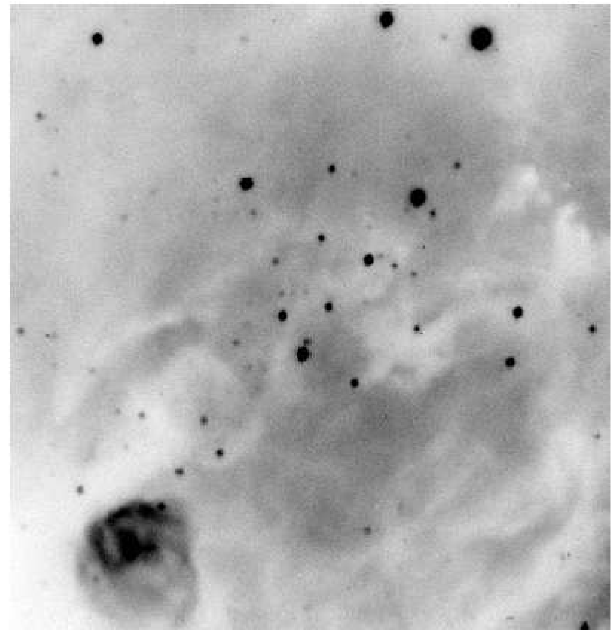

Fig. 3. Hα image of Haffner 18 taken with a narrow-band interference filter centered at $\lambda_\circ = 6563$ Å and with a passband of 10 Å. Veiled by the emission at that wavelength, FM3060a can be seen in the lower left part of the image. Also note the variable interstellar/intercluster extinction to the cluster. Orientation as in Figure 1.

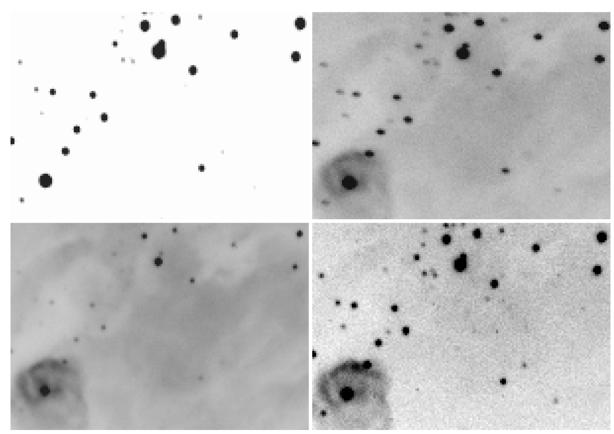

Fig. 4. Images of the small knot surrounding FM3060a. Clockwise, we see the images taken in the red-continuum, Hα + [N II], [S II] and the Hα filters. Orientation as in Figure 1.

(cf. PM76), and if it is located at 8.5 kpc (i.e., a compromise for the distance, see final remarks), we find an age estimate for the knot of $\approx 4 \times 10^4$ yr, yet another indicator of the youth of Haffner 18.

3.3. *Photometric Results*

3.3.1. *Photometric Spectral Types*

Making use of Strömgren's photometric and reddening-free color indices $[u-b]$, $[m1]$, and $[c1]$ as defined in the works of Crawford & Mandwewala (1976), Chavarría-K et al. (1987), and Terranegra et al. (1994), and following the procedure outlined by the last authors (see their Figures 3 and 4), the spectral types given in Table 3, Column 7, are a compromise of the resulting spectral types expected from the different indices. The β index was also used to check luminosities and spectral types. The reddening-free color indices used for determining the spectral and luminosity types of the program stars are strongly dependent on the interstellar (IS) extinction law adopted. Since the IS extinction is not uniform qualitatively and quantitatively (see IS extinction below), we can expect in some cases divergences as large as three subclasses in the photometric spectral types. Considering the accuracy of the photometry and the spectroscopy, the photometry supports, in general, the spectroscopic results summarized in Table 1, Column 3, with the exception of stars 3058, 3091, 4095, and 4096. For the rest of the stars, the spectroscopic MK types are, on the mean, hotter by one subclass (scatter less than 2 sublclasses). Also note that the photometric MK types of stars 3058 and 4095 coincide with those found in a similar way with broad band photometry by FM74. On the other hand, the photometric (reddening-free) indices $[c1]$ and $[u-b]$ become insensitive for stars hotter than about spectral type B0, like they do using the Q-method of Johnson & Morgan (1953), and a small error in those indices may cause an additional error in the photometric spectral classification. But we expect the luminosity classes to be correct within one unit.

3.3.2. *On the IS Extinction Law and Haffner 18*

From the variable extinction method one expects that the color excesses and the corresponding IS visual extinctions of the program stars should be linearly related, and hence the apparent distance modulus $V - M_V$ should also show a linear relation with the color excess, with the slope of the line giving the total to selective extinction ratio for the region, and the extrapolation to zero color excess giving the true distance modulus of the cluster. From the member and probable member stars of Haffner 18 we see that the cluster suffers from variable intercluster extinction ($0.3 \leq E(B-V) \leq 1.2$). When considering only OB stars, the errors will be minimized. Systematic shifts in the apparent modulus axis are caused by differences in distance to the program stars (e.g., Terranegra et al. 1993). Two clusterings at different distances would appear in such a diagram as two linear relations shifted in the modulus axis. From our *uvby-β* photometry and from the spectral types of Table 1 we find no clear correlation between the aparent distance moduli and the color excesses of the program stars, suggesting (i) a non-unique total to selective extinction ratio for the region or/and (b) different individual distances of the program stars. To check this result, we repeated the exercise with FM74's photoelectric (and photographic) photometry and assuming our MK- or their photometric spectral types, obtaining the same results. The data suggest two clusterings (see below) but we see no linear relations in the apparent modulus vs. color excess diagram. Hence we conclude that there is not a unique extinction law for the region. The best guess is to use the canonical IS extinction law (we used Schmidt-Kaler's 1982 expression for the total to selective extinction ratio). The ratio $E(U-B)/E(B-V)$ gives support to a "normal" IS extinction law but one should be aware that near IR photometry would help to clarify this. On the other hand, we also would expect a linear relation between the $E(U-B)$ and $E(B-V)$ color excesses, which is not the case for the UBV photoelectric photometry of FM74, but the average $E(U-B)/E(B-V)$ ratio ($= 0.76 \pm 0.07$) agrees with the canonical value of 0.77 for $< E(B-V) > = 1$, which is also in agreement with the result of MCB98. Again, the best guess is a "standard" IS extinction law, which we adopt hereafter. From the photometry of the O and B stars of Haffner 18 and the MK spectral types of Table 1 we find a mean total to selective extinction ratio $< A_V/E(b-y) >= 4.394 \pm 0.007$, a mean color excess $< E(b-y) >= 0.502 \pm 0.063$ ($< E(B-V) >= 0.78 \pm 0.10$, i.e., slightly higher than MCB98), giving a mean visual extinction of $< A_V >= 2\overset{\mathrm{m}}{.}57 \pm 0.29$ for the region.

3.3.3. *On the Distance to the Cluster Haffner 18*

Regardless of the spectral types assumed (those given here or those by FM74), and making use of *uvby-β* and FM74's UBV photoelectric (and photographic) photometry three groupings of the program stars are suggested: (a) A group of nearby stars represented mainly by those with late spectral types, (b) a group of intermediate and late B stars at a distance of about 4 kpc, and (c) a third group given by early B and O type stars at a distance of about 9 kpc. Depending which stars are considered when deriving the distance, one may get a value anywhere between 1 and 9 kpc. From the hotter six stars of Haffner 18, we derive a mean "true" distance modulus to the cluster of 14.6 ± 0.3 or $< d >= 8.4 \pm 1.2$ kpc. (Star FM4095 is at about that distance but FM74 consider it a non member of Haffner 18). The photometry also confirms the variable extinction present in the region with $\Delta A_V \approx 2\overset{\mathrm{m}}{.}5$ (cf. Fig. 3). Since the region does not have a characteristic IS extinction law, the photometric spectral types are more uncertain than the spectroscopic results given in Table 1. In any future discussion, we will adopt the spectroscopic results.

3.4. *Final Remarks*

The spectral types reported here considerably enlarge those given by previous authors and are, in general, in agreement with them as deduced from the stars in common (see Table 1, Columns 4 to 5). If the OB stars are assumed to belong to the cluster, the spectral types given here also confirm FM74's cluster membership of 11 stars, including the probable members reported by them, like FM3058, FM3079, and FM3082, as well as the non-membership of FM3074. The spectral types found for the cooler stars contained in Table 1 confirm that they are field stars, as already suggested by FM74. Our spectral types also confirm the youth of Haffner 18, since at least

TABLE 3

uvby-β PHOTOELECTRIC PHOTOMETRY OF SELECTED STARS IN HAFFNER 18

FM	V	$b-y$	β	$m1$	$c1$	SpT_{ph}	J.D. 2453000+
3057	14.799	0.583	3.666:	−0.229	0.534	B6 V	018.8851
3058	14.675	0.343	3.135:	0.060	0.542	B8 V	018.8931
3059	14.280	0.192	2.656	0.042	0.718	B8/B9 V	018.9017
3060a	12.042	0.148	2.496	0.015	−0.025	B1.5 V	017.8705
3066	14.475	0.707	2.190	0.054	−0.035	B0.5 V	018.8771
3067	12.044	0.320	2.566	−0.043	−0.034	B0 V	017.8649
3070	13.534	0.276	2.692	0.120	0.062	B0 V	017.8778
3072a	14.413	0.624	2.700	−0.120	0.054	O9.5 V	017.8840
3074	12.824	0.128	2.816	0.038	0.609	B8 V	018.8687
3077	13.065	0.994	2.453	0.636	0.103	K3 III	017.8580
3081	11.282	0.252	2.555	−0.005	−0.111	O9.5 V	017.8510
3084	10.138	0.637	2.543	0.498	0.190	G9 V	017.8351
3085	12.024	0.641	2.554	0.349	0.235	G3 V	017.8434
3091	12.401	0.208	2.706	0.157	0.554	B8 V	018.8608
4095	14.707	0.369	2.630	−0.001	0.009	B1.5 V	019.8983
4096	14.086	0.153	2.745	0.141	0.769	B9 V	019.9052
	$1\sigma_V$	$1\sigma_{b-y}$	$1\sigma_\beta$	$1\sigma_{m1}$	$1\sigma_{c1}$		J.D.2453000+
	0.020	0.021	0.011	0.020	0.015		017
	0.012	0.020	0.016	0.013	0.014		018
	0.006	0.017	0.005	0.018	0.012		019

12 of the 49 estimated members (= 24 %) are OB stars. What is more significant, four of them are main sequence O-stars, with spectral types between O7 and O9.5. It is well known that the evolutionary time on the main sequence of an early star of type O5–O7 is of the order of 2×10^6 yr. On the other hand, the spectra of some of the hotter stars in Haffner 18 show remnants of the material from which they formed, indicating that these stars are in their early evolutionary phase on the main sequence. Hence, the age of the cluster is of about 1×10^6 or even less. Moreover, the existence of the bright and very young Hα knot surrounding FM3060a, confirmed by our monochromatic images of the cluster and the (long slit) spectroscopy of the star, are in accordance with the above remark.

TABLE 4

CONSPICUOUS LINES OF THE Hα KNOT

λ_m^{a}	λ_l^{b}	EW(λ_m)	ID
5006.268	5006.88	−1.043	[O III]
6234.135	6233.80	−0.280	He II
6298.370	6300.31	−3.284	[O I]
6361.603	6363.82	−1.116	[O I]
6547.620	6548.09	−3.047	[N II]
6562.565	6562.90	−21.57	H_α
6582.961	6583.36	−8.127	[N II]
6715.624	6716.52	−6.534	[S II]
6729.886	6730.74	−4.940	[S II]

[a]Measured wavelength; [b] laboratory wavelength.

Finally, the true distance modulus to Haffner 18 given by FM74 is of 14.2 ± 0.3, implying a distance of 6.9 kpc. Although LSS92 enlarge the sample of stars observed towards the cluster, they do not comment on the distance. MCB98 estimated a true distance modulus of 14.0 ± 0.2 from their data, which translates into a distance of 6.3 kpc. However, using the spectroscopic data of four stars, they find $5\log(d) - 5 = 14.57 \pm 0.94$, situating them at 8.2 kpc from the Sun. More recently, Moitinho (2000) obtained photometrically a distance modulus of 14.54 (= 8.09 kpc). From the spectral types of the early B and O stars observed by us spectroscopically and photometrically, we find a true distance modulus of 14.6 ± 0.3 or a distance of 8.4 ± 1.2 kpc for the cluster. In any case, all recent data indicate that Haffner 18 is a very distant cluster, with the larger (and more recent) distance moduli as the more appropriate.

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