SPECTRAL CLASSIFICATION AT ULTRA-LOW DISPERSION

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Abstract. We demonstrate here the possibility of using very low dispersion (10 000 Å mm^{-1}) slitless spectroscopy of stars for a fairly accurate spectral classification. The technique is shown to be very useful in studies of star clusters.

1. Introduction

The technique of ultra-low dispersion spectroscopy and its advantages for classification have been described by Bappu and Parthasarathy (1977) and Parthasarathy (1980). Bappu *et al.* (1978) have utilised this technique to pick up easily the red stars in the direction of the Large Magellanic Cloud. However, its use for picking out early-type stars at large distances from the Sun which, in turn, can later be used for discovering young galactic clusters, has not been fully demonstrated. Such an effort would be worthwhile for studies relating to the spiral structure of our Galaxy.

In this short note, we wish to demonstrate the accuracy of spectral classification in the absence of high interstellar extinction even at this low dispersion.

2. Observations

The technique employed is the same as the one already described by Bappu and Parthasarathy (1977). A 5 min exposure of the cluster NGC 2362 on IV-E emulsion is shown in Figure 1. The spectrum is unwidened and the limiting magnitude in this 5 min exposure is about 13.5 in V and 13.0 in B.

3. Results and Discussion

Longward of the green dip of the IV-E emulsion, the spectrum is almost stellar in appearance and can, therefore, very well be assumed to give an effective photographic magnitude equivalent to a filter centred on λ 6000 Å and a passband of about 750 Å.

The longward limit of the sensitivity of the E emulsion (λ 6700 Å) and the green dip of the emulsion (λ 5200 Å) together with the employment of a small angle quartz prism (3°) extends the blue image while restricting the red image to stellar appearance.

The length of the blue image in relation to the strength of the red image can effectively be used as a spectral type criterion. The photographic plate is still the largest two dimensional detector of high resolution. The drawbacks are its low quantum efficiency and nonlinear response. The disadvantage of low quantum efficiency for the present technique is not of much importance, since exposure times are limited by sky background

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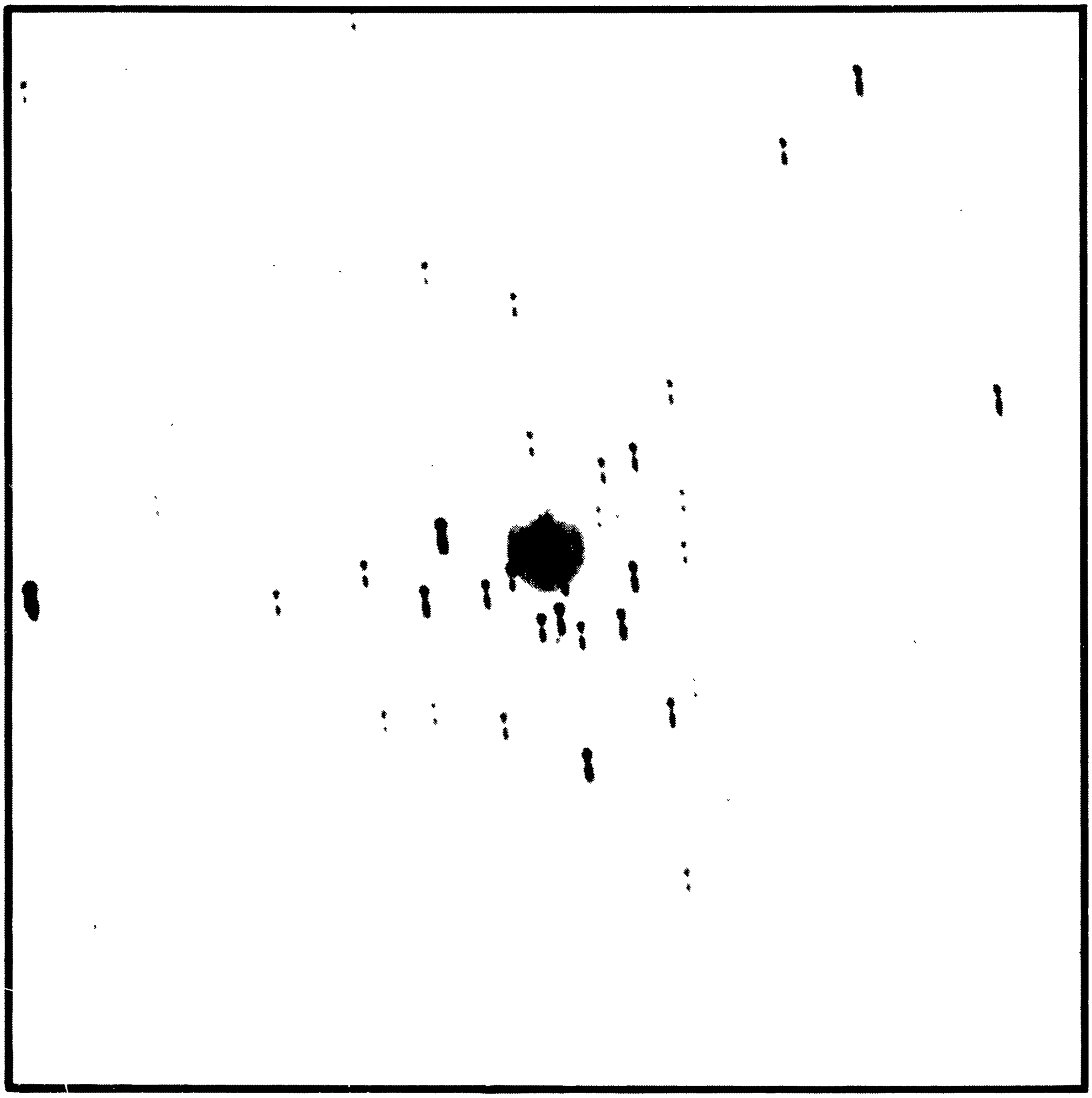

Fig. 1. Enlargement of a 5 min. exposure of NGC 2362 on IV-E emulsion. North is at top and east to the left.

only. This limit is reached in 90 min when a 103a-E emulsion is used. The nonlinear response of the plate can be overcome if one uses quantitative measurement techniques instead of using the 'eye' alone to judge the length of the blue spectrum in relation to the strength of the red image.

Microphotometric tracings of the images shown in Figure 1, were obtained at a magnification of 125. The star numbers are from Johnson (1950).

Figure 2 shows microphotometric tracings of stars Nos. 9 and 66. The lengths of the red and the blue images were measured at 25% and 50% relative densities as shown in Figure 2. Measurements at both densities were analyzed. Since the behaviour of these length measurements at both densities are found to be similar, we use only the measure-

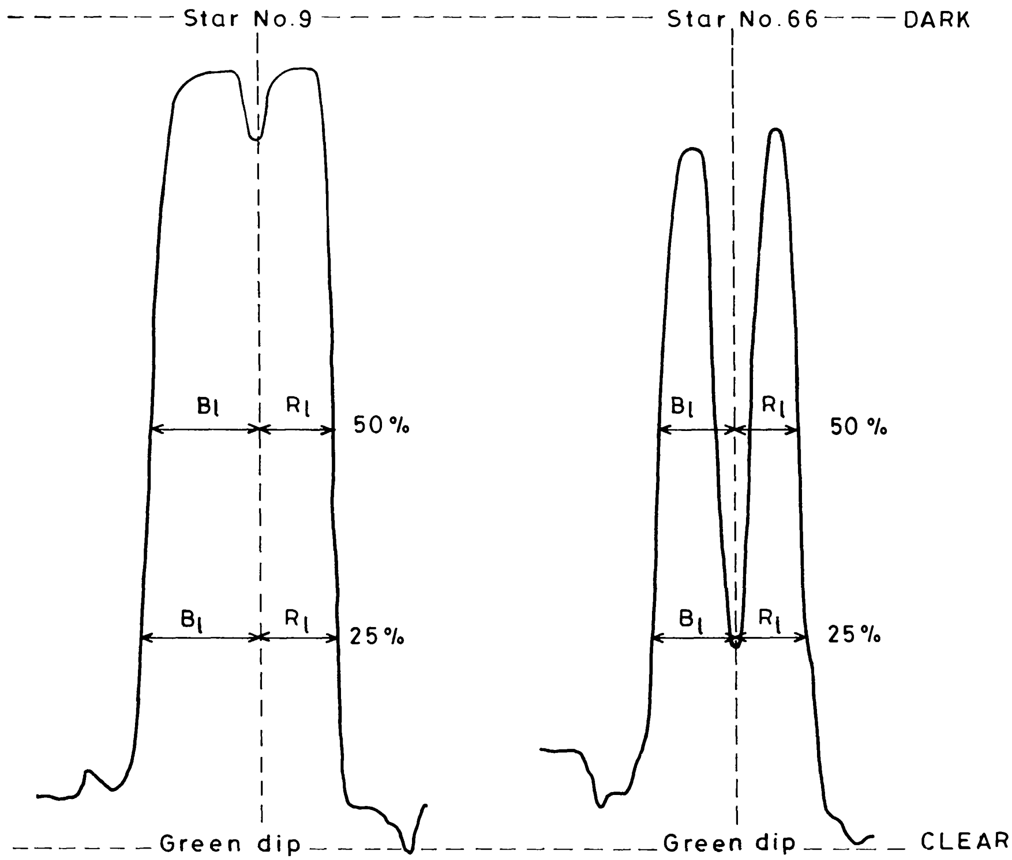

Fig. 2. Representative microphotometer tracings of the ultra-low dispersion spectra. The definition of the blue length and red length from the green dip is shown. Star numbers are from Johnson (1950).

ments at 25% deflection. This is listed in Table I. The following factors affect these measurements of the lengths:

(i) Spectral type of the star which is what we expect to derive from such lengths.
(ii) Atmospheric extinction.
(iii) Interstellar extinction.
(iv) Exposure time.
(v) Nonlinear response of the photographic plate to light intensity.
(vi) Confusion due to superposition of spectra of unresolved stars.

The effects of atmospheric extinction can be kept to a minimum by observing stars close to meridian passage at low air mass. These effects can be eliminated if stars of known spectral types in the field can be used to calibrate the measurements. Differential extinction over the 40 arc-min field can be neglected.

Figure 3 shows the relationship between the blue length of the ultra-low dispersion spectrum and the blue magnitudes of the stars at 25% relative deflection. Irrespective of whether the stars are members of the cluster or not, they define a unique relationship between the length of the blue spectrum measured at 50 or 25% of the relative deflection. That is, all stars of a given B magnitude have the same length of the blue spectrum at

TABLE I
NGC 2362

Star number[a]	Blue length (B_l)[b] (in mm)	Red length (R_l)[b] (in mm)	V[a]	$(B - V)$[a]
1	17.0	13.1	11.39	+0.00
2	17.7	13.6	11.18	−0.02
3	15.1	14.6	11.05	+0.09
4	12.5	11.2	12.44	+0.08
5	19.0	14.7	10.78	−0.06
8	9.2	12.1	12.51	+0.38
9	22.5	15.3	9.84	−0.08
11	15.2	14.0	11.92	+0.05
12	22.8	15.4	10.05	−0.07
13	16.4	16.6	10.48	+0.11
14	22.4	15.9	9.60	−0.12
15	14.9	13.2	11.76	+0.03
16	18.8	14.9	10.57	+0.07
21	19.4	15.3	10.44	−0.07
22	15.5	14.5	11.93	+0.02
26	19.4	14.6	10.43	−0.07
27	20.2	15.8	10.17	−0.07
28	14.7	12.0	12.05	+0.02
29	16.0	14.0	11.34	−0.02
31	23.5	15.6	9.32	−0.12
32	15.2	14.6	10.77	+0.28
34	18.1	15.0	10.49	−0.03
36	18.5	14.3	10.76	+0.02
37	8.3	12.5	12.56	+0.36
39	24.0	16.3	9.78	−0.09
42	16.5	13.9	11.35	−0.05
48	22.2	14.8	9.54	−0.11
49	10.1	13.7	12.30	+0.39
50	20.6	16.0	10.20	−0.00
51	10.0	13.7	12.23	+0.43
52	15.2	12.6	11.93	+0.03
56	12.3	11.4	12.01	+0.13
58	12.6	12.1	12.23	+0.07
59	10.5	11.5	12.21	+0.23
64	9.8	14.2	11.80	+0.47
65	15.2	14.0	11.67	+0.23
66	16.1	13.9	11.44	−0.01

[a] From Johnson and Morgan (1953); Johnson (1950).
[b] Magnified 125 times only measurements at 25% relative deflection are given.

a given density on a given plate irrespective of their distance. Therefore, Figure 3 also defines the relationship between spectral type and blue length for all stars at the same distance. This method is, therefore, extremely useful for picking out the most probable

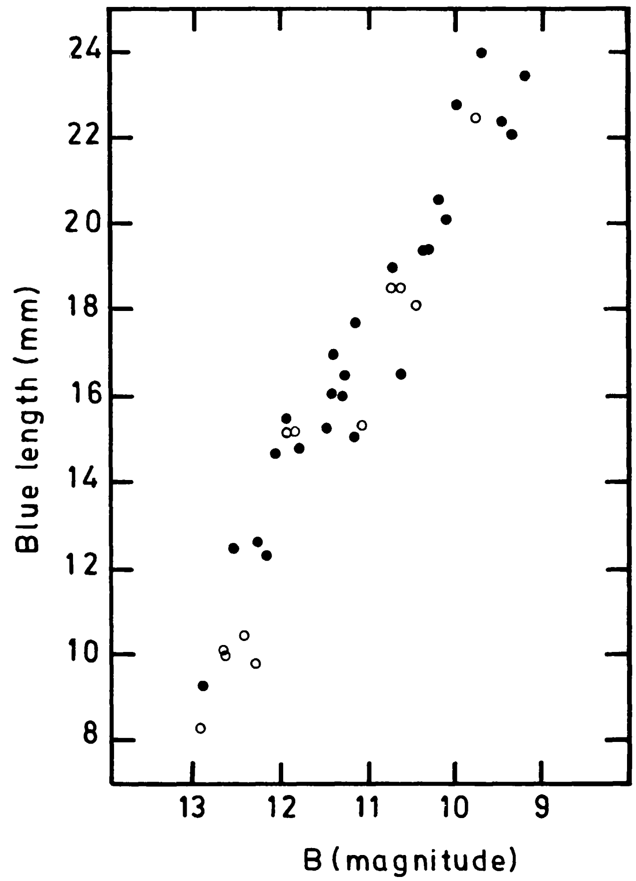

Fig. 3. Blue lengths magnified 125 times are plotted against B magnitudes of the stars. Open circles are non-members according to Johnson and Morgan (1953).

members of a cluster provided we can establish another criterion which can separate the foreground and background members having the same blue length as that of the members.

This is achieved by taking the ratio of the blue length to the red length. This ratio is observed to be the same whether taken at 25 or 50% relative deflection. A plot of this ratio against the observed colour index $(B - V)$ taken from Johnson and Morgan (1953) is shown in Figure 4. Also indicated in Figure 4 are the spectral types of the stars which correspond to their unreddened colours assuming $E(B - V) = 0.10$ for cluster members. Another set of measurements from a different plate of similar exposure indicates that the ratio of B_l/R_l remains constant within the uncertainties of measurement errors. With this technique it is therefore possible to classify unreddened stars within ± 2 spectral subclasses.

Figure 5 shows a plot of the blue length (which is a good indicator of the blue magnitude) versus the ratio of the blue length to the red length (which indicates the colour index $(B - V)$ of the star). For comparison, the standard V vs $(B - V)$ diagram from Johnson and Morgan (1953) is also shown.

The blue length defines the shortest wavelength to which the spectrum is exposed (at

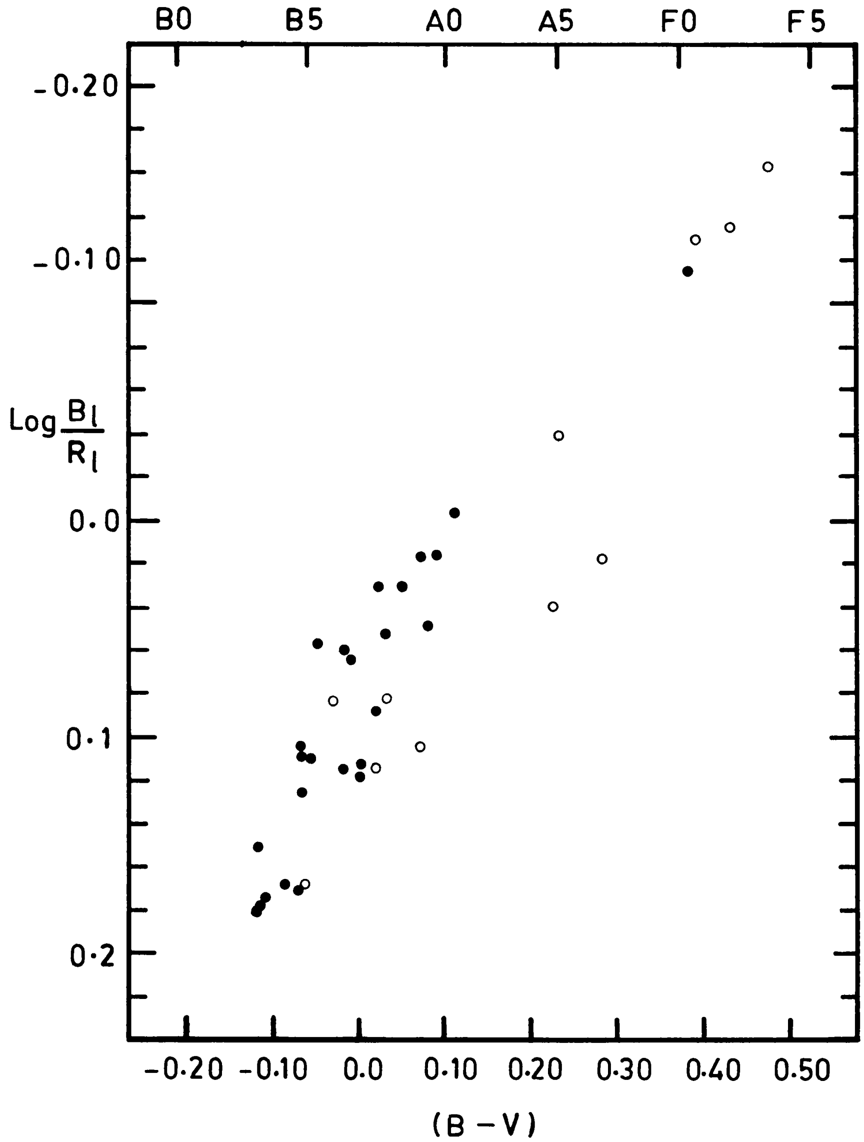

Fig. 4. The ratio of the blue length to the red length is plotted against the colour index $(B - V)$; spectral types corresponding to the unreddened colours are also indicated. Open circles are non-members.

a given density). Therefore, this length acts as a good indicator of the blue magnitude of the star. The plot of this blue length versus the ratio B_l/R_l is equivalent to an H–R diagram. Figure 5 compares very well with the familiar V vs $(B - V)$ plot from the same stars.

Interstellar extinction would certainly affect the derived spectral types of stars if this technique is used. But as long as such effects are small (see also Sculte, 1956a, b) and fairly uniform over a cluster, this technique can be used for classifying stars and deriving colour indexes provided the zero point is set up with photoelectric photometry of a few stars in the field.

As long as the same emulsion is used in this work, these characteristics would remain

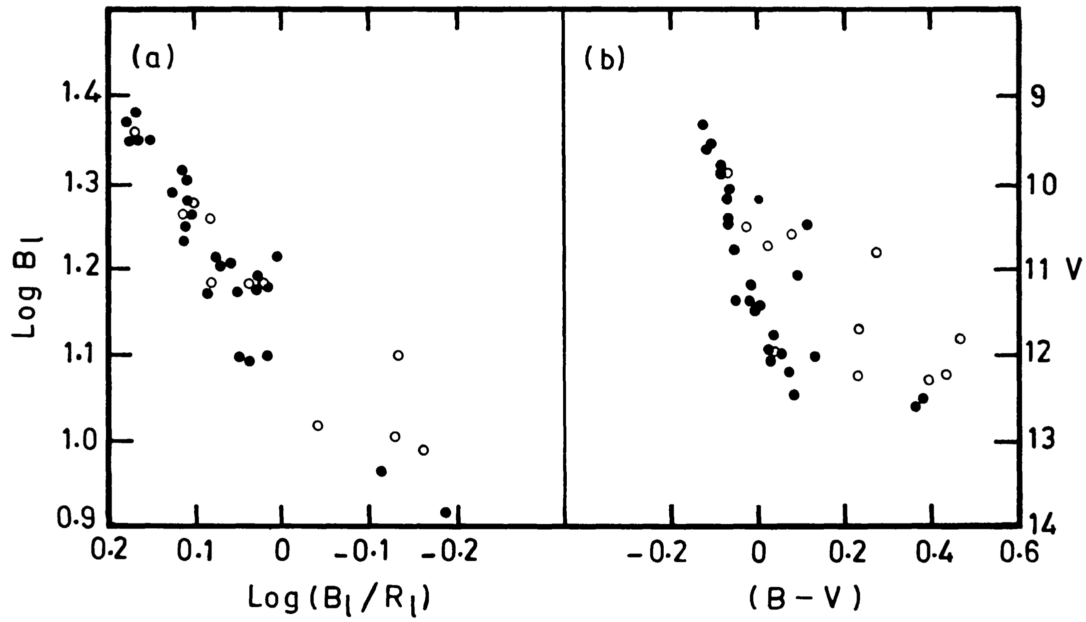

Fig. 5. (a) The blue lengths plotted against the ratio B_l/R_l is shown. (b) The H–R diagram corresponding to 'a' from photometry of Johnson and Morgan (1953) is shown for comparison. Open circles are non-members.

the same. Therefore, Figure 4 can be used as a calibration of the ratio B/R against spectral type, in the absence of large interstellar extinction and against the observed colour index if interstellar extinction is large.

4. Conclusions

We find that by quantifying the measurements the technique of ultra-low dispersion spectroscopy can be used for a fairly accurate spectral classification in the absence of large and differential interstellar extinction. The technique would give observed colours in the presence of extinction and the spectral type estimated would, therefore, only be later. Hence, the identification of regions with early-type stars can be undertaken with this technique.

Ultra-low dispersion spectroscopy is very well suited for cluster work in determining possible members of new as well as known clusters. In fact in windows of low extinction in the galaxy, this technique can identify the clusters at large distances from the Sun.

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