PART IV

HR DIAGRAMS, CLUSTERS

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Robert P. Kraft and A. Renzini on stage.

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SPECTROPHOTOMETRY IN STELLAR ASSOCIATIONS

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When analyzing the spectral energy distributions of early type stars as measured at Cerro Calán, we find that many of them have a feature which we have called ΔD (Gutiérrez-Moreno et al., 1968); the internal error of the measure of ΔD for a single star is ± 0.02. An analysis of the spectrum scans and the energy distributions shows that this feature may be interpreted as an emission in the Balmer continuum. A few stars have values of $\Delta D < 0$, and a comparison of their scans with those of normal stars ($\Delta D = 0$) suggests an absorption larger than normal in the Balmer continuum.

In this paper we propose to analyze the behavior of ΔD in two stellar associations, the Orion aggregate (Moreno, 1974) and the Upper Scorpius group (Gutiérrez-Moreno and Moreno, 1977). Practically all the stars observed are located in the HR diagram in the region of pre-main sequence stars. We have preferred to obtain the value of ΔD from the absolute energy distributions, calling it ΔD_a. To avoid possible systematic errors depending on right ascension we reduced the two groups independently to the absolute Oke and Schild system (1970) by using secondary standards located as close as possible to the corresponding right ascension zone.

A comparison of these two stellar groups with field stars shows that positive ΔD values are more frequent in the associations than in the field stars. This fact would confirm the theory that pre-main sequence stars have circumstellar envelopes which produce emission in the Balmer continuum.

We found that ΔD_a is well correlated with c_1^0, the dis-

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tance of a star to an arbitrary "main sequence" in the c_1°, $(b-y)_o$ plane, and that they have similar behavior when correlated with other photometric parameters. It is interesting to mention the correlation between ΔH and ΔD_a, where ΔH, the distance of any star to the mean (Hδ, Hβ) relation, is a measure of the emission in the lines. It is possible to appreciate a correlation between these two indices of shell strength, but there are two stars, HD36917 (V372 Ori) and HD142983 (48 Lib), which show emission in the lines, but a rather large negative ΔD_a. This fact suggests that the values of $\Delta D_a < 0$ correspond also to a shell effect.

We have also measured an ultraviolet gradient, ϕ_u ($2.831\ 1/\lambda < 3.030\ \mu^{-1}$). These gradients have been reduced to the Paris system (Chalonge et Divan, 1952), and corrected for reddening according to the usual procedures. The standard deviation of the transformation to the absolute system is ± 0.08, in good agreement with the probable error of ± 0.05 found for one gradient on the basis of the errors of the measured magnitudes. These errors are comparable with those quoted by Ardeberg (1969). Nevertheless, when comparing the absolute intrinsic gradients $\phi_{u,o}$ with the mean values corresponding to the spectral types, we find a scatter much larger than could be expected on the basis of the errors previously computed. Besides, it is evident that Orion stars have

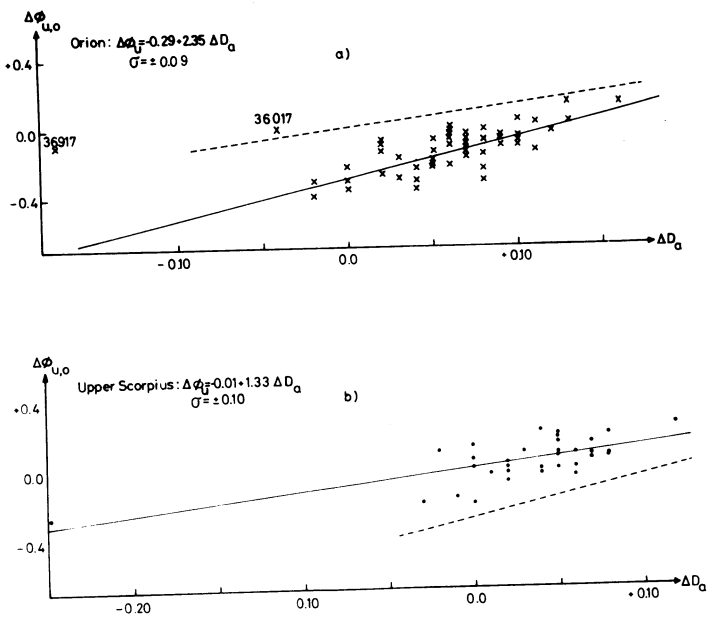

Fig. 1. Correlation between ΔD_a and $\phi_{u,o}$; a) the dashed line represents Upper Scorpius relation; b) the dashed line corresponds to Orion stars.

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smaller $\phi_{u,o}$ gradients than Upper Scorpius stars.

An analysis of the residuals found shows that they are functions of ΔD_a. The correlation (Fig. 1) implies that stars with emission in the Balmer continuum have gradients larger than normal, while those with an excess absorption have gradients smaller than normal. The effect for positive ΔD_a values confirms quantitatively the conclusion of the early work by Barbier and Chalonge (1941) in the sense that stars with emission in the Balmer continuum are redder (have larger gradients) than normal stars. We notice that Orion and Scorpius stars satisfy different relations, with different zero points. Thus, the gradients are smaller for Orion stars, which confirms the Schild and Chaffee (1971) conclusion that the energy distributions of several Orion stars suggest that continuum temperatures are higher than those inferred from the MK spectral types. Upper Scorpius stars satisfy a relation similar to that of the field stars.

The same type of correlation is found when comparing our results with uvby photometry. If we determine the difference between the observed gradients and the mean gradients corresponding to a given observed (u-b), we find that the residuals are also functions of ΔD_a. The stars HD36017 and HD36917 seem to behave more like Upper Scorpius stars. We are not sure if this fact has a physical meaning.

The fact that positive and negative ΔD_a values satisfy the same relation for a given group of stars suggests again that both have the same origin, that is to say, that both originate in circumstellar shells. The difference between the two types of phenomena would be due to different characteristics of the shell.

It is evident that the spectral characteristics analyzed here have influence in the photometric spectral classifications. For example, the S_Q classification is based in a measure of the Balmer jump D; but D appears too small for stars with $\Delta D_a > 0$, which would be classified earlier than their MK type; and it appears too large for stars with $\Delta D_a < 0$, which would be classified later.

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DISCUSSION

WARREN: Have you looked for and/or noticed any correlation between the parameter ΔD and spectral type?

GUTIÉRREZ-MORENO: No, we have never compared our ΔD_a with spectral types; we have compared them with differences between MK types and photometric types; and we have found that a slight correlation seems to exist.

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