THE STRÖMGREN FOUR-COLOR SYSTEM AND THE LOG T_{eff}, LOG G DIAGRAM

Lawrence J. Relyea

Dudley Observatory

A. G. Davis Philip

Dudley Observatory and Union College

1. INTRODUCTION

Strömgren (1966) set up the four-color system of photometry as a means of studying early-type stars in the spectral range O through F. In this spectral range one of the important measures that can be made of a stellar spectrum is the magnitude of the Balmer jump. For stars of a given (b-y) color the discontinuity is very large for stars of high luminosity and small for low luminosity stars. For very hot stars (O and B stars) this luminosity effect becomes too small to be used as a luminosity indicator, but because of this insensitivity to luminosity changes the magnitude of the Balmer discontinuity becomes a temperature indicator (see Philip and Newell 1974 and Davis and Shobbrook 1977). Photoelectric measures of the strength of the Hβ line can be used in a similar, but reverse, manner. For the B and O stars the index is a measure of luminosity; for late A and F stars the index is a good temperature index. In the spectral range A0-A3 both the Balmer jump and the Beta index are functions of temperature and luminosity. For a bibliography of the many uses of Strömgren four-color and Hβ photometry see the paper prepared by Philip and Perry (1977).

Kurucz (1977) has computed a grid of model atmospheres for O-G stars with the input parameters of T_{eff} (5500K to 10000K), log g (4.5 to 2.0) and [M/H] (solar abundance, 1/10 and 1/100 solar abundance). By means of this grid, it is now possible to transform a set of intrinsic four-color indices into the fundamental parameters log T_{eff} and log g for stars in the spectral range

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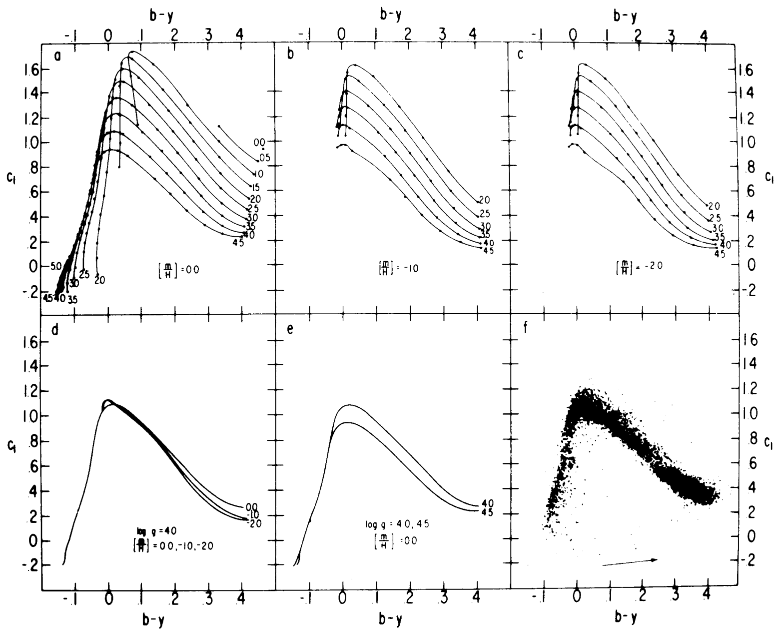

Fig. 1. The (c_1) vs. (b-y) diagrams for (a) models with [m/H] = 0.0, (b) models with [m/H] = -1.0, (c) models with [m/H] = -2.0, (d) models with log g = 4.0, three separate abundances, (e) models with log g = 4.0 and 4.5, [m/H] = 0.0, and (f) stars (not dereddened) in the HMC with the direction of reddening indicated by an arrow.

A-F and luminosity classes V-III of both Pop I and II, provided one learns the approximate metal abundance of the star by means of some other investigation (see Relyea and Kurucz 1977).

2. THEORETICAL COLORS

A theoretical photometric system was defined in Relyea and Kurucz (1977), who used the photometric calibration of Vega (Hayes and Latham 1975) to calibrate the system. Transformation coefficients between the theoretical colors and the observed colors for Vega (Crawford and Barnes 1970) were determined by convolving the filter transmission curves of the uvby filters from Matsushima (1969) with the fluxes predicted by Kurucz's atmospheric models.

The transformation between the theoretical colors, $(c_1)_o$ and $(b-y)_o$, and the observed colors was checked by comparing the calculated log T_{eff} and log g values for 28 stars (considered as standards because spectroscopic measures had been made from which log T_{eff} and log g were calculated) with the published values (see Philip, Miller and Relyea 1976). The rms errors of the calculated values relative to the published values were $\pm$ 250 K in

T_{eff} and ± 0.2 in log g. A small discrepancy in log g's calculated for F-type stars (noted in Relyea and Kurucz 1976) was corrected by moving the grid so that the ZAMS of Crawford (1975) fell on the log g = 4.3 grid line in the c_1, (b-y) diagram. The grid of log g values was corrected at log g = 2.0, 2.5, 3.0, 3.5, 4.0 and 4.5 by moving the grid up, along the temperature lines by the amount which corrects the ZAMS. The theoretical m_1 indices, calculated for log g's of 4.0 and 4.5, do not agree with the distribution of points in an observational m_1 versus (b-y) diagram for stars with (b-y) > $0^m.05$, so this grid was not used for the calculation of T_{eff} and log g.

The $(c_1)_o$, $(b-y)_o$ grid for [M/H] = 0, -1.0 and -2.0 is shown in Fig. 1 abc (from Relyea and Kurucz 1978). The effects of changes in [M/H] and log g are shown in Fig. 1 de. The distribution of 5183 stars in the Hauck Mermilliod catalogue (uncorrected for interstellar reddening) is shown in Fig. 1 f. Philip and Relyea (1977) have prepared large scale grids for use in transforming dereddened $(c_1)_o$ and $(b-y)_o$ indices in Θ_{eff} and log g. To use the grids, one must first deredden the star, and then knowing the population type and the metallicity, plot the point in the $(c_1)_o$, $(b-y)_o$ grid and read off the Θ_{eff} and log g. If the star is peculiar, luminosity class I or II, or outside the limits $0^m.0 < (b-y)_o < 0^m.4$ then Θ_{eff} and log g can not be determined.

Code et al. (1976) give T_{eff} for some early-type main sequence stars in their Table 6 and a relation between T_{eff} and $(B-V)_o$ in Table 7. The T_{eff}, $(b-y)_o$ relation for log g = 4.3 is very close to the Code relation and does as well or better than similar relations determined by Palmer (1977), Olson (1974), or Breger (1975).

3. APPLICATIONS

Four-color observations of any normal Population I or II stars in the $(b-y)_o$ color interval of $0^m.0$ to $0^m.4$ can be transferred into the log T_{eff}, log g plane. Astronomers who calculate evolutionary tracks present their calculations in such diagrams, so it is possible to make direct comparisons between theory and observation. Some comparisons of this sort will be described in more detail in another paper at this Symposium (Philip 1978).

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