ENERGY DISTRIBUTIONS AND SPECTRA OF ORION B STARS

Rudolph E. Schild and Frederic Chaffee
Smithsonian Astrophysical Observatory
Cambridge, Massachusetts

ABSTRACT

New MK spectral types and energy distributions are presented for B stars in Orion for which far ultraviolet flux excesses have recently been discovered. Significant differences between HD spectral energy distributions show the Orion late B stars to have smaller Balmer discontinuities than do field stars of the same spectral types. For the late B stars, these effects cause the 1500 Å fluxes to be under-estimated by approximately 0.5 mag. No comparable systematic effects were found for the early B stars.

Recent studies of ultraviolet fluxes of the Orion B stars by Weber, Henry and Carruthers (1970) and by Celescope appear to have shown that some stars are upwards of 1 magnitude too bright in the 1500 Å region. It is important to realize that these inferences are based largely on spectral classifications and UBV photometry, which are combined to infer the temperature and reddening. Because modern MK spectral types are unavailable for many Orion stars, and frequent reference is made to the HD catalogue, we first investigate the possible errors in the classifications.

New spectrograms for classification were obtained with a small grating spectrograph at the Cassegrain focus of the new Mt. Hopkins 60" Tillinghas reflector. The disperson was 85 Å/mm, and all spectra were widened to 1 mm. Stars observed include the Orion objects identified by Celescope as too bright in the far ultraviolet by at least one magnitude, and the B stars in the stellar ring surrounding ε Orionis.

The new spectral types are shown in Figure 1, where the HD spectral types are shown in comparison. It is evident from

Figure 1 that large systematic differences are present for the late B stars in Orion. Available UBV photometry confirms the correctness of the new MK types.

We conclude that substantial errors affect the HD spectral types of the Orion B stars, and that many are hotter and more reddened than had previously been determined.

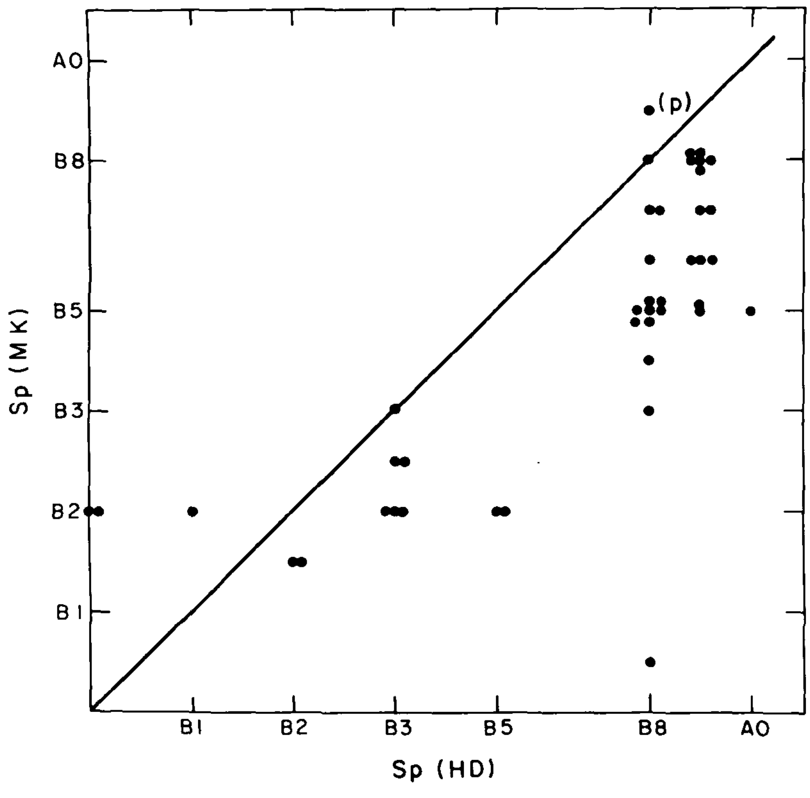

Figure 1.

To investigate the possibility that stars found too bright in the far ultraviolet may have energy distributions inconsistent with their absorption line spectra, we have measured the energy distributions for all of the stars in the Celescope list, except for θ Ori. We used the Mt. Hopkins 60" telescope and a scanner constructed by Dr. Latham. The scanner has a McPherson monochromator with a pre-programmable grating drive, punched card output, and a refrigerated ITT FW 130 photomultiplier. Nightly extinction coefficients were computed, and the agreement between scans of the same star on different nights was better than $0\overset{m}{.}015$ at all wavelengths.

In Figure 2 we show the comparison between the observed energy distribution of HD 36936 and an Atlas model for T_{eff} =

16000°K, log g = 4.0. The models incorporate the far ultraviolet silicon opacities and hydrogen line blanketing. Similar comparisons for the 18 stars observed permit effective temperatures to be estimated, primarily from the size of the Balmer discontinuity.

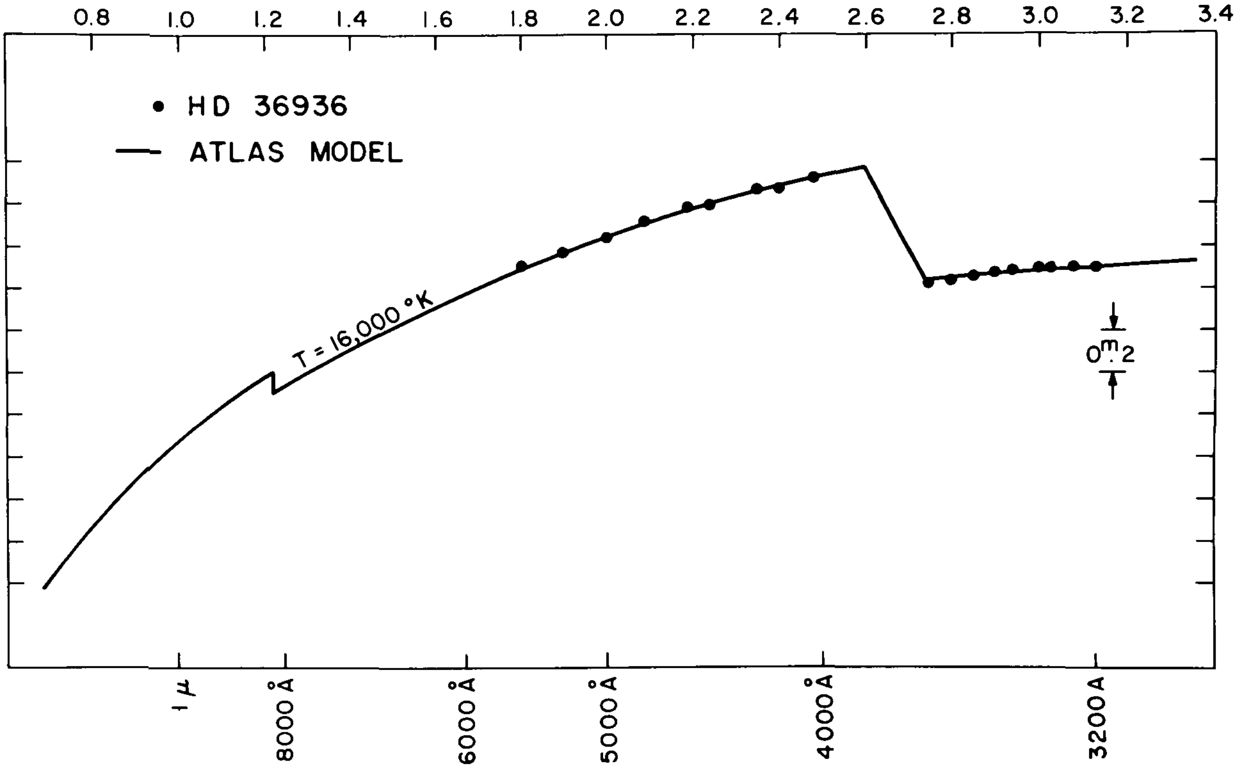

Figure 2.

The effective temperature-spectral type relation found for the Orion stars is shown in Figure 3, in comparison with the mean relation found from similar data for field stars. While scatter may appear to be relatively large for the early B stars because of the steepness of the spectral type-effective temperature relation, systematic effects appear to be present for the late B stars. In particular, at given late B spectral type, an Orion star is likely to have a higher effective temperature than a field star.

A similar effect has been found by Garrison in his comparison of MK spectral types with UBV photometry of the Scorpio Centaurus stars, which probably are of similar age to the Orion objects. The effect is illustrated in Figure 4, which compares MK spectral types of Orion and Scorpio Centaurus

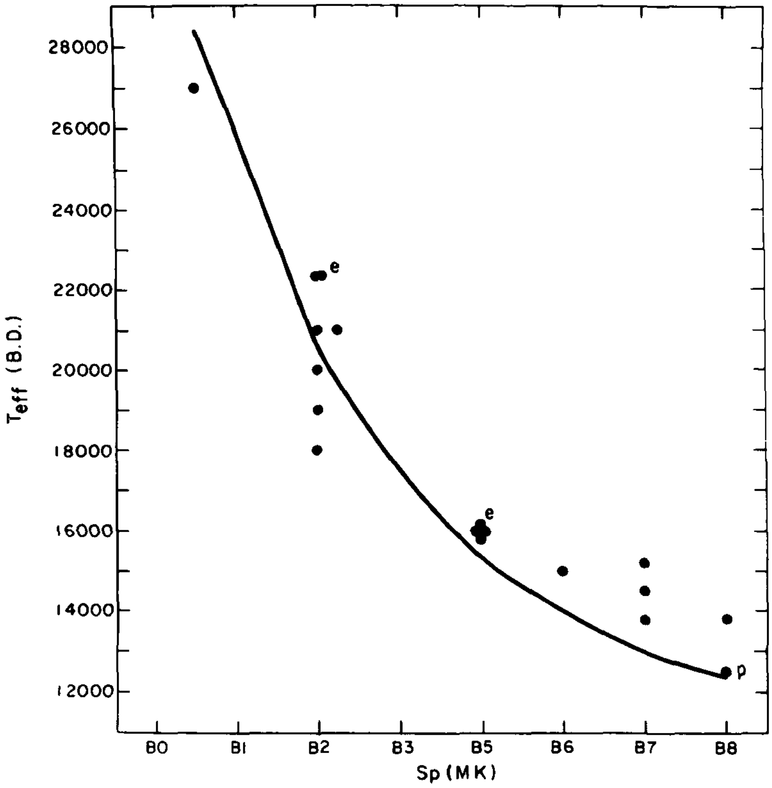

Figure 3.

stars with spectral types inferred from the Q method using UBV photometry. Stars identified as peculiar by Garrison are found to depart most strongly from the regression line, but it appears that many more stars show the effect to some extent. The effect appears to be limited to stars having MK spectral type B5 or later.

Results to this point suggest that reddening will have been underestimated by the procedure adopted in the past, where temperature has been estimated from HD or MK spectral type and reddening from UBV photometry. The two effects tend to cancel one another.

We may attempt to estimate the net effect on the 1500 Å fluxes by the following procedure. We note first that the reddening law appropriate to the Orion Belt stars appears to be $E_{1500-V}/E_{B-V} = 6.0$. An integration of the 1500 Å fluxes from Atlas models gives $\Delta(1500-V)/\Delta(B-V) = 12 \pm 1$ over the relevant range of effective temperature. Thus we find for a typical star having an HD spectral type of B8 and an intrinsic color of (B-V) = -0.16, corresponding to B5, that the 1500 Å

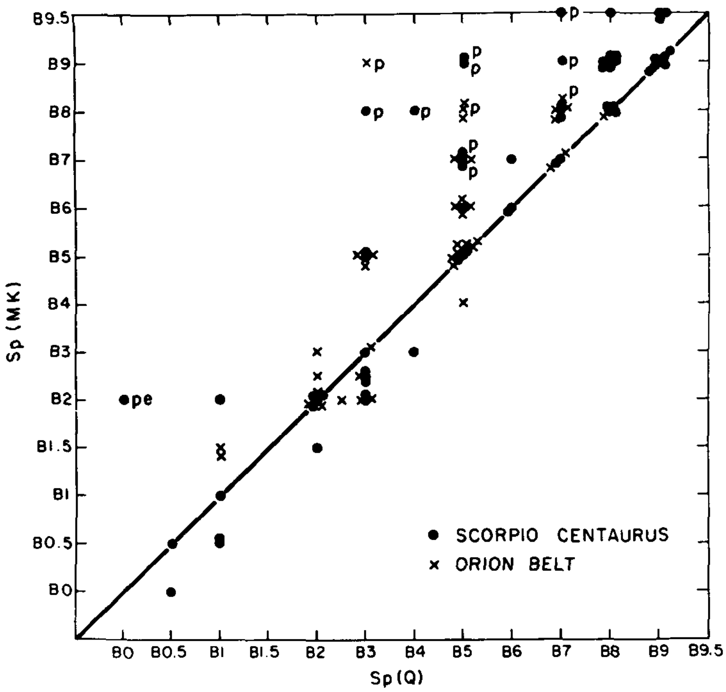

Figure 4.

flux will have been underestimated by nearly 0.5 magnitudes. This is only about half the amount found in the Celescope photometry.