THE TEMPERATURE SCALE OF G AND K SUBGIANTS

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ABSTRACT: This investigation of nearby Population I stars was motivated by our need for accurate effective temperatures in order to be able to obtain reliable N abundances from lines belonging to the CN red system. These determinations are based on narrowband photometry calibrated by means of synthetic spectra. It is believed that the temperatures are accurate to within 100 K. The results show that recent calculations of evolutionary tracks of G and K subgiants predict the observations quite well. However, a value for the mixing length parameter l/H_p close to 1.6 is required.

1. THE PHOTOMETRIC SYSTEM

The selection of bandpasses is based on the work on the effective temperature of Arcturus by Frisk et al. (1982). Three 0.01 micron wide bandpasses were selected; their central wavelengths are 0.59, 0.78 and 1.06 micron. The bandpasses fit well into the atmospheric windows and avoid uncertain or large stellar blocking. The observations were normalized against Vega and have maximum total errors of less than 5%.

Detailed synthetic spectra were calculated using the Synthetic Spectrum Generating (SSG) program as described by Bell and Gustafsson (1978). These spectra were calculated for a grid of models (Bell et al. 1975, plus additional models calculated using the same methods) covering effective temperatures from 4000 K to 6000 K in steps of 500 K, surface gravity from log g equal 3.00 to 5.25 in steps of 0.75 and for metallicities [M/H] from -2.0 to solar. Spectra were also calculated for a model of Vega (Dreiling and Bell 1980) and for a grid model with solar parameters. The theoretical colors were produced by evaluating the integral of the product of the spectra and the filter passbands.

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The solar flux was also computed at the wavelength of the passbands using a grid model from Bell et al. (1975, BEGN) and for two semi-empirical models, one from Holweger and Müller (1975, HM) and one due to Vernazza et al. (1976, VAL). These are compared to the observed flux as by Arvesen et al. (1967, AGP) and Labs and Neckel (1968, LN) in Table I.

TABLE I

CALCULATED AND OBSERVED SOLAR FLUXES

Flux ratio	model flux BEGN	HM	VAL	obs. flux AGP	LN
$2.5\ \mathrm{LOG}_{10}\ F_{590}/F_{780nm}$	0.42	0.44	0.43	0.44	0.43
$2.5\ \mathrm{LOG}_{10}\ F_{590}/F_{1060}$	1.10	1.13	1.11	1.12	1.10

2. THE EFFECTIVE TEMPERATURES

The determination of the effective temperatures assumes that the metal content is proportional to the iron abundance which is based on the calibration of weak ($\log W/\lambda < -4.8$) Fe I lines. The surface gravity is based on the assumption of solar mass and the trigonometric parallax. The temperature calibration is not very sensitive to small changes of the metallicity or surface gravity.

The temperatures determined from the theoretical calibration were used to calibrate the Johnson R-I colors. According to our scale a star like the Sun would have an R-I index close to $0\overset{m}{.}35$. This high value is in agreement with direct measurements of the solar B-V color. For the stars in this sample the excitation temperatures based on weak Fe I lines do not disagree much with the color-based temperatures. The mean difference is 30 ± 30 K. The excitation temperatures are hotter.

The dominating uncertainty in the temperature scale comes from the calibration source, Vega. Changing the effective temperature of the Vega model by 300 K corresponds to a shift of 60 K for a star with an effective temperature of 5000 K.

3. COMPARISON WITH EVOLUTIONARY TRACKS

Since we know the effective temperature of each star and we can infer the luminosity from the parallax together with the V-magnitude and a bolometric correction it is of interest to compare these values to evolutionary tracks of Population I stars. These were taken from VandenBerg (1983). Bolometric corrections were adopted from Bell and Gustafsson (1978). The results have been plotted in Fig. 1. The set of tracks has not been shifted to agree with the position of the Sun. One should be aware that the selection of stars was not unbiased. From Fig. 1 it is clear that the stars cluster around a line which we believe to be the base of the red giant branch.

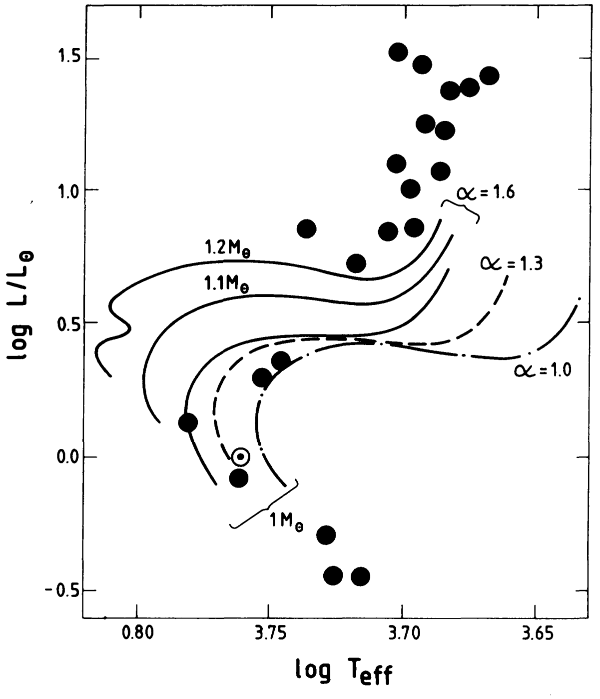

Fig. 1. The position of the program stars in a temperature-luminosity diagram. For comparison calculated evolutionary tracks for stars of solar composition (VandenBerg 1983) have been included.

However, the stars were not selected to cluster, and on the contrary an attempt was made to sample a range both in temperature and luminosity. If we believe that the mass of a red giant is close to solar then we get a reasonable agreement with our determination for a value of the mixing length parameter l/H_p close to 1.6.

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