STEPS TO A NEW CALIBRATION OF THE SPECTRAL TYPE — EFFECTIVE TEMPERATURE RELATIONSHIP FOR EARLY-TYPE STARS

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The spectral type - effective temperature calibration is a cornerstone of our understanding of massive stars and their environment. Any uncertainty in determining their effective temperature is directly reflected in an uncertainty in defining the bolometric luminosity and the number of ionizing photons. We suggest that previous calibrations of bolometric luminosity and the number of ionizing photons as a function of spectral type may be uncertain by at least a factor of 3 for the early O-type stars (Table 1).

TABLE I: COMPARISON OF STELLAR PARAMETERS FOR SPECTRAL TYPE O4If.

	T_{eff}	log g	B.C.	M_V	M_{bol}	log N_{phot}
Panagia (1973)	45,000	3.5	-4.1	-6.5	-10.6	49.9
Conti (1973)	50,000	4.0	-4.5	-6.2	-10.7	49.9
zeta Puppis	42,000	3.5	-4.0	-6.2	-10.2	49.5

We have begun a new determination of the basic stellar parameters of massive stars with an analysis of zeta Puppis (O4f). The most accurate method of determining the temperature of any hot star is to model photospheric line profiles (Abbott and Hummer 1985). For our analysis new high precision observed line profiles of zeta Puppis are fitted with theoretical calculations that include the effects of wind-blanketing. Observed line profiles were obtained with the coude spectrograph and an RCA CCD camera at Kitt Peak National Observatory in February 1984. We observed 11 hydrogen, neutral and ionized helium lines between 3900Å and 6700Å at a resolution (2 pixels) of 0.59Å in the blue and 0.89Å in the red. Measured signal-to-noise ratios range from 100:1 to 650:1.

The model atmospheres are Mihalas (1972) atmospheres modified at the upper boundary condition to account for the radiation reflected back onto the photosphere by the stellar wind, the mechanism referred

C. W. H. De Loore et al. (eds.), Luminous Stars and Associations in Galaxies, 111–112.

https://doi.org/10.1017/S0074180900148776 Published online by Cambridge University Press

to as wind-blanketing (see Abbott and Hummer 1985 for details). The effect of wind-blanketing on a stellar photosphere appropriate to zeta Pup is to warm the layers where the helium lines arise so that lines of equivalent strength are formed at an effective temperature some 4,000K^{o} cooler than in a wind-free atmosphere.

For zeta Puppis, the relation between spectral type and effective temperature is changed from earlier spectroscopic analysis roughly 20% by accounting for gravity, 10% by using higher precision observations, and 10% from wind-blanketing (Tables 1 and 2).

TABLE 2: STELLAR PARAMETERS FOR ZETA PUPPIS

	$T_{effective}$	log g	[Y]
Kudritzki *et al.* (1983)	42,000±2,500	3.5±0.15	0.14±0.03
unblanketed (this analysis)	46,500	3.6	0.16
blanketed (this analysis)	42,000±1,500	3.5±0.1	0.17±0.03

We determine the same temperature with our wind-blanketed analysis as did Kudritzki *et al.* (1983) from their unblanketed study because of a systematic difference in measured equivalent widths (this analysis - Kudritzki *et al.* = 0.070±0.093Å). Kudritzki *et al.* co-added line profiles from spectra obtained with Kodak type IIIa-J photographic emulsion for an estimated signal-to-noise ratio of 100:1. They would have found a higher temperature similar to our unblanketed result with line profiles equivalent to ours.

The emergent flux of luminous stars is very sensitive to gravity. For zeta Puppis, an uncertainty of 0.2% in the wing of H gamma represents a change of 0.1 in log g. The gravity must be measured with this precision to define with realistic accuracy bolometric corrections and the flux of ionizing photons. The RCA CCD camera we used for these observations is limited in its photometric precision by calibration of fringing effects. For this analysis we have minimized residual fringing effects by adding together spectra taken at slightly different grating settings and thus different fringe patterns.

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https://doi.org/10.1017/S0074180900148776 Published online by Cambridge University Press