SUBLUMINOUS STARS IN THE HR DIAGRAM

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1. INTRODUCTION

Eggen (1969) has defined a subluminous star "... as one that is fainter by at least a factor of 10 in visual luminosity than the main sequence stars of the same (U-V)." Implicit is the suggestion that single stars might exist in the region of the HR diagram between the subdwarfs and the normal degenerate sequence. While the evolutionary calculations of Chin and Stothers (1971) indicate that stars with masses $<0.2\ M_{\odot}$ will pass through this region following the completion of nuclear burning, these models have not yet been confirmed. We summarize Naval Observatory astrometry and photometry as it pertains to the existence of such stars.

2. PROPOSED SEQUENCE OF SUBLUMINOUS STARS

Several observational investigations have suggested the existence of a sequence of subluminous stars which apparently bridges the region between the normal degenerate sequence and the subdwarf domain in the HR diagram. Evidence for this hypothesis has been presented by Eggen (1970, 1971) based on six stars with apparently reliable luminosity determinations. Four of these stars (L870-2, R974, LTT6662, and W1037) have trigonometric parallax determinations greater than 0".05, and a fifth star (LTT6333) appears to have a common proper motion with β TrA (HD141891) which has a trigonometric parallax of about 0".08. The sixth star (HG7-138) has a position and a proper motion indicating a 90% probability of membership in the Hyades cluster (van Altena 1969).

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Naval Observatory parallax determinations have been completed for the four stars north of -20^{o} declination. The results are summarized in Table I below, where M_V (Eggen), the visual absolute magnitude adopted by Eggen, is compared with M_V(USNO), the corresponding quantity obtained from the Naval Observatory parallax. Our deduced status of the star is given in the last column; the data do not support the proposed subluminous sequence.

TABLE I

STAR	USNO	M_V(USNO)	M_V(Eggen)	STATUS (USNO)
L870-2	0".084±0".004	+12.5±0.1	+11.8	Normal degenerate
R974	0".012±0".004	+8.2±0.7	+12.1	Extreme subdwarf
HG7-138	0".003±0".003	+7.9±2.2	+12.7	Dwarf or subdwarf
W1037	0".023±0".004	+11.0±0.4	+12.8	Extreme subdwarf

Regarding the two southern stars, we note the following: 1) The relationship between LTT6333 and β TrA is suspect, since the two stars are widely separated ($\rho \simeq 157''$) and their proper motions differ by $\Delta\mu = 0''.05\ yr^{-1}$ (Luyten 1957); and 2) The luminosity of $M_V = +12^{m}.7$ adopted by Eggen for LTT6662 is based on a reliable Yale parallax determination (0".099) but is consistent with an extreme subdwarf interpretation for this star.

3. FIELD SUBLUMINOUS STARS

Over 400 field stars have been suggested as being subluminous by Eggen (1971 and earlier papers). These suggestions were usually based on either 1) an observed ultraviolet excess larger than the maximum expected from abundance effects, or 2) photometry which, when considered in conjunction with a measured proper motion, indicated an excessive tangential velocity if the star were considered to be a normal dwarf or subdwarf. Over 50 of the 200+ candidates north of $\delta = -20^{o}$ have been included on the USNO parallax program. Of the 42 stars with reliable solutions, 12 are normal degenerates. The remaining 30 stars have parallaxes which for the most part are small (<0".020). Considering only the 17 candidates for which the measured parallaxes exceed their mean errors, we examined the locations of the 12 stars with $0^{m}.6 \leq (B-V) \leq 1^{m}.3$ in the M_V *vs.* (B-V) color magnitude diagram; the M_V vs $(V-I)_{KM}$ diagram was employed for the 5 later candidates. When compared with the average dwarf sequences defined by the nearby stars ($\pi \geq 0''.05$), we find no stars convincingly subluminous in the sense of Eggen's definition. However, we do find considerable evidence for extreme subdwarfs up to 2.5 mag subluminous, although the large errors in absolute magnitudes associated with the small parallaxes involved limit the conclusiveness of this

evidence.

We can, however, supplement the above sample with 54 additional stars from the USNO Parallax Program which apparently have kinematic and photometric properties similar to Eggen's subluminous candidates. Examination of this larger body of data leads to the following preliminary conclusions: 1) stars as subluminous as 1.5 mag below the mean main sequence (defined by the nearby stars) seem well established for the color range of $0^m.6 \leq (B-V) \leq 1^m.3$ in the M_V vs. (B-V) diagram. Subluminosities as large as 2.0 mag are less well established but are highly likely, while subluminosities as large as 2.5 mag seem doubtful but still possible. No evidence is found for stars more subluminous than 2.7 mag. 2) Stars as subluminous as 2.0 mag below the mean main sequence (defined by the nearby stars) seem well established for the color range of $0^m.8 \leq (V-I)_{KM} \leq 1^m.9$ in the M_V vs. $(V-I)_{KM}$ diagram. Furthermore, subluminosity as large as 2.5 mag seems quite likely over this color range. No evidence is found within this sample of stars for subluminosities in excess of 2.9 mag. 3) Stars with tangential velocities as large as 250 km/sec are well established in this sample, while values as large as 300 to 350 km/sec are probable. No reliable evidence for tangential velocities above 400 km/sec is found.

4. CONCLUSIONS

Available Naval Observatory data do not support the presence of field stars between the normal degenerate sequence and the subdwarf region. However, our data do support the existence of subdwarfs as much as 2.0 to 2.5 magnitudes below the main sequence defined by the nearby stars in both the M_V vs. (B-V) and M_V vs. $(V-I)_{KM}$ diagrams.

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DISCUSSION

LIEBERT: What was the trigonometric M_V for G165-47?

DAHN: $M_V = +12^m.5 \pm 0^m.3$.

LIEBERT: I wonder if Dr. Greenstein might comment on his spectra of the low luminosity subdwarf or subluminous stars mentioned in his talk -- $M_V \sim +13^m$, I believe -- compared with the spectra shown for G165-47?

GREENSTEIN: I can't remember the details of the G165-47 spectrum, except that it has strong hydride bands. In any case, the colors indicate a luminosity $M_V \approx +10^m.8$, rather than $+12^m.5$ from the recent good parallaxes. The evidence is therefore that even my "subluminous" sequence is not sufficiently faint. The more depressing prospect is that any color-magnitude diagram will be still affected in the late M's by differential line-blocking. The blanketing vector is so large, from the model-atmosphere to the observed colors, that composition changes might make a high-velocity dM look like a sdK and a late sdM like an early dM, and make its predicted luminosity too bright and its space motion too large.

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