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ABSTRACT

Recent reanalyses of *HIPPARCOS* parallax data confirm a previously noted discrepancy with the Pleiades distance modulus estimated from main-sequence fitting in the color-magnitude diagram. One proposed explanation of this distance modulus discrepancy is a Pleiades He abundance that is significantly larger than the Hyades value. We suggest that, based on our theoretical and observational understanding of Galactic chemical evolution, nitrogen abundances may serve as a proxy for helium abundances of disk stars. Utilizing high-resolution near-UV Keck/HIRES spectroscopy, we determine N abundances in the Pleiades and Hyades dwarfs from NH features in the $\lambda 3330$ region. While our Hyades N abundances show a modest ~ 0.2 dex trend over a 800 K T_{eff} range, we find the Pleiades N abundance (by number) is 0.13 ± 0.05 dex lower than in the Hyades for stars in a smaller overlapping T_{eff} range around 6000 K; possible systematic errors in the lower Pleiades N abundance result are estimated to be at the ≤ 0.10 dex level. Our results indicate [N/Fe]~ 0 for both the Pleiades and Hyades, consistent with the ratios exhibited by local Galactic disk field stars in other studies. If N

production is a reliable tracer of He production in the disk, then our results suggest the Pleiades He abundance is no larger than that in the Hyades. This finding is supported by the relative Pleiades-Hyades C, O, and Fe abundances interpreted in the current context of Galactic chemical evolution, and is resistant to the effects on our derived N abundances of a He abundance difference like that needed to explain the Pleiades distance modulus discrepancy. A physical explanation of the Pleiades distance modulus discrepancy does not appear to be related to He abundance.

Subject headings: Star Clusters and Associations – Stars

1. Introduction

1.1. The Pleiades Distance Modulus Problem

A provocative early result of the ESA's *Hipparcos* parallax mission was a Pleiades distance modulus (van Leeuwen & Hansen Ruiz 1997; van Leeuwen 1999) 0.30 mag smaller than that derived from evolutionary models via main-sequence fitting (Pinsonneault et al. 1998). Given that metal-poverty explains the small fraction of young nearby disk field dwarfs that are similarly subluminous in the *Hipparcos*-based color-magnitude diagram Soderblom et al. (1998), Pinsonneault et al. (1998) suggested that the parallax versus main-sequence fitting discrepancy was caused by small (1 mas) systematic errors in the *Hipparcos* Pleiades parallaxes. Makarov (2002) recomputed Pleiades parallaxes using the *Hipparcos* intermediate astrometry data, finding a shift in the mean parallax that places the inferred distance modulus in substantial agreement with the main-sequence fitting results. Robichon et al. (1999), however, utilize Monte Carlo simulations of the *Hipparcos* cluster data, and find that no systematic biases or small angular scale effects are present in the Pleiades *Hipparcos* parallaxes.

Percival, Salaris & Groenewegen (2005) have cautioned against using lower main-sequence $(B-V)$ colors, which appear anomalous in the Pleiades (Stauffer et al. 2003), in deriving distances from main-sequence fitting. Excluding these data, Percival, Salaris & Groenewegen (2005) find that various color-magnitude planes consistently yield Pleiades distances 10% larger than parallaxes. Distance determinations of the Pleiades eclipsing binary HD 23642 (Southworth, Maxted & Smalley 2005) and the Pleiades binary Atlas Pan, Shao & Kulkarni (2004) are consistent with those determined from cluster main-sequence fitting, and inconsistent with the smaller distance implied by *Hipparcos*. The HST/FGS-based parallaxes of 3 Pleiades dwarfs Soderblom et al. (2005) are also in outstanding agreement with the main-sequence fitting-based results, but inconsistent with the *Hipparcos* result.

van Leeuwen (2007a) and van Leeuwen (2009) describe a new reduction, with improved treatment of small angular scale astrometric correlations noted by Pinsonneault et al. (1998), of the *Hipparcos* mission astrometric data that has lead to significantly increased accuracy. The result is a Pleiades distance modulus in accord with the original *Hipparcos* result. Indeed, van Leeuwen (2009) cite 3 clusters (Pleiades, Blanco 1, NGC 2516) whose main-sequence stars appear similarly subluminous when compared to those in other clusters.

1.2. Resolutions to the Pleiades Distance Modulus Problem: Metallicity

Grenon (2001) suggests that the discrepancy can be explained by a slightly sub-solar Pleiades metallicity, [m/H]$= -0.11$, indicated by Geneva photometry. However, Stello & Nissen (2001) have used the metallicity-sensitive Stromgren m_1 index to select field stars having the same photometric metallicity as the Pleiades to form an empirical Pleiades ZAMS with which to conduct main-sequence fitting; Stello & Nissen (2001) deduce a Pleiades distance modulus in close agreement with previous fitting, but at odds with the *Hipparcos* parallaxes. Percival, Salaris & Kilkenny (2003) also carry out empirical main-sequence fitting of the Pleiades using a sample of field stars of known metallicity and high accuracy *Hipparcos* parallaxes, and infer a surprisingly low Pleiades metallicity ([m/H]~ -0.4) from a 2-color diagram. Assuming this photometric metallicity, they find that the distance from main-sequence fitting is brought into agreement with the *Hipparcos* results.

The differences between the Geneva-, 2-color plane-, and Stromgen-based ([Fe/H]$=$ $+0.08$; Eggen 1986) photometric Pleiades metallicity estimates, as well as the simultaneous claims that metallicities of both -0.11 and -0.40 shift the evolutionary model main sequences into agreement with the Hipparcos parallaxes, seem remarkable. The implication that a variety of independent modern high-resolution spectroscopic abundance analyses (Boesgaard & Friel 1990; Cayrel, Cayrel de Strobel & Campbell 1988; Wilden et al. 2002; King et al. 2000; Ford, Jeffries & Smalley 2002; Soderblom et al. 2009) have consistently overestimated a near-solar Pleiades metallicity also is remarkable.

1.3. Resolutions to the Pleiades Distance Modulus Problem: Helium

van Leeuwen (2009) posits that the dichotomy between the *Hipparcos*-based H-R diagrams of the young Pleiades, Blanco 1, and NGC 2516 clusters and older clusters like the Hyades and Praesepe is due to "age-dependent luminosity effects" that are neither empirically calibrated out of the theoretical isochrones nor included in the underlying evolutionary

models. Such a luminosity difference between the Hyades/Praesepe and Pleiades main-sequences was inferred on the basis of Stromgren photometry long ago (Crawford & Perry 1966), questioned by Eggen (1994), but confirmed by Joner & Taylor (1995). van Leeuwen (2009) note that this so-called "Hyades anomaly" has simply been forgotten, rediscovered from *Hipparcos* parallaxes, and relabeled as a Pleiades parallax anomaly.

While several origins of a real luminosity difference between the Pleiades and Hyades main-sequences exist (Labonte & Rose 1985), a suggestion as old as the Hyades anomaly itself is inter-cluster He differences (Crawford & Stromgren 1966) that yield inter-cluster luminosity differences. Pinsonneault et al. (1998) note that a Pleiades He mass fraction of $Y = 0.37$, compared to a solar value $Y_\odot = 0.27 - 0.28$ (Bahcall, Pinsonneault & Wasserburg 1995), could explain the 0.3 mag distance modulus discrepancy. Observational evidence for such large Y values in young disk stars is muddy Pinsonneault et al. (1998), and the determination of stellar He abundances is fraught with uncertainty and study-to-study differences. A relative comparison of Pleiades He abundances with those in the Hyades, for which the *Hipparcos*-based and main-sequence fitting-based distance moduli agree, remains elusive: stellar He abundances are best-determined in B stars, which are absent in the Hyades due to its age.

Chemical evolution models (e.g., Carigi & Peimbert 2008) that map the coproduction of He, C, O, and Fe in the Galactic disk suggest He proxies could be used to examine the relative Pleiades-Hyades Y values in the context of relative cluster C, O, and Fe abundances. While O abundances derived from high-excitation O I lines exhibit unsettling large trends with $T_{\rm eff}$ (Schuler et al. 2004, 2006) that complicate an assessment of relative cluster abundances, a reliable relative measure comes from the Schuler et al. [O I]-based determinations for 3 dwarfs in each cluster. These data suggest Δ[O/H]$= +0.01\pm0.05(4)$ (Pleiades−Hyades). The Carigi & Peimbert (2008) chemical evolution models from Carigi & Peimbert (2008) yielding the largest Y difference for this negligible O difference suggest $\Delta Y = +0.004\pm0.02(2)$ (Pleiades−Hyades), significantly smaller than the $\Delta Y = +0.09$ prescribed by Pinsonneault et al. (1998) to resolve the Pleiades' distance modulus discrepancy.

High-excitation C I-based C abundances for cluster stars with $T_{\rm eff}\leq6500$ K, above which there exists evidence that dynamic transport mechanisms can alter the photospheric abundance (Gebran & Monier 2008), yield [C/H]$= +0.06\pm0.02$ and -0.06 ± 0.03 for the Hyades and Pleiades (Friel & Boesgaard 1990). Interpreting these relative abundances with the Carigi & Peimbert (2008) models suggests Y(Pleiades) is no larger than Y(Hyades) at the $\sim3\sigma$ confidence level. The difference (Pleiades − Hyades) in mean cluster F-dwarf Fe abundance is Δ[Fe/H]$= -0.16\pm0.03$ (Boesgaard & Friel 1990). The Carigi & Peimbert (2008) chemical evolution models suggest this corresponds to $\Delta Y = -0.01\pm0.003$.

1.4.   N as a He Proxy

While these abundance comparisons are inconsistent with a He abundance difference able to resolve the Pleiades distance modulus discrepancy, it may be that C, O, and Fe are not reliable tracers of He. We suggest that N may serve as a more robust proxy for He, and that relative cluster N abundances should thus be examined.

Extant results suggest that [N/Fe]∼0 over a wide range of [Fe/H] (Ecuvillon et al. 2004; Shi, Zhao & Chen 2002; Laird 1985; Carbon et al. 1982). Such a primary nucleosynthetic production signature can not be produced by Galactic chemical evolution models that solely assume explosive nucleosynthesis in massive stars (Timmes et al. 1995); rather, it is believed (Renzini & Voli 1981; Iben & Truran 1978) that N production occurs in low- and intermediate-mass stars (LIMS; ~ 1 M$_\odot \leq M \leq 8$ M$_\odot$). Carigi et al. (2005) suggest that observations constrain the contribution of LIMS to N abundances in the solar neighbhorhood to $65 - 75\%$, with massive stars contributing most of rest and Type Ia supernovae contributing negligibly. This is consistent with the estimate of Woosley & Weaver (1995), who ascribe only a quarter of solar N to that produced in massive stars. In contrast, O is the most abundant product of massive star explosive nucleosynthesis (Woosley & Weaver 1995), over half of solar-metallicity Fe in the disk comes from explosive production (Timmes et al. 1995), and only half of C in the solar neighborhood is produced by LIMS (Carigi et al. 2005).

While recent chemical evolution models identify non-explosive massive star wind yields as a source of uncertainty in Galactic He enrichment, the classic "road map" of Woosley & Weaver (1995) identifies LIMS stars as the dominant nucleosynthetic He source (see their Table 19), and there is no question that most of mass shed by evolved LIMS stars on their way to becoming white dwarfs is in the form of H and He. The chemical evolution model and observational constraints from Carigi & Peimbert (2011) suggest that the LIMS contribution to protosolar He (over and above the primordial Big Bang contribution) is $\geq 50\%$.

The nucleosynthetic results suggest that O and Fe are unlikely to be as robust proxies of disk He as are C and N, and that it is possible that N is a more robust proxy of He than is C in the Galactic disk. The essential point is the importance of comparing the Pleiades-Hyades N abundances in considering the role of He in the Pleiades parallax anomaly. We present such a comparison using self-consistently derived N abundances in solar-type dwarfs in the Pleiades and Hyades.

2.   Observational Data

High-resolution ($R{\sim}45,000$) spectroscopy of Pleiades and Hyades NH features near 3328 Å was obtained over 3 observing runs in 1999, 2001, and 2002 using the Keck I 10m telescope and HIRES spectrograph. The spectra are those used in the Be abundance studies of Boesgaard & King (2002) and Boesgaard, Armengaud & King (2003), who provide details concerning the observations and data reduction. We utilize only a subset of these spectra here because the NH features become vanishingly weak and/or significantly blended in the hotter ($T_{\mathrm{eff}}{\gtrsim}6200-6300$ K) stars and/or similarly less amenable to abundance analysis for the stars with larger rotational velocities ($v \sin i{\gtrsim}15-20$ km s^{-1}). Given the moderate trend in [N/H] abundance with T_{eff} we find for the (more numerous) cool Hyades stars, we restrict our attention in the Pleiades to stars with $T_{\mathrm{eff}}{\gtrsim}5950$ K, and also exclude stars for which binarity has been noted by others (e.g., H II 739 and 761).

Tables 1 and 2 list the Hyades and Pleiades stars analyzed here. Hyades objects are listed with van Bueren (1952) designations, while Pleiades stars are listed by their Hertzsprung (1947) identifications. Examples of the spectra can be seen in Figure 1.

Tab. 1
Tab. 2
Fig. 1

3.   Abundance Analysis and Results

Stellar parameters taken from the Be abundance studies of Boesgaard & King (2002) and Boesgaard, Armengaud & King (2003) were used to characterize LTE model atmospheres interpolated from the grids of Kurucz[1]. The linelist of the 3328 Å region was compiled from atomic and molecular lines in the Kurucz database[2], features in the Vienna Atomic Line Database (Kupka et al. 2000), and molecular lines from LIFBASE (Luque & Crosley 1999). Our adopted NH dissociation energy adopted is 3.45 eV, intermediate to the canonical value of 3.47 eV (Huber & Herzberg 1979) and the determination of 3.40±0.03 eV implied by experimental measures of various relevant quantities by Ervin & Armentrout (1987). Oscillator strengths (gf-values) were adjusted, typically by ≤0.2 dex, to produce solar syntheses matching the Kurucz solar flux atlas (Kurucz 2005) assuming solar CNO (logarithmic number) abundances of 8.39, 7.78, and 8.69 (Allende Prieto et al. 2001; Asplund et al. 2005); all 3 abundances are prescribed because molecular equilibrium is included in the syntheses.

LTE synthetic spectra of varying N abundance were calculated using an updated version of the MOOG package (Sneden 1973) that includes updated bound-free opacity data

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[1]http://kurucz.cfa.harvard.edu/grids.html

[2]http://kurucz.cfa.harvard.edu/linelists.html

important in the near-UV. Input abundances for the syntheses are scaled to the solar values of Anders & Grevesse (1989); for CNO, the solar values given above are adopted. We used scaling factors of [X/H]= +0.13 and +0.00 for the Hyades and Pleiades respectively[3]. Table 1 provides the v sin$i$ values adopted from the literature and used to smooth the syntheses in addition to a Gaussian representing instrumental broadening.

We find a small (2-4% of the continuum level) additional continuous veiling is needed to reproduce the depth of the strong non-NH features at 3327.9, 3328.3, 3328.9, 3329.5, 3329.9 Å for our Hyades stars; this additional veiling, which might signal a slight deficiency in the bound-free opacity, also substantially improves the line-to-line scatter of the derived N abundances in a manner not mimiced by small plausible adjustments in the continuum normalization or smoothing (or both). The additional veiling is added to our synthetic spectra by applying an additive constant prior to renormalization. Syntheses and a comparison with observed spectra are shown in Figure 1.

The abundances in each star are determined from several NH features (or blended group of features) by fitting each individually[4]. The scatter in these in a given star provides a combined measure of random measurement error and continuum fitting uncertainties in the derived abundances. The abundance results are summarized in Tables 1 and 2. The final three columns contain the mean N abundance (logarithmic by number, on the usual scale where $\log N(H) = 12$.), the number of features/regions used in determining the mean, and the standard deviation of the individual measurements. The mean logarithmic number abundance of nitrogen for each star is plotted versus $T_{\rm eff}$ in Figure 2, which reveals a modest 0.2 dex trend in the Hyades dwarfs over the 5400-6200 $T_{\rm eff}$ range. The non-parametric Spearman rank correlation coefficient is significant at > 99.9% confidence level for the Hyades data.

Fig. 2

We consider three possible sources of this trend. First is a deficiency in continuous opacity– whether truly continuous (e.g., bound-free) opacity or quasi-continuous opacity in the form of myriad very weak lines unaccounted for in the linelist. As noted above, we have guarded against such a deficiency by making small effective enhancements in the assumed veiling to reproduce the depths of strong atomic lines and minimize the scatter in the N abundances derived from NH features of different strength. The second possibility is that

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[3]For both the Pleiades and Hyades, we assume [O/H]= +0.14 based upon the $\lambda6300$ [O I]-based cluster dwarf results from Schuler et al. (2004) and Schuler et al. (2006). For the Hyades, we assume [C/H]=+0.15 based upon initial abundances derived for three dwarfs from C I and C_2 features (Schuler, King & The 2006).

[4]These features are located at 3325.88, 3326.39/3326.42, 3326.94, 3327.15, 3327.60, 3327.72, 3328.18, 3328.24, 3329.75, 3330.28, 3330.38, 3330.45, 3330.50, 3330.64, 3330.81, and 3330.92 Å

our adopted NH dissociation energy is too low. However, observations of predissociation of electronic states of NH yield a robust upper limit of $D_0 = 3.47$ eV Graham & Lew (1978), a value insignificantly higher than our adopted value.

The third possibility is an origin associated with the T_{eff}-dependent abundance trends previously observed in Hyades dwarfs. Figures 3, 5, and 10 of Schuler et al. (2006) show a 0.5 dex monotonic increase in ΔFe=[Fe II/H] $-$ [Fe I/H], a 0.6 dex increase in O I-based [O/H] values, and a 0.2 dex increase in [O I]-based [O/H] values in Hyades dwarfs over the T_{eff} range 6000-4000 K. Whether the trend we see for NH reflects an overdissociation akin to the apparent overexcitation/overionization these other abundances suggest, and what the physical origin of such effects are, remain unclear; a comparison of Li abundances derived from the λ6708 resonance and λ6104 subordinate Li I features in pre-main sequence stars, however, strongly suggests the action of enhanced near UV photoionization in cool very young stars (Bubar et al. 2011). Regardless, we emphasize that the modest trends in N abundance are not surprising in the context of T_{eff}-dependent trends previously seen in the Hyades dwarfs.

4.   Discussion

Given the modest T_{eff} trend in the Hyades N abundances, we determine the relative Pleiades-Hyades cluster N difference over the same $\sim$250 K T_{eff} range spanned by the four Pleiads. For a given cluster, the standard deviation in the mean N abundance over this range, $\pm$0.06 dex for both clusters, empirically estimates internal measurement and relative stellar parameter uncertainties. This per star estimate is also that expected from the maximum T_{eff} uncertainties of Boesgaard & King (2002) and Boesgaard, Armengaud & King (2003) and the typical mean measurement uncertainties calculated from the last 2 columns of Tables 1 and 2. The unweighted mean cluster N abundances computed over the 5940-6180 K range are log N(N)= 7.78$\pm$0.03 (uncertainty in the mean) and 7.91$\pm$0.03 for the Pleiades and Hyades, respectively. Weighting the individual abundances by the squared reciprocals of the individual uncertainties in Tables 1 and 2 yields indistinguishable mean abundances of log N(N)= 7.78$\pm$0.03 (Pleiades) and 7.90$\pm$0.03 (Hyades).

The Pleiades $-$ Hyades difference is then Δlog N(N)= $-$0.13$\pm$0.05, indicating that the Pleiades N abundance is smaller than that of the Hyades. The mean cluster Fe abundances and their uncertainties from Boesgaard & Friel (1990) yield [N/Fe]= 0.00$\pm$0.04 and +0.03$\pm$0.04 for the Hyades and Pleiades respectively, where the quoted errors reflect internal uncertainties in the mean. We also consider three sources of systematic error. First, we note that the solar N abundance was fixed for each feature by slight alterations in the

gf values when calibrating the line list. Thus, the solar-normalized abundances are derived self-consistently, and are gf-independent; indeed, altering the NH log gf values by ±0.3 dex, we find differential curve-of-growth effects to be ≤0.01 dex. Second, had we not employed the veiling corrections for the Hyades stars, then the Hyades-Pleiades abundance difference would be *increased* by 0.02 dex. Third, systematic differences in dereddened colors at the 0.02 mag level for $(B-V)$ are possible; in this case, the concomitant alteration to the abundances through the adopted $T_{\rm eff}$ values is at the ±0.06 dex level. In sum, we gauge possible systematic errors in our finding of a Pleiades N abundance that is lower than that in the Hyades to be at the 0.06 dex level.

The simplest conclusions reached here, then, are that a) both the Hyades and Pleiades results are consistent with previous conclusions that [N/Fe]~0 over a range in metallicity in the Galactic disk, and b) after accounting for possible systematic error, the Pleiades N abundance (by number) is the same as or $\sim25\%$ lower than that of the Hyades–thus providing no evidence that the Pleiades He abundance (by mass) is 40% larger than that of the Hyades if indeed N production in the Galactic disk is a proxy for He production.

Another possible systematic effect that must be considered, however, is the influence of He abundance on the derived N abundances themselves. That is, we must ask if it is possible that the Pleiades He and N abundances might truly be enhanced relative to the Hyades, but our derived Pleiades N abundance is too low because we have not accounted for such a He enrichment in our analysis. One effect of such a putative He enhancement would be on the Pleiades stellar parameters. Equation 4 of Castellani, Degl'Innocenti & Marconi (1999) indicates that an enhancement of $\Delta Y = +0.10$ (that needed to explain the Pleiades-Hyades distance modulus discrepancy) would lead to a 0.05 mag reduction in $(B-V)$ colors of solar metallicity $M_V = 6$ Pleiades dwarfs. The dwarfs we compare here are brighter, and an estimate of the color sensitivity for them can be made using the reciprocal and reciprocity theorems to find $\left(\frac{\partial c}{\partial Y}\right)_T$ (where c is $(B-V)$ color, T is the effective temperature, and Y is the He mass fractions) by taking: $\left(\frac{\partial M_V}{\partial Y}\right)_c$ from equation 3 of Castellani, Degl'Innocenti & Marconi (1999), $\left(\frac{\partial T}{\partial M_V}\right)_c$ from Figure 4 of Castellani, Degl'Innocenti & Marconi (1999), and $\left(\frac{\partial c}{\partial T}\right)_Y$ from the calibration of Saxner & Hammarback (1985). The result is the same as above, with a +0.10 increase in He mass fraction leading to a $(B-V)$ color bluer by 0.05 mag.

The result of such a helium-induced color shift would be to overestimate the Pleiades $T_{\rm eff}$ values by ~170 K and to underestimate the log g values by ~0.02 dex. Compensating for these parameter errors, including the effects on [Fe/H] and the feedback of metallicity on the derived N abundance, would lower our N abundances by $0.17-0.18$. Thus, any such He-induced parameter effects act in the opposite way needed to mask a proposed truly higher Pleiades N abundance.

A second effect of a putative higher Pleiades He abundance is that on the (model) photospheric structure. We have rerun our analyses using ATLAS12 model atmospheres with the standard solar He abundance and He abundances enhanced 33% and 75% by number. For stars with $T_{\mathrm{eff}} = 4800$ K, the He-enhanced atmospheres yield N abundances lowered by 0.04 dex and 0.08 dex compared to the solar He atmospheres; for stars with $T_{\mathrm{eff}} = 6000$ K, the reductions are 0.03 and 0.07 dex. Just as for the parameter-based effects, He-induced atmospheric structure effects act in the opposite way needed to mask a proposed truly higher Pleiades N abundance.

5.   Summary

Our analysis of high-resolution and -S/N near-UV spectroscopy yields a Pleiades N number abundance that is the same as or up to 25±9% lower than in the Hyades. This result is consistent with previous abundance work suggesting that [N/Fe] ratios of local Galactic disk stars are solar over a range of [Fe/H]. If, as we argue, N production serves as a reliable proxy for He production in the Galactic disk, then our results provide no evidence for a Pleiades He abundance larger than that of the Hyades. This conclusion is consistent with those reached from the relative Pleiades-Hyades C, O, and Fe abundances in the context of our current understanding of Galactic chemical evolution. This conclusion is also robust against the effects of an unrealized but truly higher Pleiades He abundance on model atmospheric structure and our stellar parameters. If the Pleiades distance modulus discrepancy and Hyades anomaly are not due to unrealized systematic parallax and photometric measurement errors, then our results suggests their physical explanation is not associated with He abundance.

Facility: KECK.

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Table 1.   Hyades Atmospheric Parameters[a] and Abundances

Star (vB)	T_{eff} (K)	$\log g$ cgs	ξ (km s^{-1})	$v \sin i$ (km s^{-1})	$\langle \log N(\mathrm{N}) \rangle$	N	σ (dex)
9	5538	4.44	1.06	3.4[d]	7.63	16	0.12
10	5982	4.39	1.27	6.2[b]	7.86	15	0.10
15	5729	4.42	1.15	5.4[b]	7.82	16	0.10
17	5598	4.43	1.10	4.5[b]	7.78	16	0.09
27	5535	4.44	1.04	4.9[b]	7.77	16	0.08
31	6071	4.39	1.30	10.0[b]	7.89	15	0.13
59	6120	4.38	1.32	5.00[c]	7.90	14	0.09
61	6260	4.35	1.41	20[c]	7.88	5	0.11
63	5822	4.41	1.19	7.20[c]	7.84	15	0.08
64	5732	4.42	1.15	3.4[b]	7.88	16	0.07
65	6200	4.37	1.36	8.8[b]	8.06	14	0.15
69	5435	4.45	1.02	4.60[c]	7.73	16	0.09
87	5445	4.45	1.04	4.0[b]	7.72	16	0.08
92	5451	4.45	1.02	3.8[b]	7.74	16	0.09
97	5814	4.41	1.19	5.4[b]	7.78	16	0.12
106	5690	4.42	1.14	3.4[d]	7.79	16	0.09
113	6139	4.38	1.33	5[c]	7.99	15	0.14
114	5509	4.45	1.04	7[a]	7.74	16	0.07

[a]Boesgaard & King (2002)

[b]Paulson et al. (2003)

[c]Glebocki & Stawikowski (2000)

[d]Estimated as part of our analysis from non-Nitrogen features

Table 2.   Pleiades Atmospheric Parameters[a] and Abundances

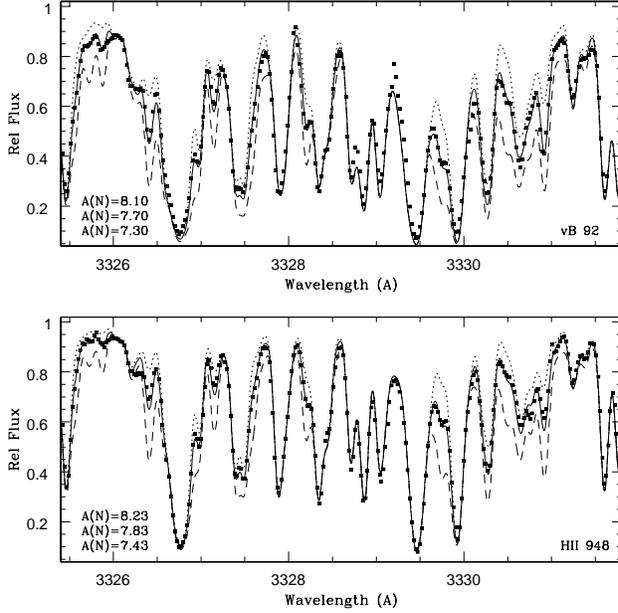| Star	T_{eff}	$\log g$	ξ	$v \sin i$	$\langle \log N(\mathrm{N}) \rangle$	N	σ
(H II)	(K)	cgs	(km s^{-1})	(km s^{-1})			(dex)
948	5960	4.39	1.36	< 12	7.83	16	0.08
1794	5940	4.39	1.35	12	7.72	11	0.12
1856	6150	4.37	1.54	16	7.75	7	0.05
3179	6180	4.37	1.56	< 7	7.83	10	0.09

[a]Boesgaard, Armengaud & King (2003)

Fig. 1.— Our observed spectra (solid points) of the Hyades dwarf vB 92 and the Pleiades dwarf H II 948 are shown with synthetic spectra of varying N abundance; $A(\mathrm{N})$ indicates the logarithmic number abundance of nitrogen on the usual scale where that of hydrogen, $A(\mathrm{H})$, is defined as 12.
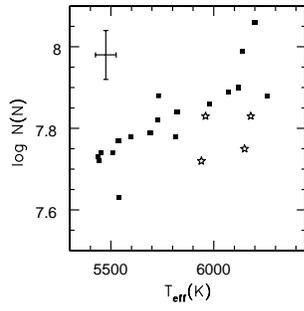
Fig. 2.— The mean logarithmic number abundance of N for each star is plotted versus $T_{\rm eff}$ for our Hyades (filled squares) and Pleiades (open stars) objects. The error bar in the upper left shows the per star uncertainty estimated as described in the first paragraph of the Discussion.