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A K GIANT WITH AN UNUSUALLY HIGH ABUNDANCE OF LITHIUM: HD 112127

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ABSTRACT

The strong-lined K giant star HD 112127 exhibits an extremely strong litihium resonance line in its spectrum. In most other respects the atmosphere of the star resembles the well-studied, strong-lined star μ Leo. A model atmosphere analysis has been carried out for HD 112127 with particular emphasis on the light element abundances. Iron peak elements show essentially solar composition, while the CNO group is enhanced by about 0.2 dex. The carbon isotope ratio is near 20, while the lithium content of this star is approximately the maximum seen in unevolved stars. Schemes for the production of lithium in a relatively low luminosity giant are discussed.

Subject headings: stars: abundances — stars: individual — stars: late-type

I. INTRODUCTION

Much research on the chemical composition of stellar atmospheres has been concerned with stars of startling peculiarity such as the carbon stars and magnetic A stars. Modern explanations of the origin of grossly anomalous atmospheric compositions usually involve a complex series of events such as nuclear burning in the deep interior followed by mixing, or by diffusion accompanied by magnetic stabilization of the atmosphere. Perhaps our understanding of the evolution of stellar atmospheres would be enhanced by the study of stars which show only one peculiarity, especially if that anomaly is very large. We have found the K giant HD 112127 to have an exceptionally strong resonance doublet of lithium, equivalent width 0.45 Å, while its spectrum is otherwise not peculiar except for enhanced bands of the CN molecule. Hence we have analyzed the atmosphere of HD 112127 with emphasis on the abundances of Li, ^{12}C, ^{13}C, N, and O.

We selected HD 112127 for observation as a K giant with strong CN bands to be compared with CN strong barium stars because Keenan and Pitts (1980) classified it as K2 III:CN+3. It had previously been recognized by Spinrad and Taylor (1969) as being strong-lined. The strong-lined K giant μ Leo was used as a comparison star in our study due to its superficial similarity to HD 112127 in all respects except for the strength of the lithium line. Properties of the two stars are listed in Table 1.

By a model atmosphere analysis Oinas (1974*a*) determined that the abundance of iron was not enhanced but some elements were overabundant by as much as 0.5 dex. He reported no excess of heavy *s*-process elements. This places HD 112127 among the mildly super-metal-rich (SMR) stars. Whether such stars have real or only apparent excesses of metals is not important for the investigation we are reporting here.

II. OBSERVATIONS

On 1980 June 28 one of us (G. W.) obtained a 10 Å mm^{-1} spectrum of HD 112127 on the O98 emulsion with the 0.8 m camera of the D.A.O. 1.2 m coudé spectrograph. Inspection of the plate while still in the wash revealed that it had an exceptionally strong line at λ6707, readily identifiable as the resonance line of Li I. The wavelength of the lithium line was found to be 6707.83 Å on the 10 Å mm^{-1} spectrogram by comparison with 20 lines of neutral metals in the interval of 6540– 6775 Å. The wavelength of the lithium line is consistent with pure ^{7}Li for a heavily saturated line on the flat portion of the curve of growth. The Hα line was also measured and showed no displacement of the absorption feature nor any evidence for emission.

Further observations of HD 112127 were gathered at McDonald Observatory to define more precisely the lithium anomaly and to determine abundances of the evolutionary-sensitive CNO elements. Table 2 gives a catalog of the spectra, all of which were obtained with Reticon silicon diode arrays placed in the coudé spectrographs of the 2.1 m and 2.7 m telescopes. The approximately 100 Å range of these spectra provided

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TABLE 1

BASIC DATA FOR THE STARS

Star	Sp	m_v	$U-B$	$B-V$	$R-I$	V_r	μ_α	μ_δ
μ Leo	K2 IIIb CN+1	3.94	1.40	1.22	0.58	+14	+0″.22	−0″.06
HD 112127 ...	K2 III CN+3	6.87	1.43	1.26	0.58	+4	0″.00	−0″.01

TABLE 2

RETICON SPECTRA

Wavelength Range	Resolution	Signal-to-Noise	Useful Spectral Features
5050–5060 Å	0.28 Å	180	C_2
6054–6154 Å	0.33 Å	150	Li I, atomics
6271–6371 Å	0.22 Å	230	[O I], atomics
6658–6758 Å	0.22 Å	190	Li I, atomic
7975–8071 Å	0.25 Å	260	CN
8079–8173 Å	0.21 Å	200	CN

sufficient atomic features to perform a model atmosphere analysis of this star. Reticon spectra were obtained for μ Leo in the wavelength regions 6100 Å, 6700 Å, and 8100 Å. The data in each spectrum were subjected to standard flat-field division and power-spectrum smoothing techniques.

Equivalent widths were measured for unblended atomic and molecular features with the assumption of Gaussian line profiles. One of the chief contributors to the strong-lined character of HD 112127 and μ Leo is the red system of the CN molecule. Consequently, many normally useful atomic lines were too severely blended with CN to be used in our analysis. Account was taken of CN blends through use of a compilation of ^{12}CN and ^{13}CN line positions (by J. F. Dominy, private communication) from sources in the literature. Finally, the contributions of terrestrial oxyen and water molecule lines to the equivalent width were subtracted, either by direct division or by comparison with a spectrum of a hot star of high rotational velocity.

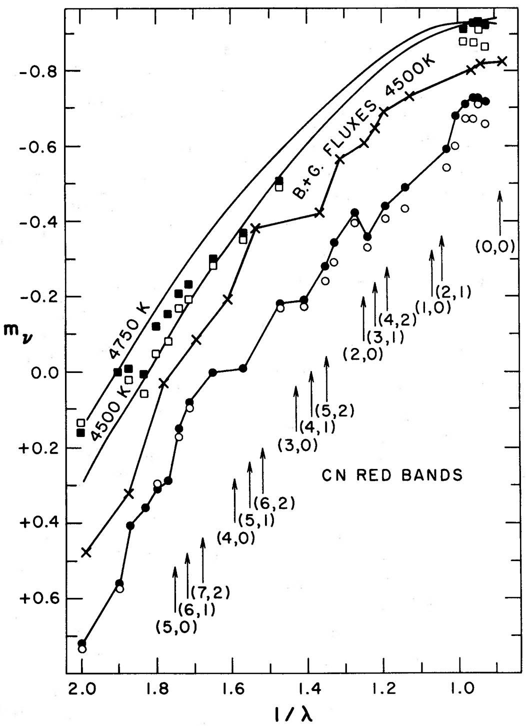

FIG. 1.—The low resolution scan data of Oinas (1974*a*). In this figure filled symbols represent HD 112127, and open symbols represent μ Leo. The raw data are given with circles and both stars' scans are normalized to $m_\nu \equiv 0.0$ at $\lambda = 0.606\ \mu m^{-1}$. The deblanketed scan data (and unblanketed scan data redward of 1 μm) are given with squares and have been shifted vertically by 0.2 mag. Shown also are blackbody curves of 4500 K and 4750 K, normalized at 1.04 μm and the Bell and Gustafsson (1978) computed fluxes for $T_e = 4500$, $\log g = 2.25$, [Fe/H] = 0.0.

III. MODEL ATMOSPHERE ANALYSIS

Effective temperature estimates for HD 112127 were obtained from the low-resolution scans of Oinas (1974*a*) and from our atomic line data. Figure 1 shows a reproduction of the data of Oinas (1974*a*) for HD 112127 and μ Leo. Blackbody curves at 4500 K and 4750 K as well as the Bell and Gustafsson (1978) model fluxes are also shown matched to the deblanketed scans. The strong CN bands in μ Leo and HD 112127 due to their high C and N abundances are notable. Oinas had no high resolution spectra of these stars beyond 7000 Å and hence did not estimate blanketing at these long wavelengths. This figure demonstrates that the effective temperature of HD 112127 lies between 4500 K and 4750 K but more importantly indicates that this star and μ Leo must have closely related atmospheric parameters. Therefore, we list in Table 3 some of the analyses of the two stars, especially some of the extensive work which has been done on μ Leo. Most authors, while debating the metallicity of μ Leo, agree that its effective temperature is 4600 ± 125 K.

The similarities between the spectra of μ Leo and HD 112127 are also evident at high resolution (see Figs. 3–6). Therefore, we adopted 4500 K and 4750 K as estimates of the likely limits on the temperature for HD 112127 in a model atmosphere analysis. Model stellar atmospheres from the grid of Bell *et al.* (1976) were employed along with a standard line analysis code to

TABLE 3

ATMOSPHERE PARAMETERS

T_{eff}	Log g	ξ_t	[M/H][a]	Reference
			μ Leo	
4460	2.2	2	+0.0	Blanc-Vaziaga, Cayrel, and Cayrel 1973.
4750	2.7	3 km s^{-1}	+0.2	Strom, Strom, and Carbon 1971.
4650	2.4	1.8	+0.3	Oinas 1974*b*.
4500	2.7	1.5–2.0	+0.1	Peterson 1976.
4540	2.35	1.3	+0.5[b]	Branch, Bonnell, and Tomkin 1978.
			+0.3[c]	Day 1980.
4720	2.8	2.5	+0.1	Ries 1981.
			HD 112127	
4600	2.3	2.4	+0.1	Oinas 1974*b*.
4500	2.6	2.0	+0.2	this work (ε Vir standard).
4750	2.6	2.0	+0.3	this work (Sun standard)

[a]Values of [M/H] are uncritical averages of iron peak element abundances, excluding manganese and giving iron double weight.

[b]Iron abundance only.

[c]A rediscussion of the Branch, Bonnell, and Tomkin (1978) value.

predict abundances for all atomic lines in our spectra. As is usually the case, only neutral iron exhibited enough features to be used for a test of the effective temperature of HD 112127. The analysis compared HD 112127 to the standard of the Sun and ε Vir. Line data for the Sun were taken from direct measures from the Liége atlas (Delbouille, Neven, and Roland 1973), and we adopted the solar model of Holweger and Müller (1974). For ε Vir we used the line data of Cayrel and Cayrel (1963) and Bonsack (private communication to C. A. Pilachowski) and a model atmosphere interpolated from the Bell *et al.* (1976) grid with the atmosphere parameters of $(T_{eff}/\log g/[M/H]\xi_t) = (5000/2.7/0.0/2)$. These atmosphere parameters are close to the standard ε Vir models proposed by a number of writers (e.g., see Pilachowski 1977).

The particular choices of stellar and solar models lead automatically to different effective temperatures for HD 112127. Ries (1981) has argued that the effective temperature scale for K giants should be raised by 200–300 K. Much of the difference between her work and previous analysis lies in her use of the Holweger and Müller (1974) solar model atmosphere, which is perhaps the hottest of all solar models used today. Ries (1981) derives parameters of (5300/3.2/+0.2/1.8) for ε Vir, in sharp contrast to the atmosphere parameters from earlier analyses which we adopted for this star. In our analysis, therefore, comparison to the Sun yielded higher temperatures for HD 112127 than did comparison to ε Vir. We show below that this conflict in model parameters did not alter our basic abundance results. We adopted 4500 K for HD 112127 in our analysis relative to ε Vir, and 4750 K for HD 112127 when relating it to the Sun. Both temperatures are consistent with those implied by the low resolution scans and are within the probable errors

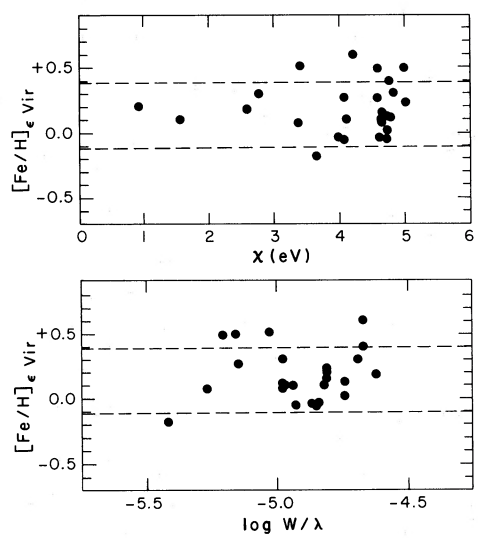

FIG. 2.—Abundances of Fe I lines as functions of the excitation potentials (*upper panel*) and the residual equivalent widths (*lower panel*). Abundances were derived relative to ε Virginis, and were computed for the model (4500/2.25/0.0/2).

of the temperature assigned to this star by Oinas (1974*a*).

Figure 2 shows the trend of Fe I abundances with excitation potential of the lines, using ε Vir as the comparison star. No slope is evident in this figure, but our data were insufficient to set severe constaints on the effective temperatures.

The microturbulent velocity was set by the demand that weak and strong lines of Fe I gave the same abundance. Figure 2 shows this test with the ε Vir standard. Again we did not have a definitive set of lines for this test, but our results, $\xi_t = 2.0 \pm 0.5$ km s^{-1}, are

TABLE 4

Abundance Results for HD 112127

Species	$[M/H]_{\odot}$	No. of lines	$[M/H]_{\epsilon\ Vir}$	No. of lines	$[M/H]_{Oinas}$
Al I......	+0.7	3	+0.4	2	...
Si I......	+0.3	2	+0.2	1	...
Sc I......	+0.5	2	...	...	+0.51:
Sc II	+0.4	3	+0.2	2	−0.05
Ti I......	+0.4	9	+0.1	9	+0.14
V I......	+0.5	3	+0.4	6	+0.54
Cr I	+0.2	2	+0.0	1	−0.01
Fe I	+0.3	25	+0.2	21	−0.09
Fe II	+0.2:	2	+0.1:	1	+0.04
Co I	+0.8:	2	+0.6:	2	...
Ni I	+0.4	7	+0.4	8	...
Y I......	−0.9:	1	...	...	...
Y II	−0.5:	1	−0.1:	1	...
Zr I......	+0.1	3	−0.1	3	+0.04
Zr II	+0.2:	1	+0.0	1	...
Ba II	−0.4:	1	−0.5:	1	+0.30:
La II	+0.2	1	+0.2	1	...
Nd II ...	−0.9:	1	−1.0	1	...

consistent with the Oinas (1974*b*) results for HD 112127 and the analyses of μ Leo given in Table 3.

We applied the usual demand of equal abundances from neutral and ionized lines of a given element in determining the gravity of our star. The red spectra contained few ionized lines, so our analysis here was limited to five lines of Fe II and Sc II. Relative to both standard stars we derived $\log g = 2.6 \pm 0.4$.

Our final atmospheric parameters are listed in Table 3 and abundances in Table 4. Individual abundance discrepancies, especially those obtained from measurements of one line, should not be taken seriously. The overall metallicity of HD 112127 is however quite consistent with values commonly derived for other strong-lined stars and in particular points once more to the fact that our star is in most respects very similar to μ Leo. In Table 4 we also show the abundances derived by Oinas (1974*b*) from different transitions. Good agreement is found between the two data sets.

Several investigators beginning with Strom, Strom, and Carbon (1971) have explored the possibility that the SMR phenomenon is caused chiefly by excess molecular line blocking and/or lower boundary temperatures for these stars. We have chosen to work with standard temperature structure, solar metallicity model atmospheres for the following reasons. First, most of our atomic and molecular lines are formed at depths no shallower than $\tau \sim 0.1$. At this relatively deep layer the boundary cooling effects found by workers who have analyzed SMR stars is probably 100 K or less. Only very strong lines will be strongly affected by the distorted temperature structures. Second, our data provide no definitive tests of the atmosphere details of HD 112127. Finally the purpose of this analysis is simply to show that our star is nearly identical to μ Leo except in lithium content. Further discoveries about the structure of the atmosphere of μ Leo should probably apply equally well to HD 112127.

IV. LIGHT ELEMENT ABUNDANCES

a) *Lithium*

In Figure 3 we show the spectrum of HD 112127 in the two observable lithium line regions. It is apparent from this figure that the lithium resonance doublet at 6707 Å may not be used in a quantitative analysis. With an equivalent width of 443 mÅ the lithium feature obviously lies far up on the Doppler portion of the curve of growth and possibly in the damping region. Moreover, such a strong line must be formed in the shallower layers of the atmosphere of HD 112127, where at least some departures from the normal assumptions about K giant atmosphere have occurred, and where scattering is important for resonance lines. Hence we chose to analyze the 6103.6 Å lithium transition. Parameters for this transition were taken from Wiese, Smith, and Glennon (1966): lower excitation potential = 1.85 eV and $gf = 4.00$ (parameters for the resonance doublet are 0.0 eV and $gf = 1.51$). This line was blended with lines of Fe I at the resolution employed, so we used standard synthetic spectrum techniques to match the profile of the 6103.6 Å feature. Solar oscillator strengths were derived for the other contributors to the blend. Only an approximate abundance may be derived from a single blended feature: with use of the 4500 K model, $\log \varepsilon(\text{Li}) \sim 2.8$; for the 4750 K model $\log \varepsilon(\text{Li}) \sim 3.2$. For comparison, Boesgaard (1976) shows that the maximum lithium contents in unevolved stars (the so-called "cosmic" lithium content) is about $\log \varepsilon(\text{Li}) = 3.0$. We note that the

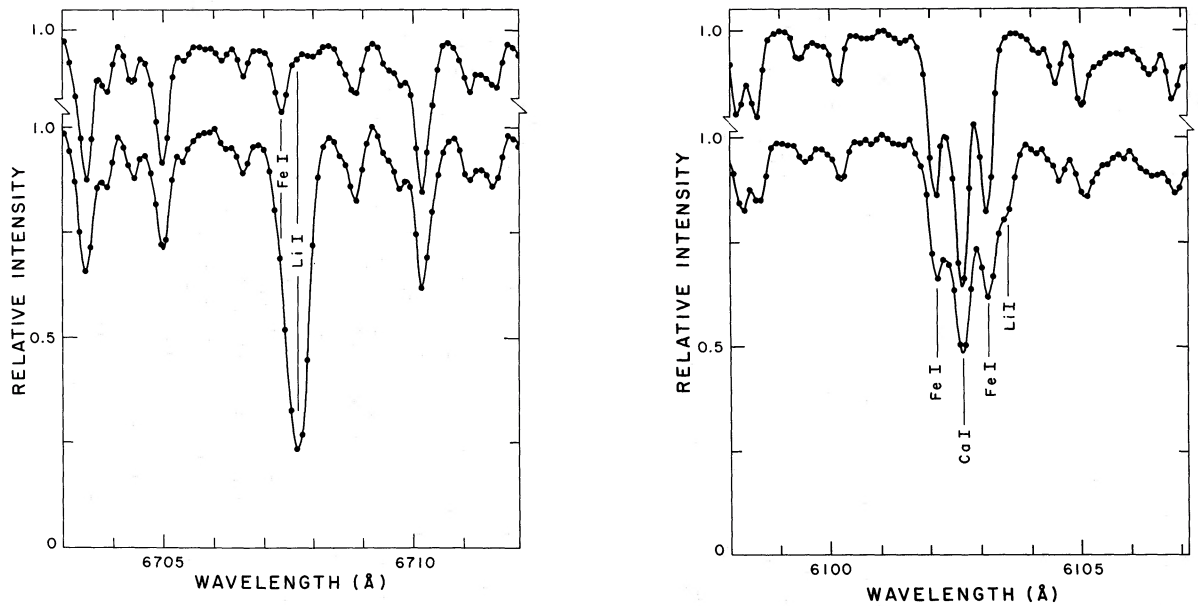

FIG. 3.—The lithium line regions in μ Leo and HD 112127. The resolution of the spectra is about 0.2 Å except for the 6104 Å spectrum of HD 112127. In that case the resolution is 0.3 Å.

sample of Lambert, Dominy, and Sivertsen (1980) contains no giant (other than the peculiar weak G-band stars) with $\log \varepsilon(\text{Li}) \gtrsim 1.3$. Therefore, it is clear that HD 112127 contains the highest lithium content of any nonpathologic red giant discovered to date. Also, from the discussion in § III and from inspection of Figure 4, we see that the lithium contents of HD 112127 and μ Leo are radically different: Lambert *et al.* derive $\log \varepsilon(\text{Li}) = -0.3$ for the latter star. Since our lithium spectra are of lower resolution than that of Lambert *et al.*, no reanalysis of this element in μ Leo is warranted here.

Abundances for the 6707 Å resonance doublet were computed as a check on the 6104 Å abundances. For each stellar model the derived 6707 Å abundance was about $\log \varepsilon(\text{Li}) \gtrsim 4$. This discrepancy is in the proper sense because the 6707 Å resonance lines are formed in shallow levels of the atmosphere where they are strengthened by a core formed by scattering, which is not included in our line formation code. Our line formation program included thermal and turbulent broadening but not the fine-structure broadening of the lithium line. The effect of this omission is minor in view of the thermal and turbulent velocities but leads to an overestimation of the lithium abundance for λ6707. Since the 6103.6 Å lithium feature is unsaturated, the omission of the fine-structure splitting of 0.11 Å has no effect on the derived abundance.

Finally, we searched our 8100 Å spectrum for the 8126 Å lithium feature. This line arises from the same 1.85 eV lower state as the 6104 Å line, but its oscillator strength, $gf = 0.69$ (Wiese *et al.* 1966), is less than 1/5 of the 6104 Å line. Moreover, the 8126 Å line is severely blended with two strong CN red system lines. As expected this line could not be readily detected.

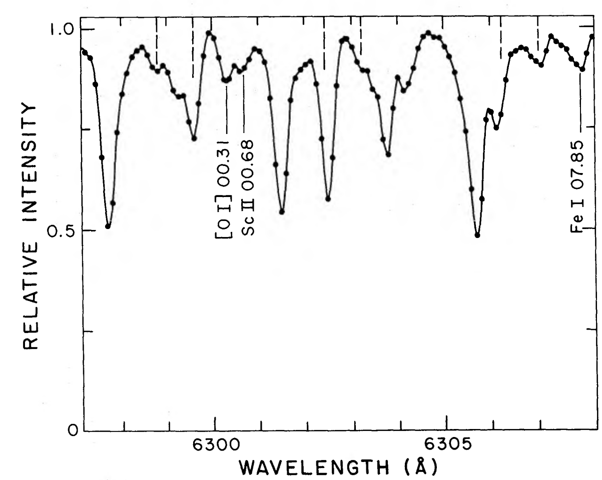

FIG. 4.—The forbidden oxygen line region in HD 112127. Dashed lines indicate the locations of terrestrial O_2 features.

b) CNO and $^{12}C/^{13}C$

Our analysis for the CNO group of elements followed closely the techniques and transitions employed by Lambert and Ries (1977, 1981) for normal K giants and by Sneden, Lambert, and Pilachowski (1981) for barium stars. The carbon abundance was derived from C_2

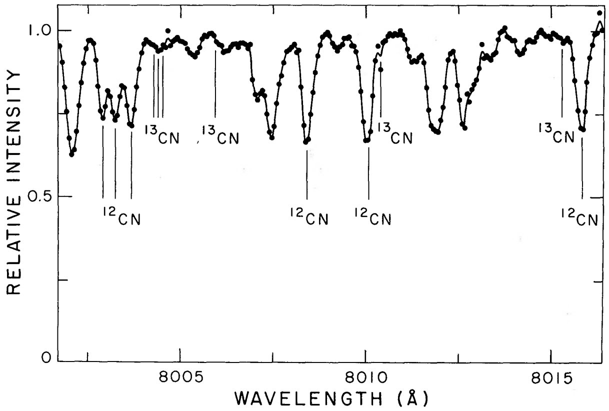

FIG. 5.—A portion of the (2–0) CN red system in HD 112127. The ^{13}CN features are seen clearly in this spectrum.

features near 5100 Å, the oxygen from the [O I] line at 6300 Å, and the nitrogen and $^{12}C/^{13}C$ ratio from the CN red system lines. However, the resolution of our spectral data, about 0.2 Å, was only half that employed in the earlier studies, which were carried out on brighter stars. Therefore, it is worth noting that at this resolution the [O I] line at 6300.31 Å is clearly resolved from the Sc II line at 6300.69 Å (Fig. 4). Also individual CN red system rotational lines from both ^{12}CN and ^{13}CN may be measured (Fig. 5). However, the C_2 spectrum is crowded, especially so in the strong-lined spectrum of HD 112127. Therefore, synthetic spectrum techniques were applied to these data. Oscillator strengths for atomic contaminating lines were derived from the solar spectrum data (details are given in Cottrell and Sneden 1981). The other parameters for C_2, [O I], and CN transitions are discussed by Sneden *et al.*

Carbon and oxygen abundances are linked through the formation of CO, and therefore we solved for these abundances simultaneously. Figure 6 exhibits part of the C_2 spectrum. Since C_2 involves two carbon atoms, the C_2 lines are very sensitive to changes in carbon abundance. Also note that in the oxygen analysis we chose not to use the 6363.79 Å [O I] line due to (a) the crowding with atomic features, (b) the direct blend with a relatively strong CN (10–5) line, and (c) the presence of an extremely broad calcium auto-ionization line. In Table 5 we list the abundances of carbon and oxygen. Since the dependences on temperature and gravity are not very different for C_2 and [O I], the C/O ratio is fairly independent of model atmosphere uncertainties (see Sneden, Lambert, and Pilachowski 1981; or Lambert and Ries 1981).

The CN red system was represented in many of our spectra and consequently rotational lines of the (2–0), (3–1), (7–3), and (6–2) vibrational bands were measured. In Figure 7 a curve of growth for CN is illustrated. The presence of ^{13}CN and a ratio of $^{12}C/^{13}C = 22 \pm 7$ may be noted in Figures 5 and 7. This ratio, indicative of an evolved star, is crucial to a discussion of the evolutionary status of HD 112127. In Table 5 the nitrogen abundance for this star is given. With the usual caution about the uncertainty in the CN dissociation energy, it may be said that nitrogen is enhanced in HD 112127. The excess CN blanketing in this star (and in μ Leo: Lambert and Ries 1981, listed in Table 5) may be

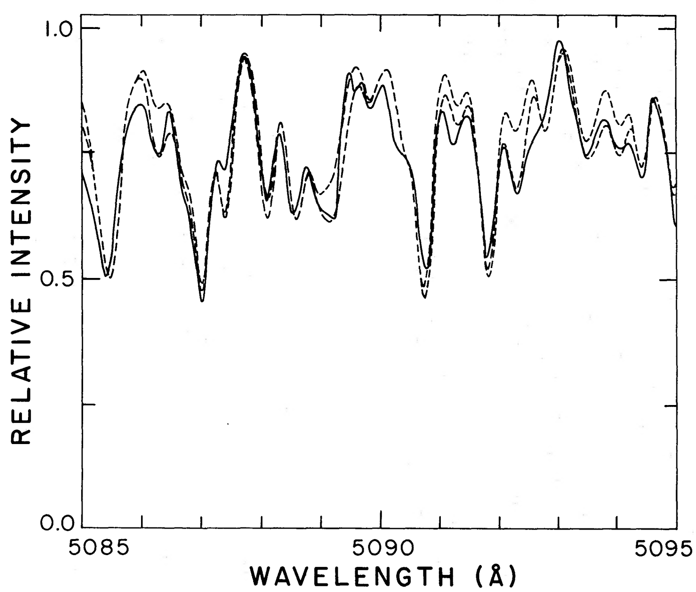

FIG. 6.—Observed and synthetic spectra of the C_2 region in HD 112127. The observed spectrum is given with a solid line and the synthetic spectra with log ε(C) = 8.60 and 8.75, log ε(O) = 8.95 and model (4500/2.25/0.0/2), are given with dashed lines. Spectral features which do not change with changing carbon abundance are dominated by atomic species or MgH.

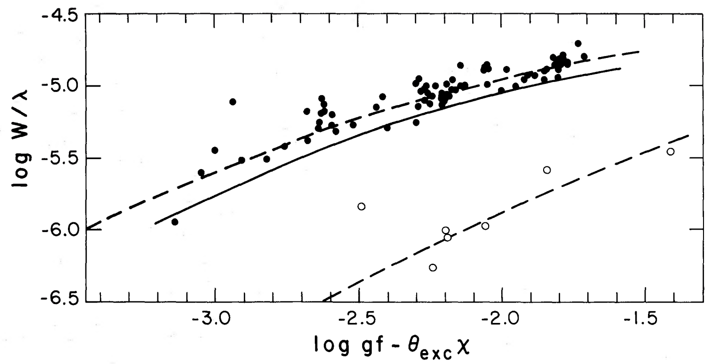

FIG. 7.—A curve-of-growth analysis for CN lines in HD 112127. Filled circles represent ^{12}CN lines and open circles represent ^{13}CN lines. A theoretical curve of growth from one of the stellar models is given by the solid curve, and the dashed curves are eyeball estimates of the actual curves of growth. From these curves nitrogen abundances and carbon isotope ratios were derived.

TABLE 5

LIGHT ELEMENT ABUNDANCES

QUANTITY	SUN[a]	AVERAGE K GIANT[b]	μ Leo[b]	HD 112127 4500 K	HD 112127 4750 K
log ε(Li)	1.0	~0.0	−0.3:	2.8	3.2
log ε(C)	8.67	8.35	8.69	8.9	8.8
log ε(N)	7.99	8.26	8.65	8.3	8.3
log ε(O)	8.92	8.87	9.20	9.2	9.1
^{12}C/^{13}C	89	19	18	22	22
C/O............	0.56	0.30	0.30	0.52	0.50
C/N............	4.8	1.2	1.1	4.2	2.9

[a]Lithium from Müller, Peytremann, and de la Reza (1975); CNO from Lambert 1978.

[b]Lithium from Lambert *et al.*; CNO from Lambert and Ries 1981.

therefore viewed as a normal nitrogen content and overabundant carbon in a giant, or as normal carbon and overabundant nitrogen when compared to the Sun. However, note that the C/O and C/N ratios for HD 112127 are like those of the Sun, while these ratios in μ Leo compare favorably with normal giants.

V. DISCUSSION

We wish to understand the origin of the abundances in the atmosphere of HD 112127. The simplest hypothesis is that the present composition is unchanged from that with which the star was formed. The lithium abundance is that of the T Tauri stars and stars in the Pleiades (Boesgaard 1976). Hence we could understand the lithium abundance as unmodified by mixing because HD 112127 is moving into the giant region of the HR diagram for the first time and has not yet mixed to such depths as would dilute the surface lithium. The elemental abundances are similar to those in the G supergiant, HR 8626, which Baird *et al.* (1975) suggested to be evolving to the right for the first time. Unfortunately, the ^{12}C/^{13}C ratio of 20 contradicts this suggestion because it implies an enhancement of ^{13}C by mixing to depths at which both ^{6}Li and ^{7}Li would be destroyed by reactions with protons. Only if the ^{12}C/^{13}C ratio was near 20 in the material out of which HD 112127 formed could we accept that it is a star moving to the right in the H–R diagram for the first time. While hydrogen burning and mixing may reproduce the CNO abundances, there is no way to preserve the original lithium unless it was more than an order of magnitude larger than its present value when the star formed. In addition, calculations by Iben (well illustrated by Boesgaard 1976, Fig. 4) show a lithium depletion greater than a factor of 24 by the time a star has reached $B-V=1.0$ on its *first* excursion into the red giant region of the H–R diagram.

Rather than rake over and reject a variety of unlikely schemes to produce the observed abundances, we turn directly to a reasonable model of flash mixing in red giants. The detailed convection models by Sackmann, Smith, and Despain (1974) describe convective events that may occur at the time of the helium shell flash in stars evolving to red giants for the second time. By inspection of their Figure 5*b*, *c* which corresponds to stars of 2 and 5 $M_\odot$, respectively, we see that ^{7}Li/H reaches our observed value of 10^{-9} twice during the event. The first interval is extremely brief at about 10^8 s after the flash, and occurs before any enhancement of ^{13}C/^{12}C has reached the surface. Since a 15 Å mm^{-1} spectrogram taken at Mount Wilson in 1970 indicates that the lithium line had a similar strength 3×10^8 s ago, it is unlikely that we have caught the mixing event during its initial appearance. By the second time that ^{7}Li/H reaches 10^{-9} (now declining), the ^{14}N/^{12}C ratio has reached about 30 which is much higher than the observed value. In addition, the ^{12}C/^{13}C ratio is near 3, which is much too high. We could alleviate the problems with carbon and nitrogen by saying that the mixing ratios used by Sackmann *et al.* should be changed by diluting their mixture with 10 times as much

TABLE 6

PREDICTED SURFACE ABUNDANCES AFTER SHELL FLASH MIXING

	a	b	c
Li/H	$10^{-8.6}$	$10^{-8.6}$	10^{-9}
N/C	6.6	0.66	0.5
C/O	0.08	0.8	0.4
$^{13}C/^{12}C$ ...	0.4	0.04	0.05

a) From Sackmann *et al.* Fig. 5*b*, after 2×10^{11} s.

b) The abundances in column a after multiplying the ^{12}C abundance by 10.

c) The observed abundance ratios in HD 112127.

unprocessed material but such dilution would drive the lithium abundance down by a factor of 10. It seems preferable to suggest that the mixing has incorporated a greater amount of ^{12}C than predicted by Sackmann *et al.* Such a possibility has been indicated by Sackmann (1980) who has shown that a "pocket" of ^{12}C from helium burning may be scooped up by convection. We get a good fit if we take the predictions of Sackmann *et al.* for the star of 2 $M_\odot$ at 4.78×10^3 yr. We display in Table 6 the predicted surface abundances and the results for an enhancement of ^{12}C by a factor of 10. The latter appears to come reasonably close to the abundances observed in HD 112127. We must remember that the Sackmann *et al.* calculations refer to a specific model, and we have no way to know how closely the initial parameters such as mass correspond to those of HD 112127.

The high lithium abundance in HD 112127 is most unusual. None of the stars investigated by Bonsack (1959) or by Lambert, Dominy, and Sivertsen (1980) showed a lithium abundance within two orders of magnitude of that in HD 112127. This indicates that the time between lithium appearance and its dilution by continued mixing must be very short. According to Sackmann *et al.*, (their Fig. 5*b*) the interval is about 2×10^4 yr. The fraction of K giants at a given mass to show a strong lithium line should be the ratio of 2×10^4 to the interval between lithium-producing flashes. Such a ratio can be calculated theoretically for any mass but is difficult to investigate observationally because of the uncertainty in the mass of individual K giants and the near impossibility of recognizing which K giants are in the shell flashing stage and which are "clump" giants that are quiescently burning helium in their cores.

There remains one hypothesis for the origin of lithium in a few red giants that should be mentioned, no matter how unlikely it appears to be. Alexander (1967) suggested that the abundance of lithium in a red-giant atmosphere could be enhanced when a lithium-rich planet is consumed by an evolving star. Alexander's hypothesis suffers from gross uncertainties in the mass, composition, and orbit of such a planet but could also be related to the enhancement of the metals in the atmosphere of a red giant. Unfortunately, we see no way that ^{13}C could be enhanced when a red giant consumes its nearby planet(s). Such putative planetary systems, however, might be good candidates for the search for extraterrestrial intelligence because the inhabitants of their outer planets might be screaming for help as they watch their inner planets disappear into their central star.

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