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BORON AND BERYLLIUM IN GAMMA GEMINORUM

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ABSTRACT

Observations have been made of the B II resonance line at 1362 Å in the A0 IV star γ Gem with the Princeton spectrometer on the *Copernicus* satellite at a spectral resolution of 0.05 Å. Complementary ground-based observations of the Be II resonance lines at 3130 and 3131 Å have been made at Mauna Kea Observatory with a comparable resolution. A model-atmosphere abundance analysis has been done which includes the effects of the lines that blend with the B II and Be II lines. Previous data on α Lyr and α CMa for B II (which blends with a V III feature) have been reanalyzed with the help of new photographic and Reticon data from Mauna Kea which enable us to determine the V abundance. The results show that γ Gem is depleted in B by a factor of 5–10 relative to α Lyr and other normal B stars and depleted in Be by at least a factor of 4. By comparison, the hot Am star α CMa is B-deficient by about 3 orders of magnitude and Be-deficient by at least 15 times. It is suggested that the abundance deficiencies are due to diffusion, and that α CMa is intrinsically a slow rotator, and γ Gem is a slightly evolved slow rotator where some, but not all, of the B and Be has resurfaced.

Subject headings: stars: abundances — stars: individual — ultraviolet: spectra

I. INTRODUCTION

The abundance of B has now been determined in 18 B and A-type stars from high-resolution *Copernicus* satellite spectra of the B II resonance line at 1362.46 Å (Praderie *et al.* 1977, hereafter Paper I; Boesgaard and Heacox 1978). High-resolution, high signal-to-noise observations were possible for the bright A stars α Lyr (Vega) and α CMa (Sirius) studied in Paper I. A value for B/H of 1.5×10^{-10}, as corrected for non–LTE effects, was found in α Lyr, but no B II line was present in α CMa and only an upper limit abundance could be derived: B/H $\leq 5 \times 10^{-12}$. Boesgaard and Heacox (1978) found an LTE average B/H of 1.4×10^{-10} for 16 normal B and A stars. Inclusion of the effects of non–LTE would increase this value by about 50%, and they give B/H = 2×10^{-10} as the cosmic or universal abundance. This is similar to the solar value of $4(+4, -2) \times 10^{-10}$ found by Kohl, Parkinson, and Withbroe (1977). (Discussions of the solar and meteoritic B abundance determinations are given by Boesgaard and Heacox 1978 and in Paper I.)

Boron is almost totally in the form of B II at 10,000 K, and, for an abundance of B/H of 1×10^{-10}, B is by far the dominant contributor to the feature near 1362.4 Å as shown by Boesgaard and Heacox (see their Fig. 2). However, since even the brightest A stars are faint at 1362 Å, the continuous flux of the four stars with temperatures near 10,000 K observed by them had a lower signal-to-noise ratio ($\pm 2\,\sigma \approx 14\%$) than that for the hotter stars. They could only say that the data were *consistent with* a B/H abundance of 10^{-10}.

We have made high-quality observations of another bright A0 star, γ Gem, to try to understand the dichotomy in the observations of α Lyr and α CMa. Vauclair *et al.* (1978) suggest that the observed deficiencies of both B and Be in α CMa can be explained by microscopic diffusion processes relevant to Am stars. From a recent abundance analysis of γ Gem, Sadakane and Nishimura (1979) indicate that "γ Gem is slightly metallic lined and may be an example of the transitional case between hot (or marginal) Am stars and normal stars." One goal of this work was to clarify whether γ Gem resembles the normal star, α Lyr, or the hot Am star, α CMa, in its B and Be content.

II. OBSERVATIONS

a) B in γ Gem

Repeated scans were made with the Princeton spectrometer on the *Copernicus* satellite at a spectral resolution of 0.05 Å (U1) with 40–50 scans covering the region 1361.4–1363.1 Å and a concentration of 80–90 scans over the interval 1362.0–1362.8 Å. The photon count level reaches 16 counts per 14 second integration. These data and the $\pm 2\,\sigma$ error envelope are shown in Figure 1. In this plot corrections have been made for the background due to cosmic-ray particles and for scattered light. In addition, four U2 scans were made from 1355.5 to 1368.5 Å. These data were corrected for background

[1] Guest Investigators, Princeton University Telescope on the *Copernicus* satellite, which is sponsored and operated by the National Aeronautics and Space Administration.

radiation, stray and scattered light, and were used as one means of locating the continuum for the U1 scans. A continuum "window" appears between 1359.6 to 1359.8 Å and gives one measure of the continuum. Comparable highs and lows in the overlap region with the U1 data give another measure. The best measure is probably through comparison with the U1 data for α Lyr and α CMa since the continua in those stars were more accurately placeable due to the higher signal-to-noise ratio for both U1 and U2 data and the larger wavelength coverage available. Similarly, the zero-point of the wavelength scale (within the ± 0.025 Å precison of U1 observations) could be determined through comparison of the many spectral features in common with α Lyr and α CMa on the U1 tracings. Figure 2 shows the region near the B II line with a common continuum and wavelength scale for the three stars. It seems apparent from this figure that B II contributes to the blended feature in γ Gem, but to a lesser degree than in α Lyr. The longer wavelength contributor (1362.52 Å) is clearly present in the spectra of all three stars. We note that the asymmetry of the blend in γ Gem is in the opposite sense from that in α Lyr. The spectral resolution of these spectra is ~ 0.05 Å which corresponds to ~ 11 km s^{-1} at this wavelength.

b) *Be and V in γ Gem, α Lyr, α CMa*

Photographic spectra of the Be II resonance lines at 3130 and 3131 Å were obtained of γ Gem with the 48 inch (1.2 m) focal length coudé camera of the University of Hawaii 2.2 m telescope at Mauna Kea. Five spectrograms, each widened to 1.1 mm on the plate, were taken at a dispersion of 3.4 Å mm^{-1} which corresponds to a spectral resolution of 0.07 Å or a velocity resolution, full width at half-maximum, of 6.5 km s^{-1}. Direct intensity tracings of these spectra from 3100 to 3150 Å were made and digitally summed to provide data on the abundances of Be and on $v \sin i$ in γ Gem. In addition, multiplet 1 of V II has seven relatively unblended lines in that wavelength region; since a V III line blends with the B II feature at 1362 Å, the coudé spectra were used to give an independent determination of the V abundance.

Scans of the spectra of α CMa, α Lyr, and γ Gem in the region 3100–3175 Å were also made with a Reticon photodiode detector from the University of British Columbia (see Campbell and Walker 1979) attached to the 96 inch (2.4 m) focal-length coudé camera of the 2.2 m telescope and cooled by liquid nitrogen. The slit width covered three diodes and at the dispersion of 3.4 Å mm^{-1} this yields a spectral resolution of 0.15 Å. Integration times of 15, 40, and 58 minutes for α CMa, α Lyr, and γ Gem, respectively, resulted in signal-to-noise ratios at 3130 Å of 400, 340, and 140.

III. ANALYSIS OF DATA

a) *Identification*

The B II line at 1362.46 Å is clearly blended. In Figure 2 we have identified two possible contributors to the feature at λ1362.5. The situation here illustrates the importance of proper identification if one wants to perform line synthesis. In Paper I, the feature at λ1362.51 had been attributed to V III, but we were unsatisfied with this identification; first because we had to assume a *gf*-value 10 times higher than given by Kurucz and Peytremann (1975) and second because even with that high (but not unlikely) *gf*-value, the abundance V/H had also to be assumed higher than the solar value by a factor of 8 in α Lyr. Furthermore, Boesgaard and Heacox (1978) did not find it necessary to increase published *gf*-values when matching the line profiles for the B stars.

Figure 2 shows that the line λ1362.51–1362.52 is even stronger in γ Gem than in α CMa and α Lyr; since γ Gem

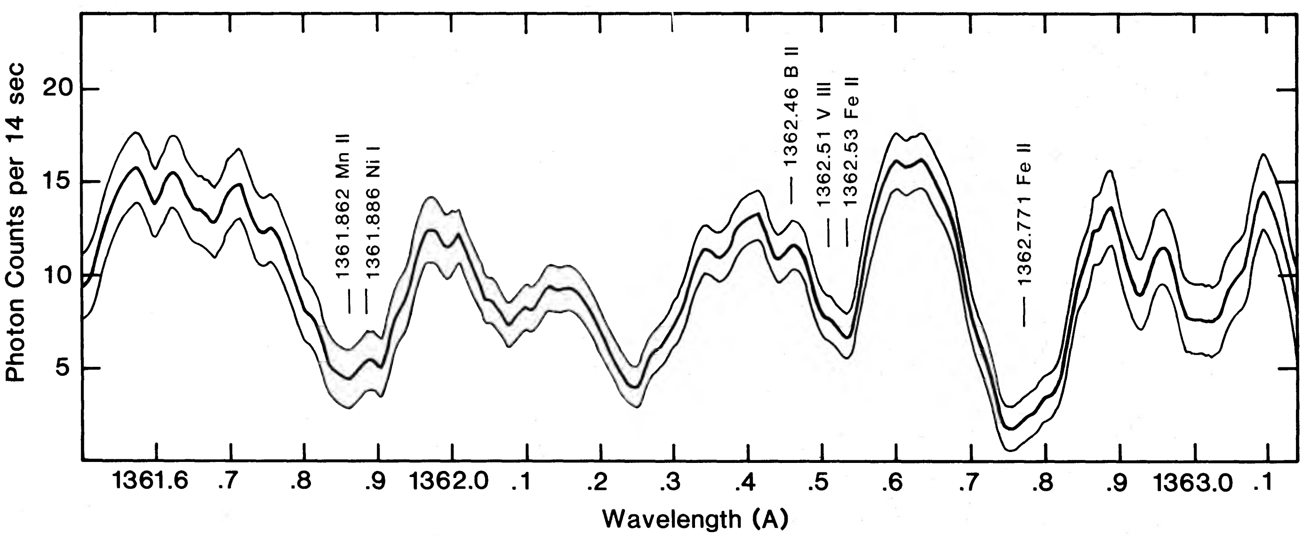

FIG. 1.—The observed U1 *Copernicus* spectrum in the B II region of γ Gem, corrected for comsic-ray background and scattered light. The lighter lines represent the $\pm 2\ \sigma$ error envelope: between 1362.0 and 1362.8 there are 80–90 scans.

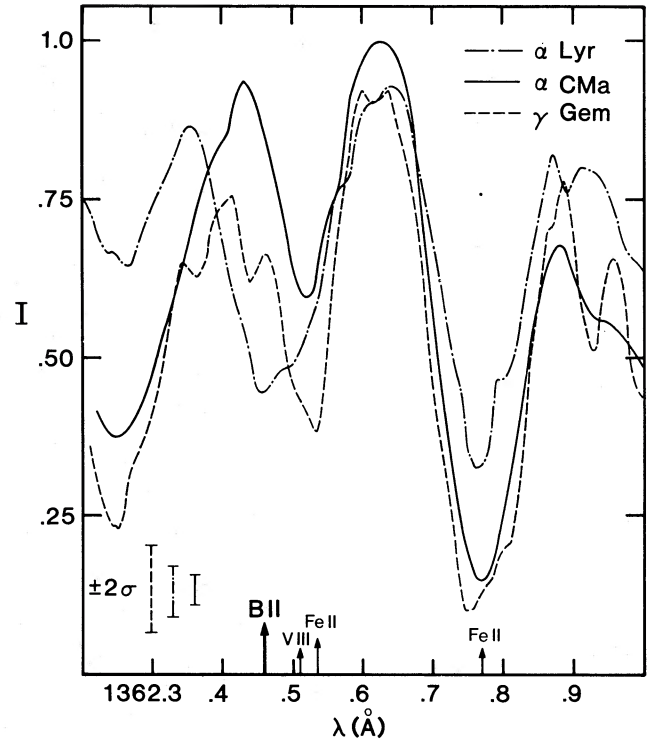

FIG. 2.—Comparison of the B II region in the three stars γ Gem, α CMa, and α Lyr. The $\pm 2\ \sigma$ error bar for the scans for each star is shown in the lower left corner. Note that the sense of the asymmetry in the feature at B II is opposite in γ Gem and α Lyr, such that Fe II and V III dominate over B II in γ Gem, and that B II makes little or no contribution in α CMa.

is the coolest of the three stars (see below), this does not support the attribution of the line to a twice-ionized atom only. Other contributors to the blend were therefore looked for again. A search of the recent literature led us to suspect S I and Fe II. For S I, Berry *et al.* (1970) report an unidentified line at $\lambda \sim 1362$ (λ given in integer value); no further data are yet available. In his new analysis of the Fe II spectrum, Johansson (1978) lists 200 new levels, eliminates 23 old ones, and lists a rather weak line at $\lambda 1362.535$ $(3d^7a^2D_{3/2}$–$3d^6(b^3F)4p^2D_{5/2})$; no *gf*-value is available for this line. In the absence of other data, we proceeded with V III and Fe II as candidates for the blend (or line) at $\lambda 1362.51$–1362.52.

b) *Model Atmospheres*

For α CMa and α Lyr the model atmospheres are those used in Paper I. For γ Gem, a hydrostatic equilibrium, LTE model has been computed with a temperature distribution derived from Kurucz, Peytremann, and Avrett (1974), and by adopting the effective temperature $T_{\rm eff}$ and gravity g from Code *et al.* (1976): $T_{\rm eff} = 9260$ K, $\log g = 3.6$. The microturbulence parameter is taken equal to 2 km s^{-1} for all three stars (see Sadakane and Nishimura 1979, 1980 for α Lyr and γ Gem; Gehlich 1969 for α CMa).

c) *Vanadium Abundance*

As very discrepant values for the V abundance in α CMa exist in the literature (see references in Paper I), and as only few determinations of V/H had been published to our knowledge for α Lyr, it seemed useful to determine the amount of V in the atmospheres of all three stars by analyzing the lines of multiplet 1 of V II. Experimental *gf*-values by Roberts, Andersen, and Sørensen (1973) were used. Table 1 gives the lines measured in each star, as well as the LTE derived abundance. The latter value is compared with previous determinations. In what follows, we use the LTE V/H ratios that we derived; the errors in our V abundances are a factor of ± 2. For comparison the solar V abundance is 1.26×10^{-8} (Withbroe 1971).

d) *Spectral Line Synthesis in the Region of* B II

The lines contributing to absorption around the resonance line of B II, $\lambda 1362.46$, can be restricted to five, not including possible unidentified lines; they are listed in Table 2. The contribution of each of these lines (except the Fe II line) for solar abundances can be seen in Figure 2 of Boesgaard and Heacox (1978). (They also show the effect of varying $v \sin i$ and the B abundance in subsequent figures.) Only in α CMa is Si III $\lambda 1362.366$ noticeable (due to high silicon abundance), and its equivalent width is about 9 mÅ; in the two other stars Si III is of no influence.

The unknowns of the problem are (1) the *gf*-value of Fe II $\lambda 1362.535$, and (2) the boron abundance, which we want to derive for each star. The abundances of other elements are taken from previous studies. In Table 2, the *gf*-values of the lines are given (Kurucz and Peytremann

TABLE 1

VANADIUM EQUIVALENT WIDTHS AND ABUNDANCES

λ (Å)	gf	EQUIVALENT WIDTH (Å) α CMa	α Lyr	γ Gem
3102.30	2.57	0.054	0.054	0.059
3110.71	2.00	0.050	0.045	0.056
3118.38	1.51	0.056:	0.042:	0.056:
3121.14	0.35	0.043	...	0.048
3126.22	0.54	0.043	0.023	0.047
3130.26	0.51	0.035	0.021:	0.036
3133.33	0.35	0.040	...	0.047
LTE abundance V/H		2×10^{-8}	6×10^{-9}	2×10^{-8}
Previous determinations		$2.5\text{–}4 \times 10^{-8}$ (1)	4×10^{-9} (6)	1×10^{-8} (7)
		1.1×10^{-6} (2)	1×10^{-8} (7)	
		2.2×10^{-8} (3)	1×10^{-8} (5)	
		1.3×10^{-6} (4)	1.2×10^{-9} (8)	
		4×10^{-9} (5)	2×10^{-8} (9)	

REFERENCES.—(1) Strom *et al.* 1966; (2) Kohl 1964; (3) Latham 1970; (4) Gehlich 1969; (5) Boyarchuk and Snow 1978; (6) Sadakane and Nishimura 1979; (7) Hunger 1955; (8) Smith 1974; (9) Sadakane and Nishimura 1980.

1975 unless otherwise quoted), as well as the set of abundances tried for each star. In each case the equivalent width W for the computed blend in LTE is compared to the measured value.

After several unsuccessful attempts where no compatibility was found among the three stars between the accepted abundances and the gf-value for Fe II line, we eliminated values of gf for $\lambda1362.535$ as high as 10^{-2} and as low as 10^{-3}. In the first case, for α Lyr and γ Gem the observed W's can be fitted, but W computed for α CMa is unacceptably large (63 mÅ corresponding to the upper limit B/H $= 5 \times 10^{-12}$ found in Paper I). If gf(Fe II) is as low as 10^{-3}, the observed W (42 mÅ) can be matched for α CMa, but the computed W's for α Lyr and γ Gem are too small. We finally adopt gf ($\lambda1362.535) = 5 \times 10^{-3}$ (Table 2), but note that the real variable is N(Fe) gf and the abundance of Fe is uncertain by a factor of two.[2]

The present results, summarized in Table 2, confirm the very low boron abundance in α CMa, and establish that boron has an intermediate content in γ Gem, relative to α CMa and α Lyr. For α Lyr, we recall that in Paper I, an LTE value of B/H $= 1.0 \times 10^{-10}$ had been derived from the B II line alone, whose short wavelength half had been symmetrized.

In this paper, we give high weight to the possibility of reproducing both the observed W and profile for α CMa (the best data are for this star) and γ Gem. Apparently, a component of the blend at $\lambda1362.51\text{–}1362.52$ is still missing in α Lyr, because Table 2 shows that W which we computed is too low for B/H $= 1 \times 10^{-10}$. (The B abundance in α Lyr cannot be increased much since then the wavelength of the computed profile would not match the observed.) However, in view of the uncertainties in the abundances of the blending elements in each star, the agreement between the observed and calculated equivalent widths seems to be very good.

e) *Beryllium Abundance in γ Gem*

The two Be II resonance lines at 3130.416 and 3131.064 Å lie adjacent to two lines primarily due to V II at 3130.261 Å and Ti II at 3130.791 Å. Line profiles were calculated from the γ Gem atmosphere (described in § III*b* above) for the blends. In addition to the lines of Be II, V II, and Ti II, the contributions due to Cr II (3130.544) and Mn II (3130.549) were included; with solar abundances these ions contribute 11 and 0.3 mÅ, respectively, to the lines. (The dominant lines have equivalent widths of about 50 mÅ for V II and 43 mÅ for Ti II.) At the value derived for $v \sin i = 6.5$ km s^{-1}, both Be lines are significantly removed from the cores of the V II and Ti II lines. Line profiles of the spectral region from 3130.0 to 3131.4 Å were calculated for a range of Be abundances, broadened by 6.5 km s^{-1}, plotted and compared to the observed tracing—the summation of five well-widened spectrograms. This comparison is shown in Figure 3. If the Be abundance were the solar/stellar value, Be/H $= 1.3 \times 10^{-11}$ (Boesgaard 1976), the two Be lines would have strengths of 11 and 6.6 mÅ; it is clear from the observations that contributions of this size are ruled out. The maximum Be contribution, based on both Be features, is Be/H $\lesssim 3.2 \times 10^{-12}$, or about 4 times less than solar.

IV. DISCUSSION AND CONCLUSIONS

Table 3 summarizes the abundance results and physical properties for α Lyr, α CMa, and γ Gem. The reanalysis of the symmetrized profile in α Lyr again gives the "cosmic" B abundances as found in 16 other B and A stars (Boesgaard and Heacox 1978), in the Sun (Kohl *et al.*), and now in the interstellar gas in the direction of κ

[2] Subsequent to the acceptance of this paper we have learned from R. Kurucz of his semi-empirical calculations of the gf-values of Fe II transitions (to be published as a *Smithsonian Special Report*, 1981). His gf-value for the Fe II line at $\lambda1362.535$ is 2.3×10^{-3}; this agreement is well within our mutual error bars.

TABLE 2

LINE LIST AND ABUNDANCES FOR B BLEND COMPUTATIONS

				Abundance Relative to H				
				α CMA		α Lyr		γ Gem
Ion	Line λ(A)	gf	Source	(B + S)	(G)	(S + N)	(G)	(S + N)
Si III	1362.366	0.30	Wiese *et al.*	...	2.0×10^{-4}	6.3×10^{-6}	3.2×10^{-5}	2.6×10^{-5}
Ni II	1362.477	1.05×10^{-2}	K + P	2.5×10^{-5}	3.3×10^{-6}	4.6×10^{-7}	...	1.5×10^{-6}
V III	1362.508	5.01×10^{-2}	K + P	2.0×10^{-8}[a]	2.0×10^{-8}[a]	6.0×10^{-9}[a]	6.0×10^{-9}[a]	2.0×10^{-8}[a]
Fe II	1362.535	5.0×10^{-3}	this paper	6.3×10^{-5}	2.0×10^{-4}	8.1×10^{-6}	1.4×10^{-5}	2.3×10^{-5}
Mn II	1362.55	1.62×10^{-5}	K + P	1.0×10^{-6}	1.2×10^{-6}	1.3×10^{-7}	8.1×10^{-9}	2.7×10^{-7}
B II	1362.460	1.1	Kernahan *et al.*	...	...	...	...	...
Blend			computed with B/H =	1.0×10^{-13}	1.0×10^{-13}	$\begin{cases}1.0 \times 10^{-10}\\2.0 \times 10^{-10}\end{cases}$	$\begin{rcases}1.0 \times 10^{-10}\\2.0 \times 10^{-10}\end{rcases}$	2.0×10^{-11}
			W (mA)	49	51	$\begin{cases}82\\91\end{cases}$	$\begin{rcases}88\\97\end{rcases}$	80
		observed	W[b] (mA)	42 ± 4		94 ± 4		78 ± 4

[a] V/H determined in this paper.
[b] W is given for the blend.
B + S = Boyarchuk and Snow (1978); G = Gehlich (1969); S + N = Sadakane and Nishimura (1979).

Ori (Meneguzzi and York 1980). Although B contributes to the blend in γ Gem, its abundance is about an order of magnitude less than the cosmic value. Boron is apparently absent in α CMa with an upper limit on its abundance of at least 2–3 orders of magnitude below the cosmic value. A similar trend is present for Be: α Lyr has normal Be while the upper limit for γ Gem is at least 4 times below normal and for α CMa, from Bonsack's (1961) work, at least 15 times below normal. With respect to Be, both γ Gem and α CMa appear to be hotter temperature analogs of the Be-deficient F stars discussed by Boesgaard (1976).

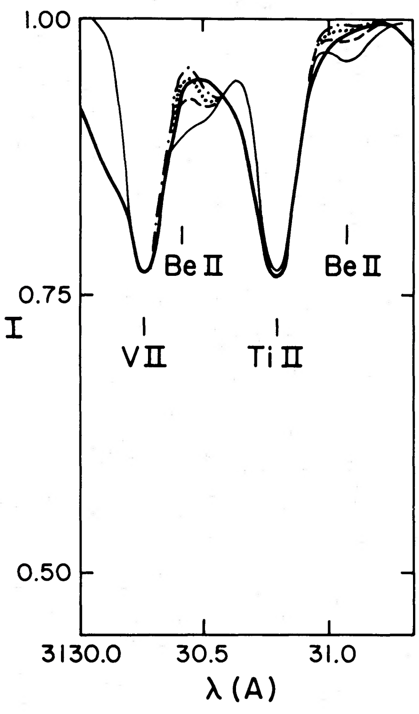

FIG. 3.—The observed and calculated line profiles in the Be II resonance line region in γ Gem. The heavy solid line is the integration of the 5 observed spectra. The light solid line corresponds to the synthesized line profile with the solar-stellar Be abundance, Be/H = 1.3×10^{-11}. The dashed line is for a Be/H of one-half the stellar value, the dotted line to one-quarter the stellar value, and the dashed-dotted line to one-eighth the stellar value.

The abundances of B and Be in α Lyr are normal, but both γ Gem and α CMa show abundance anomalies in those two light elements and in several other elements as well. The deficiencies of B and Be as well as anomalies in other elements are less pronounced in γ Gem than in α CMa. Kohl (1964) proposed that α CMa is an Am star, a result confirmed by Gehlich (1969) and others. Sadakane and Nishimura (1979) find indications of metallicism in γ Gem–Fe is overabundant by a factor of 4 and other metals are slightly enhanced relative to α Lyr. However, two typical signatures of other hot Am stars, an enhancement by 1–2 orders of magnitude more in Sr and a deficiency in Sc, are not present in γ Gem. For example, the logarithmic Sr abundance relative to α Lyr, Δ, for α CMa is $+2.34$ (Gehlich 1969), for α Gem A (A1 V) is $+2.02$, and for θ Leo (A2 V) is $+1.28$ (Smith 1974), while in γ Gem, Sr is only overabundant by $\Delta = +0.26$ (Sadakane and Nishimura 1979). Moreover, Sc is underabundant in α CMa relative to α Lyr with $\Delta = -0.37$, while in γ Gem Sc is slightly overabundant, $\Delta = +0.36$ (Sadakane and Nishimura 1979). The effects of diffusion through the bottom of the convection zones, during and after the disappearance of the He^+ ionization zone, will be observable as abundance anomalies in the atmospheres of low-rotation stars (Vauclair 1976). A mechanism has been offered by Vauclair *et al.* (1978) to account for the absence of Be and B in α CMa: Be and B sink at the same time as He through the bottom of the second convection zone in a 2 $M_\odot$ star. This second convection zone disappears when He/H has been reduced by a factor

TABLE 3

STELLAR PROPERTIES AND ABUNDANCES

Star	Type	T_{eff}(K)[a]	log ($L/L_\odot$)	log ($R/R_\odot$)	log ($M/M_\odot$)[b]	$\|B\|$[c] (gauss)	$v \sin i$[d] (km s^{-1})	Be/H	B/H
α Lyr ...	A0 V	9660 ± 140	1.777 ± 0.045	0.441	0.382 ± 0.060	−8 ± 18	18	1×10^{-11}	1.5×10^{-10}
α CMa ..	A1 V	9970 ± 160	0.843 ± 0.029	0.225	0.330 ± 0.030	0 ± 9	10–12	$\leq 8 \times 10^{-13}$	$\leq 1 \times 10^{-13}$
γ Gem ..	A0 IV	9260 ± 310	2.01 ± 0.14	0.60	0.405 ± 0.075	−165 ± 120	6–7	5×10^{-12}	2×10^{-11}

[a] T_{eff}, log ($L/L_\odot$), log ($R/R_\odot$) from Code *et al.* 1976.
[b] log ($M/M_\odot$) from Code (1975).
[c] $|B|$ from Landstreet (personal communication).
[d] $v \sin i$ from Milliard *et al.* (1977) for α Lyr, α CMa, from this work for γ Gem.

of ≈3. Then a stability phase starts for the star, the so-called Am phase.

There are many factors which can affect the basic diffusion model and abundance anomalies as pointed out by Bonsack and Wolff (1980): "the relative importance of accretion and diffusion, the presence or absence of a magnetic field, the extent of mixing by meridional circulation, turbulent diffusion, and convection." These in turn are affected by the stellar mass, rotation, and evolutionary phase. As shown in Table 3, none of these three stars is magnetic and all have low $v \sin i$ values. Stars with the slowest rotational velocities will be among those with the most stable atmospheres and subsurface regions and would be expected to show diffusion effects. Meridional mixing in more rapid rotators would counteract the impact of diffusion. The diffusion mechanism of Vauclair *et al.* (1978) can work in α CMa, if one asserts that this star has a small intrinsic rotation velocity and that the rotation is uniform. Gamma Gem is slightly more evolved than α CMa, and if it is an intrinsically slow rotator, it may have already gone through the Am phase of its life (Vauclair 1976) and redeveloped a partial mixing of the previously sorted elements. Although speculative this suggestion would be reinforced if the typical pattern of abundances found by Sadakane and Nishimura (1979) in γ Gem could be interpreted as an advanced phase in the life of a previously classical Am star.

Dr. G. Michaud kindly provided us with computations of the mass above the bottom of the He II convection zone for a star with γ Gem parameters ($T_{eff} = 9260$ K, $M = 2.5\ M_\odot$; Code 1975), and for various decreasing He abundances (from He/H = 0.1 to He/H = 0.01). The characteristic time, θ_{He}, for He to diffuse downward depends on the gravity of the star (see, e.g., Cox, Michaud, and Hodson 1978). These computations show that θ_{He} is shorter than the lifetime of the star for main-sequence stars and those with $g \gtrsim 10^3$ g cm^{-3}. Therefore in a star like γ Gem, with $g = 4 \times 10^3$, He is allowed to sink through the bottom of the convection zone, and the star may still be in the Am phase. There has not been enough time available for the end of the Am phase to have been reached, according to Vauclair (1976), within the assumptions of these computations, but a slightly more efficient convection would marginally change this conclusion; in that case, B and Be would be brought back into the surface layers.

In α Lyr, where B and Be are observed at normal abundances, some other effect must be operative: either the star has a large uniform rotational velocity, or the state of uniform rotation has not been reached. In the first case, note that the observed $v \sin i$ is small (Table 3), and the probability of the rotation axis of the star being oriented within 30° of pole-on is only 13%, so the *a priori* statistical chance that α Lyr is a rapid rotator seen pole-on is low. In the second case, shear instability would be present in the whole envelope, and the material would be kept homogeneous, without the possibility of diffusion effects becoming observable; therefore B would not sink in the envelope, and we must assume from observations that it is not selectively expelled from the star at atmospheric levels, even though the radiative forces in the photosphere are large (Borsenberger, Michaud, and Praderie 1979).

An observational test of the Vauclair (1976) and Vauclair *et al.* (1978) suggestions and our interpretations would be the He abundance in the atmosphere of all three stars. Gehlich (1969) doubts that λ5875 and λ4471 are really He lines in α Lyr while Smith (1974) finds the He abundance in α Lyr to be normal. In α CMa the He abundance found by Kohl (1964) is astonishlingly large, He/H = 0.3. In none of these stars is the atmospheric abundance of He known with any accuracy. In the absence of a test given by the He abundance, it turns out that B and Be themselves are excellent indicators of the structure and depth of convective zones in the early A stars, a point already stressed by Vauclair *et al.* (1978). More speculatively, B and Be may also be able to trace the true rotational velocity of the stars; from our study, and the explanation scheme presented, α CMa and γ Gem are true slow rotators, while α Lyr is not necessarily rotating slowly and/or uniformly.

These results for B in these three well-observed A stars are not inconsistent with the findings of Boesgaard and Heacox (1978) on B in B-type stars. A far higher percentage of A stars than B stars are classified as peculiar; with the possible exception of κ Cen all of the 12 B stars studied showed normal B abundances.

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