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G62-46: AN UNRESOLVED DOUBLE DEGENERATE BINARY CONTAINING A MAGNETIC DA COMPONENT[1]

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ABSTRACT

A detailed analysis of the white dwarf star G62-46 is presented. High signal-to-noise spectroscopy reveals Zeeman splitting of the Hα line profile, indicating the presence of a magnetic field. Model atmosphere calculations are used to demonstrate that the observed energy distribution and line profiles cannot be reconciled with those of a single magnetic hydrogen-line (DA) white dwarf. Instead, G62-46 is shown to be an unresolved double degenerate binary, composed of a featureless DC white dwarf diluting the line profiles of the magnetic DA component. We show from the inferred mass of the DA component that the system most likely has undergone at least one phase of common envelope evolution. The observed line profiles of the DA star are reproduced with a dipole strength of $B_d = 7.4$ MG, offset from the center of the star by an amount equal to about one-tenth of the stellar radius.

Subject headings: binaries: close — stars: individual (G62-46) — stars: magnetic fields — white dwarfs

1. INTRODUCTION

The rapidly growing number of magnetic stars discovered among the population of white dwarf stars can be attributed mainly to the increased sensitivity of polarimetric, spectropolarimetric, and spectroscopic observations, which can detect the presence of very weak magnetic fields. Systematic surveys with these improved observing techniques should help us study in greater detail the field strength and effective temperature distributions of the magnetic white dwarf population (Schmidt 1987, 1989). In turn, these analyses will provide a better understanding of the formation and subsequent evolution of these fascinating objects.

We have recently undertaken a spectroscopic and photometric survey of cool white dwarfs aimed at understanding their spectroscopic and chemical evolution (Ruiz, Bergeron, & Leggett 1993). As part of this survey, we have discovered that G62-46 (WD 1330+015, LP 618-1) is a magnetic hydrogen-line (DA) star. The high signal-to-noise spectrum exhibits the characteristic Zeeman splitting at Hα which reveals the presence of a magnetic field. The star was previously classified as a DC–DA weak white dwarf, with possible carbon features, by Greenstein et al. (1977). Subsequent observations by Wegner & Yackovich (1982) failed to detect any spectral features in the range 3500–7000 Å, and G62-46 was therefore reclassified as a DC star. Since it is extremely faint ($V \sim 17$ mag), the presence of weak hydrogen absorption features could only be detected from high signal-to-noise spectroscopy. The usefulness of high signal-to-noise spectroscopy has been illustrated by Greenstein (1986), who discovered such weak hydrogen features in many of the previously classified DC stars.

The Zeeman splitting in G62-46 was discovered shortly after we had completed the analysis of two other magnetic DA stars, LHS 1044 and LHS 1734, found in our spectroscopic survey (Bergeron, Ruiz, & Leggett 1992a, hereafter Paper I). A similar analysis of the line profiles and energy distribution of G62-46 revealed that this object was more peculiar than those we had discovered previously, and it was deemed necessary to analyze it separately. We present here the results of our investigation.

In § 2 we describe our observations, which are then used in § 3 to demonstrate that the observed properties of G62-46 cannot be reconciled with those of a single degenerate object. Instead, we show in § 4 that the object is most likely to be an unresolved double degenerate binary composed of a featureless DC star and a magnetic DA star. The atmospheric parameters of each component are then determined and used along with the observed line profiles to analyze the structure and geometry of the magnetic field. Our conclusions follow in § 5.

2. OBSERVATIONS

Details of our observing procedure and data reduction have been discussed at length in Paper I and will only be summarized here. The spectrum of G62-46 was obtained on 1992 April 12 with the CTIO 4 m telescope equipped with the Cassegrain spectrograph and a Reticon (1200 × 400) CCD detector. The spectral coverage is 5440–8060 Å at ~8 Å resolution, and the signal-to-noise ratio achieved is about 90. A portion of the spectrum centered at Hα is displayed in Figure 1, along with the spectra of three similar magnetic DA stars: LHS 1044 and LHS 1734 have been analyzed in Paper I, while the spectrum of G99-47 has been kindly made available to us by J. L. Greenstein. We also show for comparison the spectrum of G141-2, which will be discussed in § 5. The latter was obtained

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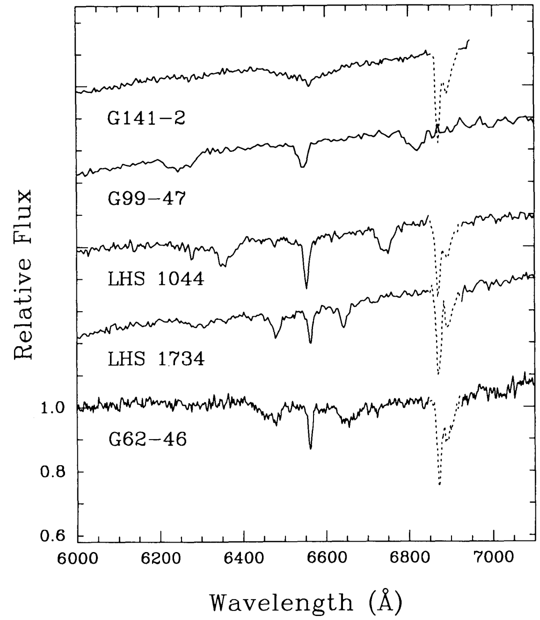

FIG. 1.—Optical spectrum in the region of Hα for the magnetic white dwarf system G62-46. For comparison, the spectra of three similar magnetic DA stars and the spectrum of G141-2 discussed in § 5 are displayed as well. All spectra are normalized to unity at 6100 Å and offset vertically for clarity. The dashed portion of the curves represents terrestrial atmospheric absorption lines. The spectral resolution of the G99-47 spectrum is ~12 Å, while that of the other spectra is ~8 Å.

on 1992 August 4 at La Silla (ESO) using the 3.6 m telescope equipped with EFOSC, the O150 grism, and a 512 × 512 TEK CCD detector. The spectral coverage is 5000–7000 Å at ~8 Å resolution. Details of our data acquisition and reduction are similar to those described in Paper I.

Except for G141-2, all spectra exhibit the characteristic Zeeman splitting which indicates the presence of magnetism at the surface of the star. As in Paper I, we fitted Gaussian profiles to the observed line components to determine the central wavelength, full-width at half-maximum (FWHM), central depth (A_c), and equivalent width (W) of each component of the Zeeman triplet. These values are reported in Table 1. Since the shift of the σ^+ and σ^- components relative to the unshifted π component is ~20 Å MG^{-1} at Hα (Kemic 1974), the mean field strength in G62-46 is about 4.6 MG, which is slightly larger than the value of 4.1 MG obtained for LHS 1734.

From the results of Paper I, LHS 1044 and LHS 1734 have effective temperatures of 6000 and 5230 K, respectively. For this analysis we have used previously published optical (Eggen 1968) and infrared (Leggett 1989) photometry to obtain an estimate of the effective temperature for G99-47 of $T_{eff} \sim 5840$ K. Therefore these three objects have comparable temperatures, and it can be inferred from the observed line profiles that the temperature of G62-46 should be similar. On the other hand, the slope of the spectrum of G62-46 displayed in Figure 1 is somewhat flatter than those of the other magnetic stars, which seems to suggest that the temperature of G62-46 is significantly hotter. This is confirmed by our detailed analysis of the energy distribution (see § 3).

TABLE 1

LINE PROFILE PARAMETERS FOR G62-46

λ (Å)	FWHM (Å)	A_c	W (Å)
6468.0........	18.8	0.042	1.97
6561.8........	4.2	0.130	1.37
6653.5........	18.1	0.045	2.05

TABLE 2

COLORS FOR THE G62-46 SYSTEM

V	$B-V$	$V-R$	$R-I$	J	$J-H$	$H-K$
17.00.......	0.39	0.23	0.16	16.38	0.13	0.08

B, V, R, and I photometry was obtained on 1992 March 28 with the CTIO 1.5 m telescope. Similarly, infrared J, H, and K photometry was obtained on 1992 April 23 with the CTIO 4 m telescope. Details are given in Paper I. The optical and infrared photometry is reported in Table 2, where the data are given in the Johnson B and V system, the Cousins R and I system, and the CIT J, H, and K system. The accuracy of the photometry is approximately 4% in all filters, except for the K-magnitude, where the uncertainty is about 10%. As in Paper I, we have converted this photometry into flux densities which will be used in the next section to estimate the atmospheric parameters of G62-46.

3. ANALYSIS OF G62-46 AS A SINGLE STAR

The model atmospheres used in the analysis have been described in Paper I and references therein. These new models make use of the improved H_2 collisional induced opacities developed by Lenzuni, Chernoff, & Salpeter (1991). Ruiz et al. (1993) have shown, in particular, that these models were able to reproduce successfully the observed energy distributions of cool, hydrogen- and helium-rich white dwarf stars.

We have calculated energy distributions and fitted the data presented in Figure 2 using a nonlinear least-squares technique (see Paper I). The two parameters fitted are the effective temperature and the scaling factor (R^2/D^2), i.e., the square of the ratio of the radius of the star to its distance from Earth. As

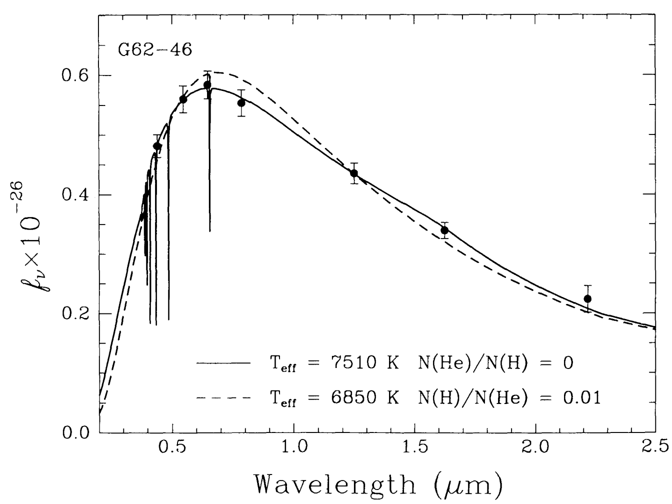

FIG. 2.—Our fits to the energy distribution of G62-46 using pure hydrogen models (*solid line*) and helium-rich models [$N(H)/N(He) = 0.01$; *dashed line*]. All models have log $g = 8.0$. The atmospheric parameters from each set are indicated in the plot. The filled circles correspond to the observed flux densities (with corresponding uncertainties) derived from the photometry given in Table 2.

discussed in Paper I, it is not possible to constrain the surface gravity of the star from the energy distribution alone. Since there is no available measurement of the trigonometric parallax, we have assumed a value of $\log g = 8.0$ in the following analysis. We have also considered various mixed hydrogen and helium compositions.

In Figure 2 we present our best fits to the energy distribution with both pure hydrogen models and $N(\mathrm{H})/N(\mathrm{He}) = 0.01$ models. A pure hydrogen model at $T_{\mathrm{eff}} = 7510$ K matches the observed energy distribution perfectly at all filter bands. With the helium-rich models, the estimated temperature is slightly lower ($T_{\mathrm{eff}} = 6850$ K), but, more important, our best fit fails to reproduce the observed energy distribution, especially in the *R*, *I*, and *H* bands. Therefore, such a high helium abundance can be ruled out; it was not possible, however, to exclude helium abundances smaller than $N(\mathrm{He})/N(\mathrm{H}) \lesssim 1$. The temperature obtained for G62-46 is thus significantly higher than those obtained for the three other magnetic stars displayed in Figure 1. In contrast, the observed line profiles for all four objects look remarkably similar.

The problem becomes even more acute when synthetic line profiles are compared with the observed spectrum of G62-46. Figure 3 presents the results of our calculation; details of our line profile computation in the presence of a magnetic field can be found in Paper I. Here we assume a homogeneous field distribution, and adjust the mean field strength to approximately match the observed splitting of the σ^+ and σ^- components. With a more realistic distribution of the field strengths (e.g., centered or offset dipole models), the central π component remains unaffected when the mean field strength is small (see Paper I). The solid line shows the calculation with pure hydrogen models at the temperature obtained from the energy distribution (Fig. 2). The spectral lines predicted are much stronger than the observed profiles. Both the widths and especially the depths of all lines are not well reproduced. We could obtain a reasonable fit to the central π component with a cooler model, but then the temperature derived from the line

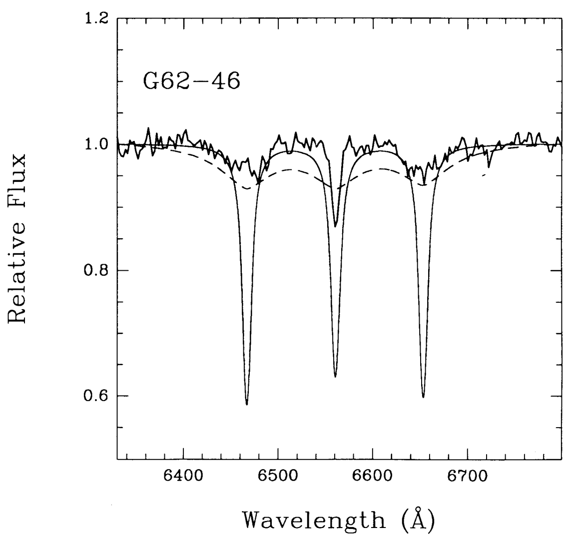

FIG. 3.—Comparison of the observed line profiles of G62-46 with synthetic models calculated under the assumption of a homogeneous distribution of magnetic field strengths. The solid and dashed lines are calculated with the same atmospheric parameters as those used in Fig. 2. The strength of the magnetic field has been adjusted to match the observed splitting. All line profiles are normalized to a continuum set to unity.

profile ($T_{\mathrm{eff}} \sim 5400$ K) is in conflict with that obtained from the energy distribution ($T_{\mathrm{eff}} = 7510$ K). Therefore, we conclude from the results of Figures 2 and 3 that pure hydrogen models fail to reproduce *simultaneously* the observed line profiles and energy distribution of G62-46. Although the calculations are illustrated for $\log g = 8.0$ models only, a similar conclusion is reached if the surface gravity is varied.

The other free parameter in our analysis is the helium abundance. One might think that increasing the helium abundance in the atmosphere would cause the hydrogen-line profiles to become weaker. Figure 3 shows the result of our calculation for an $N(\mathrm{H})/N(\mathrm{He}) = 0.01$ model at the corresponding temperature obtained from the energy distribution ($T_{\mathrm{eff}} = 6850$ K; *dashed line*). The calculated line depths are in slightly better agreement with the observed profiles. The line widths, however, are predicted too large owing to van der Waals broadening by neutral helium. Furthermore, we have already shown above that such a high helium abundance could be ruled out from the energy distribution analysis. Even then, it would be difficult to conceive how sharp hydrogen features such as those seen in G62-46 could survive in a helium-rich environment. For example, Liebert (1977; see his Fig. 2) showed that the observed Hα line profile of the white dwarf Ross 640 is extremely broad and can be reproduced nicely with a helium-rich model [$N(\mathrm{H})/N(\mathrm{He}) = 3 \times 10^{-4}$] when van der Waals broadening is included in the calculation.

We therefore conclude that the temperature obtained from the energy distribution cannot be reconciled with that obtained from the line profile, even by varying the values of the surface gravity and/or the atmospheric composition. Such a discrepancy has been reported by Bergeron, Greenstein, & Liebert (1990), where three nonmagnetic DA stars are analyzed. The energy distributions and hydrogen-line profiles for all three objects were shown to be inconsistent with those of a single DA star (see also Liebert, Bergeron, & Saffer 1991). Instead, the analysis indicates that these objects are probably composite systems consisting of pairs of unresolved DA and DC stars, with a featureless DC component diluting the hydrogen-line strengths of the DA star. In the next section we demonstrate that G62-46 is also a double degenerate binary.

4. ANALYSIS OF G62-46 AS A DOUBLE DEGENERATE BINARY

4.1. *General Considerations*

The spectroscopic signature of unresolved double degenerate binaries has been studied by Bergeron et al. (1989), Bergeron et al. (1990), and Liebert et al. (1991). These analyses have shown, in particular, that the *combined* line profiles from two DA white dwarfs with different temperatures and surface gravities can always be reproduced with a *single* DA spectrum with intermediate values of T_{eff} and $\log g$. The double degenerate L870-2 discovered by Saffer, Liebert, & Olszewski (1988) is a good example of such a system. Bergeron et al. (1989) showed that the composite spectrum of L870-2 could be fitted with that of a single DA star. Therefore, DA+DA double degenerate binaries are almost impossible to recognize from an analysis of the line profiles alone. Other information such as the energy distribution, high-resolution spectroscopy, radial velocity analyses, or an apparent overluminosity are needed to unveil the binary nature of these systems.

If one of the degenerate components is a featureless DC star, however, the line spectrum of the DA component will be diluted by the continuum flux of the DC component. Three such systems have been discovered and analyzed by Bergeron et al. (1990). For some systems, such as GD 402, the line spectrum could be fitted with a single DA model, but the derived effective temperature was not consistent with that obtained from the energy distribution. For other objects, such as G4-34, it was not possible to reproduce the observed Balmer-line spectrum with any given model, even by varying the effective temperature, surface gravity, or atmospheric composition. Instead, composite DA + DC systems were invoked to show that both the observed line profiles and energy distribution could be reproduced *simultaneously*.

G62-46 shares common characteristics with the three systems analyzed by Bergeron et al. (1990). In particular, the effective temperature inferred from the Hα line profile is significantly cooler than that estimated from the energy distribution. In the following, we attempt to reproduce the observed properties of G62-46 with a double degenerate binary. The procedure employed here is similar to that outlined in Bergeron et al. (1990).

4.2. *Determination of the Atmospheric Parameters*

There are six free parameters involved in the calculation, three for each component of the system [$T_{\rm eff}$, log g, and N(He)/N(H)]. Since hydrogen features are observed in the composite spectrum, one of the two components of the system needs to be a DA star. But since Hα is the *only* feature, the DA star needs also to be relatively cool ($T_{\rm eff} \lesssim 6000$ K). The second component of the system, however, cannot be a DA star. Indeed, in order to match the observed energy distribution, this second component needs to be fairly hot ($T_{\rm eff} \gtrsim 7500$ K) and would thus produce many high Balmer lines. Since these lines are not present in the spectrum of G62-46, we conclude that the second component of the system is a DC star. Similarly, this DC star needs to be cool enough ($T_{\rm eff} \lesssim 10{,}000$ K), since otherwise neutral helium lines would be observed. For simplicity, we assume in the following that the DA component has a pure hydrogen composition and that the DC star has a pure helium composition. Intermediate compositions would not change the main conclusion of the analysis as discussed by Bergeron et al. (1990).

The total flux of the system is obtained from the sum of the monochromatic Eddington fluxes of the individual components, weighted by the respective radii. The latter values are calculated from the evolutionary models of Wood (1990) for a carbon core composition. The monochromatic fluxes, in turn, will depend on $T_{\rm eff}$ and log g. Because the value of the solid angle is considered a free parameter in fitting the energy distribution, only *relative* log g (or radius) values are obtained; a simultaneous decrease of the stellar radii can be compensated for by increasing the value of the solid angle.

The first step is to assume a surface gravity of the DC star, log g(DC). In a second step, we assume an effective temperature for the DA star, $T_{\rm eff}$(DA), and adjust $T_{\rm eff}$(DC), log g(DA), and the solid angle, until the energy distribution is well reproduced. We then use the central component of the Hα profile to better constrain the atmospheric parameters. As discussed above, this central component is not sensitive to the assumed distribution of the field strengths, and can be fitted independently of the shifted components. We adopt the same trial value of log g(DC), and also the values of $T_{\rm eff}$(DC) and log g(DA) determined above from the energy distribution, and adjust $T_{\rm eff}$(DA) until the central component of the Hα profile is well reproduced. This value of $T_{\rm eff}$(DA) obtained from the line profile analysis may be inconsistent with the initial value used to fit the energy distribution. We thus repeat the entire procedure with this new value until the temperature of the DA component inferred from the line profile analysis is consistent with the observed energy distribution.

The value of log g(DC), which has remained constant throughout the procedure, can then be varied as well. We find that, for all values of log g(DC), it is always possible to find a perfect match to the observed energy distribution and an acceptable fit to the line profile. Therefore, we conclude that it is not possible from the available data to obtain a unique solution for the atmospheric parameters of the G62-46 system. For each value of log g(DC), however, the other atmospheric parameters are well constrained. The results of our calculation for several assumed values of log g(DC) are summarized in Table 3. In all cases, the effective temperature of the DC component is $T_{\rm eff}$(DC) ~ 9600 K, that of the DA is $T_{\rm eff}$(DA) ~ 6000 K, and the surface gravity of the DA star is always ~0.8–1.3 dex lower than that of the DC star.

The individual stellar masses can be obtained from the evolutionary models of Wood (1990). We have calculated the absolute visual magnitudes, M_V, of each component following the prescription of Wesemael et al. (1980), and also obtained the *combined* absolute visual magnitude. From the latter value and the observed visual magnitude, $V = 17.00$, we also predict the trigonometric parallax. These values are reported in Table 3. Examination of these results indicates that a precise measurement of the trigonometric parallax would better constrain the atmospheric parameters of the system. Because of the small predicted values, however, such a measurement would be difficult to obtain.

We display in Figure 4 our fit to the energy distribution from one of the solutions given in Table 3; the other solutions yield equally good fits. The contributions of the individual components to the total flux for the adopted solution are displayed as well. Note that the energy distribution of the DA component has been calculated for a nonmagnetic star. In this case, many observable Balmer lines are predicted; in reality, these lines are smeared out by the magnetic field present in G62-46. Although our spectrum of G62-46 covered only the Hα region, Wegner & Yackovich (1982) did not report any spectral features present near Hβ or higher Balmer lines.

4.3. *Line Profile Analysis*

The geometry and strength of the magnetic field can be determined from the observed Hα profile. Details of our calculation are described at length in Paper I and references therein. In these studies, line profiles predicted from centered and offset dipole models are discussed in detail. In the present calculation, however, the dilution of the Hα line profile by the con-

TABLE 3

ATMOSPHERIC PARAMETERS OF THE G62-46 COMPONENTS

DA Component				DC Component				Composite	
$T_{\rm eff}$ (K)	log g	$M/M_\odot$	M_V	$T_{\rm eff}$ (K)	log g	$M/M_\odot$	M_V	M_V	π
6040	6.94	0.14	13.10	9570	8.20	0.70	12.78	12.17	0".011
6040	7.27	0.25	13.33	9570	8.40	0.84	13.09	12.45	0.012
6050	7.58	0.36	13.70	9570	8.60	0.97	13.43	12.80	0.014
6070	7.87	0.50	14.05	9580	8.80	1.08	13.80	13.17	0.017
6110	8.16	0.67	14.41	9600	9.00	1.19	14.20	13.55	0.020

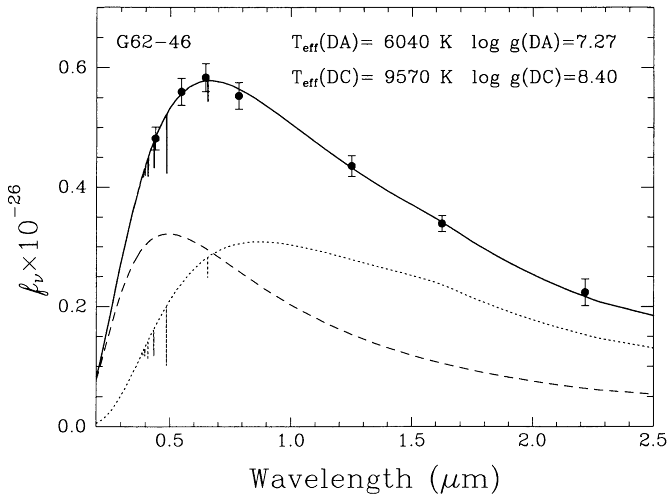

FIG. 4.—Our best fit to the energy distribution of G62-46 obtained under the assumption that a composite DA + DC system is being fitted. The atmospheric parameters of each component correspond to one of the solutions presented in Table 3. The individual contributions of the DA component (*dotted line*) and the DC component (*dashed line*) have been displayed as well.

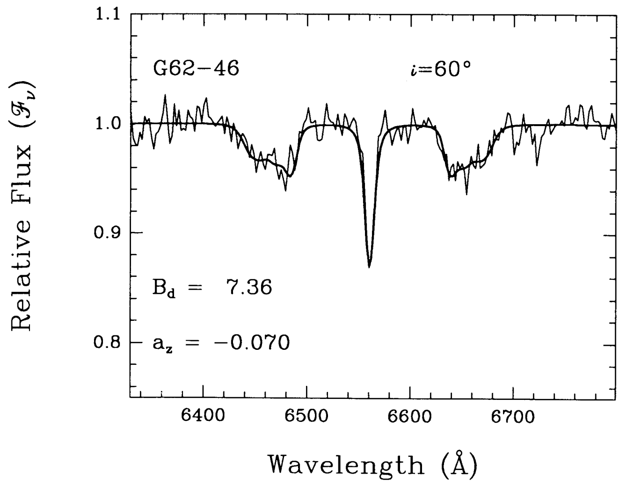

FIG. 5.—Our best fit to the observed line spectrum of the G62-46 system. Both the observed and the synthetic line profiles are normalized to a continuum set to unity. The atmospheric parameters of the DA and DC components are indicated in Fig. 4.

tinuum flux of the DC star needs to be taken into account. Our analysis indicates that the observed line profiles of G62-46 can be reproduced successfully with an offset dipole model. We achieve a best fit with a dipole field strength of $B_d = 7.36 \pm 0.11$ MG offset from the center of the star by an amount $a_z = -0.070 \pm 0.010$ (in stellar radius) and a value of the angle between the dipole axis and the line of sight of $i = 60°$. This best fit[3] is displayed in Figure 5. Although we found it difficult in Paper I to estimate the value of i precisely, the particular shape of the σ^+ and σ^- components of G62-46 allowed a determination of i to better than 15°.

As for LHS 1044 and LHS 1734 (and most likely G99-47 as well), the dipole is offset *away* from the observer. This has been interpreted in Paper I as a selection effect that operates against magnetic dipoles that are offset *toward* the observer, since such objects would not be easily detected in a spectroscopic survey (see Fig. 4 of Paper I).

5. ASTROPHYSICAL IMPLICATIONS

We have been able to reproduce nicely the observed properties of G62-46 by invoking the presence of a DA + DC degenerate binary. Not only was it possible to match simultaneously and consistently the energy distribution and the line profiles, including the magnetic structure, but the binary hypothesis seems to be the only viable model able to reproduce the data. The existence of such systems is discussed below.

From the results given in Table 3, the estimated distance of the G62-46 system is in the range ~50–90 pc, depending on the surface gravity of the DC component. These values are comparable to the distance of the other systems analyzed by Bergeron et al. (1990). If we assume a 2″ angular separation between the components, i.e., within the seeing diameter, we obtain a *maximum* physical separation on the plane of the sky of ~100–180 AU. This separation is too wide for past or future phases of binary interaction.

[3] The atmospheric parameters adopted here are from the log g(DC) = 8.4 solution, but an equally good fit to the line profile can be achieved with the other solutions given in Table 3 without affecting our determination of the magnetic field strength and geometry.

For values of log g(DC) $\lesssim$ 8.6, the inferred mass of the DA component is smaller than 0.4 $M_\odot$. Such a low mass implies that the system has undergone at least one phase of common envelope evolution. Indeed, as discussed by Bergeron, Saffer, & Liebert (1992b) and references therein, white dwarf stars with masses below ~0.45–0.50 $M_\odot$ cannot have evolved from single main-sequence stars within the lifetime of this Galaxy, and close binary evolution needs to be invoked to account for the low mass of the white dwarf remnant. Even at a value of log g(DC) = 8.8, the mass of the DA component is only 0.5 $M_\odot$. Thus, the G62-46 system is likely to be the result of close binary evolution unless the DC component is extremely massive ($M \gtrsim 1.0\ M_\odot$), in which case G62-46 could be a wide binary where both components evolved independently. Such very massive stars are rare, however, according to the recent mass distribution of Bergeron et al. (1992b). If the G62-46 system is indeed the result of close binary evolution, then the physical separation of the components is probably much smaller than that inferred above. It should also be a radial velocity variable, although this would be almost impossible to confirm, since G62-46 is too faint and lacks the presence of strong absorption features.

Since the DC star is the more massive component of the system, it evolves more slowly than the DA component at these cool effective temperatures if both stars have the same core composition, except perhaps at very high masses where crystallization effects become important (see below). Therefore, although the DA star is cooler than the DC star, it is not necessarily the older component of the system. Indeed, if we estimate the ages of each component of the system from the pure carbon-core evolutionary models of Wood (1990), we find that for all the solutions with log g(DC) $\leq$ 8.6 given in Table 3, the DC star is the older component of the system and has thus been formed first; the DA star was formed ~(3–8) × 10^8 years later. Consequently, the progenitor of the DC star was more massive than the DA progenitor and was the first to evolve. The situation is reversed, however, if the DC remnant is very massive ($M \sim 1.2\ M_\odot$), in which case, because of crystallization effects, the DC star is younger than the DA counterpart.

Alternatively, scenarios of close binary evolution such as those discussed by Iben & Tutukov (1986) and Iben &

Webbink (1989) suggest that the DA component is likely to have a helium-core composition, and consequently, its cooling time scale should be evaluated from helium-core models. Unfortunately, such models are not available yet, and one can only evaluate the effects qualitatively. Before crystallization takes place (which is obviously the case here for the DA star), Mestel's theory of cooling (Mestel 1952) shows that the ages scale approximately as the inverse of the ratio of the atomic masses. Therefore, cooling time scales for pure helium-core models should be roughly 3 times larger than those for pure carbon-core models. Thus, if the DA component of the G62-46 system has indeed a helium-core composition, the cooling time scales above have been underestimated by a factor of 3. In this case the DA is always the older star of the system, and has thus been formed first.

If the binarity of G62-46 and the low mass of the DA component are confirmed, the G62-46 system would become the first close binary system containing at least one magnetic degenerate component, except for the AM Her and DQ Her classes of cataclysmic variables. G62-46 will not evolve into an AM Her system, however, since both components are degenerate, but it may well evolve into a magnetic AM CVn system such as PG 1346+082 (Wood et al. 1987). The likely existence of a close binary system with at least one magnetic component indicates that magnetic white dwarfs can be formed even through close binary evolution. How one component of the system becomes magnetic is outside the scope of our paper. It is not clear either how the two components evolved into dissimilar spectral types. We note finally that the DC component of the G62-46 system could be magnetic as well, but since the star is featureless, polarimetry would be needed to confirm the presence of the magnetic field. Such measurement would first require that the components of the system be resolved!

G141-2 is another magnetic DA star discovered by Greenstein (1986). The weak structure observed at Hα is explained in terms of a magnetic field so small that the Zeeman components overlap. It is also reported that the observed line profile can be reproduced with a pole-on dipole model of 3 MG. However, G141-2 has not yet been confirmed, to our knowledge, by polarimetric observations. We have thus reobserved this object at much higher signal-to-noise ratio to confirm the presence of magnetism, but have found no evidence of any fine structure in the Hα profile, as can be seen in Figure 1. Instead, the Hα profile looks extremely shallow and broad, and resembles that of Ross 640, for which the shape of the line profile was attributed to a high helium abundance (Liebert 1977). Hence, it may be possible to explain the Hα profile of G141-2 with a helium-rich model as well. However, Liebert (1988) has also shown that this star is overluminous by 1.5 mag with respect to other field white dwarfs at the same color (see also the case of L870-2). This suggests instead that G141-2 is an unresolved double degenerate, and that the broad and shallow Hα profile is the result of a line-dilution effect by a DC star. We have undertaken a detailed analysis of this object, the results of which will be reported elsewhere.

The search for double degenerate binaries that are close enough to merge within a Hubble time is a complicated task (see Liebert et al. 1991 for a review). Most of these systems are likely to be unresolved binaries. Radial velocity analyses have revealed only two convincing cases of such unresolved systems (L870-2 by Saffer et al. 1988; WD 0957−666 by Bragaglia et al. 1990). Double degenerate DA+DC binaries are easily detectable from a combined analysis of their profiles and energy distributions. Such analyses have revealed at least four systems, and possibly five if G141-2 is confirmed (or perhaps even more if one includes other systems suspected by Greenstein & Liebert 1990). Bergeron et al. (1990) estimated that between 4% and 10% of the white dwarf population could be unresolved double degenerates with dissimilar spectral types. The true fraction, including DA+DA systems, could be even larger. The low-mass white dwarfs found among some of these binary systems indicate that they are the result of close binary evolution. It is impossible to tell at the moment whether the resulting components are close enough to evolve into novae or Type I supernovae in less than a Hubble time. All the DA+DC systems found so far are too faint to be analyzed with standard radial velocity techniques.

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