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THE IMPACT OF THE PRESSURE SHIFT OF HYDROGEN LINES ON "RELATIVISTIC" MASSES OF WHITE DWARFS

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ABSTRACT

Emergent profiles of the Balmer lines in white dwarf star spectra have been calculated taking into account the effect of the pressure shift (PS) in plasma. The line profiles given by our calculations are redshifted and are asymmetrical in both flux (F_λ) and residual flux (r_λ) scales. The pressure redshift inferred from the profiles increases with distance from the line center. In a broad central region where "observational line center" is defined, the pressure redshift becomes a substantial fraction of the gravitational one, especially at moderate surface gravities, log $g = 7$–8, and the effective temperatures $T_{ef} \lesssim 15{,}000$ K of the white dwarf stars. Our results probably completely explain the longstanding discrepancy between "relativistic" and "astrophysical" masses of white dwarfs.

We have used the best physically founded PS data for hydrogen lines. Their behaviors differ from those assumed by Shipman and Mehan, especially at low electron densities. We suggest that differences between assumed PS data explain the opposite conclusions obtained by those authors and by us.

Subject headings: line profiles — relativity — stars: atmospheres — stars: white dwarfs

I. INTRODUCTION

From the early seventies it has been well known that the hydrogen spectral lines in the conditions of dense plasmas are slightly redshifted and are asymmetrical. This pressure shift (PS) of hydrogen lines has been discovered in laboratory plasma by Wiese and his coworkers at the NBS (Wiese, Kellcher, and Paquette 1972). They also first suggested that the PS effect may contribute significantly to the observed redshift of hydrogen lines in white dwarf star spectra (Wiese and Kelleher 1971). Early theoretical papers which qualitatively predicted or explained this effect were published by Sholin (1969, quadrupole interactions with ions), and Grabowski and Halenka (1975, screening by electrons).

Shipman and Mehan (1976) have obtained practically zero pressure shift of Balmer Hα, Hβ, and Hγ lines, applying Wiese's PS data for calculations of emergent line profiles in several model atmospheres of white dwarfs. Consequently it was widely assumed that the PS effect of the hydrogen Balmer lines has no importance in the measurements of the gravitational redshifts in WDs (cf. also Schulz 1977). The redshifts observed in the hydrogen spectra of WDs are routinely identified with the gravitational (relativistic) redshifts and are considered as an indicator of WD masses ("relativistic" masses), independent of so-called "astrophysical" masses, which can be obtained by conventional methods (Trimble and Greenstein 1972). Wegner (1980) did not find any asymmetry of the Hα line in 40 Eri B, one of the best observed WDs, and considered this to be the observational evidence of the above viewpoint.

The PS effect on hydrogen lines is relatively small, indeed. Nevertheless, in light of the recent results (Grabowski, Halenka, and Madej 1985; Halenka and Musielok 1986), a careful evaluation of the PS effect in WD hydrogen spectra should be done again. In particular, we point out that the data measured by Wiese and his coworkers concern the wings but not the line centers where the redshift in WD spectra is measured. Moreover, the empirical relations best fitting Wiese's measurements formally predict blue pressure shift when one extrapolates these relations to a low electron density region. Shipman and Mehan (1976) assumed PS = 0 in this region, below $N_e = 7.35\text{E}+15$, $2.05\text{E}+16$, and $7.02\text{E}+15$ cm^{-3}, for Hα, Hβ, and Hγ respectively, thus avoiding the above extrapolation (which could be still more unfounded than setting PS to zero). Such N_e correspond to shallow layers of the WD atmospheres, where centers of strong Balmer lines are formed. Therefore, the nearly zero pressure shifts obtained by Shipman and Mehan for hydrogen lines in white dwarf stars are not surprising (for further details see Grabowski, Halenka, and Madej 1983).

It is remarkable that the "relativistic" masses of the white dwarf stars, which one obtains by reduction of the observed redshifts, are (on the average, with large scatter) significantly larger than the "astrophysical" ones: log $g = 8.25$ and 0.74 $M_\odot$ versus log $g = 8.00$ and 0.57 $M_\odot$ respectively (see detailed study by Greenstein 1985; see also Greenstein *et al.* 1977; Koester, Schulz, and Weidemann 1979, and references therein; Weidemann and Koester 1980, 1984; Shipman 1979; Shipman and Sass 1980). Various attempts to explain this discrepancy have been made in the past, e.g., by asymmetry-induced shifts due to slope of the continuum (Schulz 1977), but this problem still is not solved (see also the review by Weidemann 1979). In velocity units the systematic excess of the observed redshift amounts to 10–15 km s^{-1} (Shipman and Sass 1980; Shipman 1986) above "residual" redshift (i.e., redshift free of all kinematic effects).

In this context we have already reported preliminary quantitative results on strong impact—via reduction of the measured redshifts—of the pressure shift of Hβ and farther Balmer lines on the "relativistic" masses of DA white dwarfs (Grabowski, Halenka, and Madej 1983, 1985; Grabowski, Madej, and Halenka 1984). (The Hα line seems to behave unlike the other Balmer lines.) In the present paper we demonstrate this effect on the basis of representative sample of WD model atmospheres (§ IV), and using the most reliable (currently) data on the pressure shift of the centers of the Balmer line opacity profiles (§§ II–III).

Following a suggestion by Shipman (1986), we note that both cases where independent measurements of the two types of masses agree (the hot stars 40 Eri B and Sirius B) can be explained by the results of this paper, which predict decrease of PS with rising temperature.

II. REMARKS ON THE PRESSURE SHIFT OF BALMER LINE OPACITY PROFILES

Two spectroscopical circumstances press heavily on measurements of shifts of the Balmer lines in WDs: (1) Spectra of WDs are usually recorded at low dispersion (except rare image tube and image photon counting system observations; see Greenstein *et al.* 1977) due to intrinsic faintness of these stars, and (2) hydrogen lines in WD spectra are strongly broadened. Therefore, the cores of the Balmer lines are not well defined, and the observer does not use just the narrow central part of line profile to measure the wavelength of the line center, but measures wavelengths of symmetry points on various levels of the flux scale to obtain an average wavelength (and shifts) of the line. In measurements of the gravitational redshift from the low-dispersion spectra, the central 30–40 Å region of the line profile is used to define the line center (Trimble and Greenstein 1972; Shipman and Mehan 1976; Schulz 1977).

The laboratory moderate-density plasma measurements by Wiese, Kelleher, and Paquette (1972) hav been done in order to simulate this observational procedure and to determine whether pressure effects contribute significantly to the residual redshifts measured in WDs. That paper defines the so-called experimental line center (ELC) as the average wavelength of the points bisecting the $\frac{1}{2}$, $\frac{1}{4}$, and $\frac{1}{8}$ maximum intensity of the emission line, and the pressure shift (PS) is defined there as the difference between ELC and the unperturbed wavelength of the line.

It should be noted, however, that the laboratory measurements in the ELC convention have several important imperfections in the context of interpreting WD spectra: (1) The definition of ELC takes into account wavelengths outside the half-width of the emission line (inclusively), neglecting its central part, which is the most important region for redshift measurements in WD spectra. (2) A given laboratory PS value, measured in the ELC convention for, say, $(1/k)$th maximum intensity of the emission line from a homogeneous and optically thin plasma, increases considerably with k. Moreover, this shift of $(1/k)$th height has no direct relevance to a similar quantity measured in the stellar absorption line profile. The latter is formed in an optically thick semi-infinite stellar atmosphere and obviously contains contributions from all its layers, and pressure and electron concentrations can change by orders of magnitude between the top and bottom of the atmosphere. Strictly speaking, the above laboratory data can be useful in providing information only on the far wings of the local line absorption coefficient profile, and not on the emerging monochromatic line radiation.

The above-mentioned $(1/k)$ dependence of the Balmer line opacity as a function of N_e and T is still vague. Moreover, the monochromatic radiation at given distance $\Delta\lambda$ from the line center in successive atmospheric layers corresponds to different k-values (the shallower the layer, the greater the k-value). Due to these reasons, contributions of the relativistic and pressure shifts to the emergent WD line profile cannot be separated satisfactorily. Convolution of both shifts is more complicated, the more the wings come into consideration. In other words, in order to separate the actual relativistic redshift in WD spectra from the PS contribution, a grid of complete—redshifted and asymmetrical—absorption coefficients of the hydrogen lines (for various N_e and T) should be at our disposal, but this is still beyond the state of the art. In our opinion, such separation can at present be succesful only in the line-center region. (Right in the WD's line core, formed in most shallow and low-density atmospheric layers, almost nothing but relativistic redshift appears, of course.) One can approximately assume the symmetric line absorption coefficient which is pressure-shifted as a whole. Therefore we focus our attention on the central region of the line.

As is well known, in an optically thin medium the "odd" Balmer lines (Hα, Hγ, ..., with a strong central component) have a conventional line shape with a central maximum (peak), whereas the "even" lines (Hβ, Hδ, ..., without the central component) have a peculiar one, with a central minimum (dip) and two side shoulders, the separation of which depends on the electron density N_e.

The term "line center" in the case of even lines therefore demands more precise definition. In the optically thin case, the line center may be defined either (1) as the position of the minimum of the central dip, or (2) as the mean wavelength of the peaks of the side shoulders. These two definitions give only slightly different wavelengths for the line center, but strongly different (greater; see Halenka 1980; Grabowski, Halenka, and Madej 1985; Halenka and Musielok 1986) from those in the ELC convention. In the physical conditions of a WD's atmosphere, the difference between (1) and (2) may be significant only in the deep layers, contributing mainly to the wings of the absorption lines. The shallower a layer, the less distant the shoulders. In the surface layers of an atmosphere, where the core of the emergent line profile is formed, separation of the shoulders reduces to a value below the resolving power of the observations. Thus, both the above definitions of the centers of the even lines converge there definitely. Moreover, in the WD spectra thermal broadening of absorption profiles washes out the dips of Stark profiles of even Balmer lines.

In the following sections we consistently assume the most natural (in our opinion) understanding of the centers of pressure-broadened even lines—as position of the minimum of the central dip in the line profile.

III. DATA ON THE PRESSURE SHIFTS OF THE BALMER LINE OPACITY PROFILES

As far as we know, a representative sample of the measured pressure shifts of the hydrogen (emission) line center is currently available only for the Hβ line. These data are given in a paper by Halenka and Musielok (1986). In that paper it is shown that the measured PS values for the central dip of Hβ depend approximately as PS $\propto N_e/T$ (strictly: $N_e\,T^{-1.0\pm0.2}$).

It is also argued there that the PS of the Hβ line is produced mainly by the interactions of H atoms and free electrons in a plasma, and the contribution of ions is small. This is due to the lack of the central line component, in contrast to the neighboring odd Hα and Hγ lines, where the contribution of ions to the shift of the peak is large. The N_e/T-dependence of the pressure shift results from interactions between a sea of free electrons in a plasma and an H atom in the screening model approximation (e.g., Grabowski and Halenka 1975).

We attempted to take into account all effects relevant to the pressure shift of the hydrogen lines in a plasma. The calculations were performed in the framework of the formalism of Demura and Sholin (1975) for the quadrupole (H atom) and ion interactions, but we have taken into account also (1) the quadratic Stark effect, (2) the pressure ionization (both in ionic fields), and (3) the screening effects, following a simple Debye model for ions and hydrogen atoms. In the calculations of the pressure shift of the center of a line profile, we have consistently taken into account (1) the frequency shifts, (2) the oscillator strength alterations, and (3) the impact half-width alterations of each component of the line. Details of this formalism will be published elsewhere (Halenka 1987).

Figure 1 gives a comparison between our calculations of the dip-shifts of the Hβ line and the laboratory data measured by Halenka and Musielok (1986). The curves are labeled with the

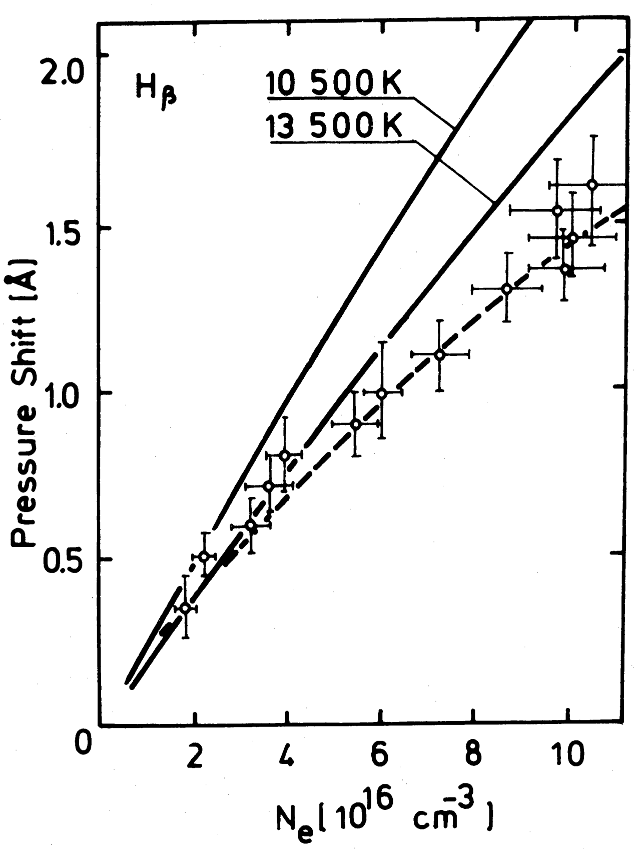

FIG. 1.—Calculated (*lines*) and measured (*pluses*) pressure shifts of the central dip of the Hβ line as a function of electron concentration N_e. All the measurements were performed at temperatures between the numbers marked on the solid curves; but the measured PSs correspond to temperatures increasing with N_e (due to experimental conditions). The dashed line exhibits the calculated shifts obtained taking into account the empirical correction factor (see text) and the temperature variations along the abcissa.

TABLE 1

THE BEST PRESSURE SHIFT FITTING

Balmer Line	a	b	c	Correcting Term
Hα	+1.37E−2	+1.37E−3	0.594	...
Hβ:				
$N_e < 4$	+1.15E−2	+1.55E−4	1.849	...
$N_e \geq 4$	−0.73E−2	+9.06E−4	1.849	$+d$
Hγ	−4.43E−2	−3.46E−3	1.661	$+e$

NOTES.—N_e in 10^{16} cm^{-3}; $d = (75 - 3T)$E-3; $e = (1.47T - 4.43)N_e^2$E−4.

temperature conditions for all the measurements. The calculations do not reproduce the measurements satisfactorily but predict the correct tendency with N_e and T. (Note that for the experimental points temperature increases with N_e, see Halenka and Musielok 1986).

In the case of the Hβ line, the calculations lead to the conclusion that only $\sim 10\%$ of the observed dip-shift is produced by ions; the overwhelming part is produced by free electrons. We conclude that the simple Debye model for H atoms, used for calculations, overestimates the electronic dip-shift by a factor of ~ 1.4, as compared with the measurements. Therefore in further calculations we use the formalism as quoted above, with the Debye potential for H atoms divided by that empirical factor,

$$-e^2[r^{-1} \exp(-r/D) + 1/D]/1.4 , \quad (1)$$

where D denotes the electronic Debye radius. Values of PS for the dip of the Hβ line calculated in this way are shown by a dashed line in Fig. 1. We can see excellent internal consistency between measurements (*pluses*) and theoretical calculations. We can report that the results of the above corrected PS calculations also agree with the few peak-shift measurements currently available for the Hα line (Halenka and Musielok 1986).

Calculated values of the resultant pressure shift of the centers of Balmer line opacity profiles (which include the empirical correction factor 1/1.4) may be satisfactorily approximated by the formula

$$\mathrm{PS} = (a + bT + c/T)N_e + \text{small correcting term} , \quad (2)$$

where $c \gg |a, b|$, PS is in angstroms, T in 1000 K, and N_e in units of 1E16 cm^{-3}. The numbers a, b, and c, given in Table 1, ensure the best fit to the grid of calculated PS values (a minus sign corresponds to the blueshift).

IV. LINE PROFILE CALCULATIONS

Preliminary computations of the Balmer line profiles in the presence of the PS effects have been published already in our earlier papers (Grabowski, Halenka, and Madej 1983, 1985; Grabowski, Madej, and Halenka 1984). These computations were based on a grid of model atmospheres of white dwarf stars obtained with the computer program ATM74 (see Madej 1980). On the basis of the above results we concluded that the calculated pressure shifts of the Balmer lines in white dwarf stars are practically independent of the assumed chemical composition of a model atmosphere. Consequently, in order to review the pressure shift effects in white dwarf stars we need to consider the grid of model atmospheres parameterized by T_{ef} and log g only. For the purpose of this investigation we choose solar-composition model atmospheres published by Wickramasinghe (1972), with $7 \leq \log g \leq 9$ and $10{,}000 \leq T_{ef} \leq 25{,}000$ K. We expect that our results discussed below are representative for DA-type WDs and also for models of peculiar chemical composition, at least tentatively.

The Balmer line profiles (in LTE) which are discussed here were computed with the computer code LINE (see Madej 1983), modified to account for PS effects, as described in § III. This program solves the radiative transfer equation inside a line under the assumption that the contribution of the line itself to the local emission coefficient is purely thermal (but overlapping continuum emission contains both thermal and scattering agents). The Balmer line absorption coefficient is carefully computed there as a convolution of the thermal, radiative, and pressure broadening profiles, the last taken from Edmonds, Schluter, and Wells (1967).

Our line profile calculations were performed ensuring that the emergent profiles, expressed in the residual flux scale r_λ, are symmetrical when the input PS is set to zero. This was done in order to separate the real pressure shift of the absorption line from the so-called "trivial" asymmetry-induced shift (Griem 1964) and from the systematic effect caused by the sloping continuum. If the pressure shift PS $\neq 0$, then the line profile r_λ becomes asymmetrical relative to the unperturbed wavelength λ_0 of the line.

It is interesting to discuss the run of those input data, the PS, as a function of some standard (monochromatic) optical depth τ in WD model atmospheres. This can give qualitative predictions of what kind of asymmetry one should expect in the core and in the inner and middle parts of the Balmer line profiles in the spectra of WD stars. Figure 2 exhibits the run of PS versus log N_e and log τ (where τ corresponds to λ = 5000 Å) for the Hα, Hβ, and Hγ lines, in the exemplary case of a pure hydrogen model atmosphere with T_{ef} = 16,000 K and log g = 8.0, computed with the ATM74 program. We see that in the case of the Hβ line the pressure shift (PS) of its absorption coefficient profile is a positive and monotonically increasing function of τ, whereas the run of PS corresponding to the neighboring odd lines (Hα and Hγ) is more complicated; and at some τ PS can assume negative values. The latter case can happen in those layers of the model atmosphere where the blueshift due to the quadrupolar effect dominates the sum of the redshifts produced by all other mechanisms. Therefore, in the case of the Hβ line one can expect a strong pressure redshift, which increases monotonically with $\Delta\lambda$, whereas in the cases of the Hα and Hγ lines the final effect is rather complicated, depending on parameters of the WD atmosphere. Obviously, the line center should not be seriously influenced by the pressure shift.

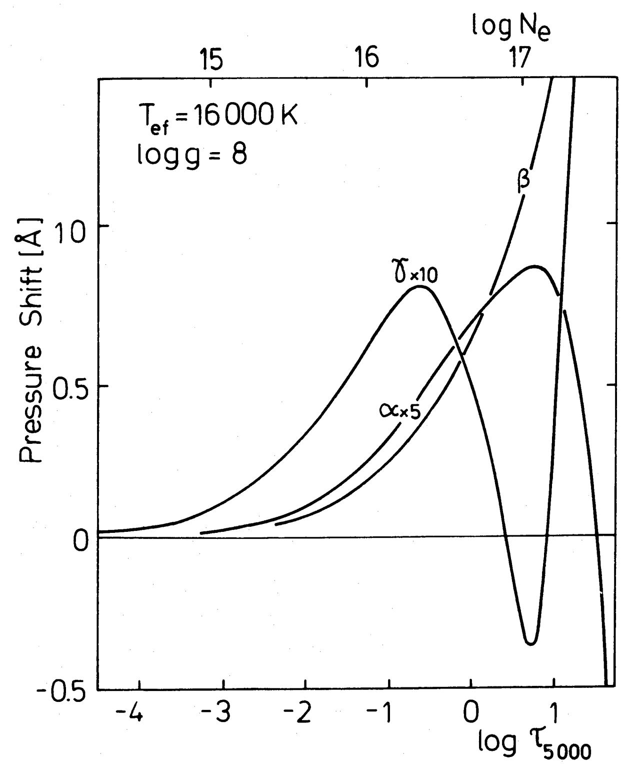

FIG. 2.—Pressure shift of the central parts of Hα, Hβ, and Hγ line absorption profiles versus optical depth (*lower scale*) and electron concentration (*upper scale*) in the WD atmosphere with parameters given at the top.

Figure 3 gives as an example the emergent profile of the Hβ line computed in the same model atmosphere, as discussed above. Each horizontal line in Figure 3 is labeled with a real number giving the ratio of the pressure redshift to the gravitational redshift, where the pressure redshift was determined at a given level of r_λ, and the latter was set to 28 km s^{-1}, according to the Hamada-Salpeter (1961) mass-radius relation for degenerate carbon configurations at log g = 8.0 (see Shipman and Mehan 1976). The depth $r_{1/2}$ corresponding to the half-width of the line profile is marked here by the arrow. In this (fairly representative) case we see that the pressure shift yields a redshift approaching 40% of the gravitational shift, if measured at the edges of the inner part of the Hβ line profile.

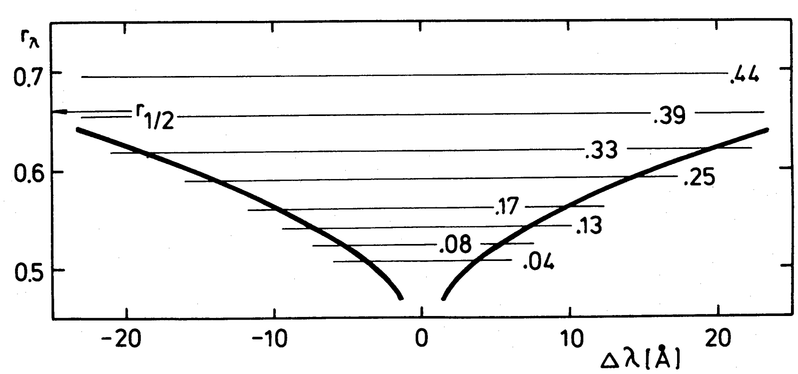

FIG. 3.—Emergent profile of the Hβ line computed in the same WD model atmosphere as in Fig. 2. Real numbers on the horizontal lines give ratio of the pressure and gravitational redshifts.

V. RESULTS AND CONCLUSIONS

Our purpose is to estimate the contribution of the PS effect alone to the redshift observed in WD hydrogen line spectra, as a function of the atmospheric parameters T_{ef} and log g and the distance $\Delta\lambda$ from the line center. In our calculations we have eliminated a masking, asymmetry-induced redshift (due to dependence of the source function on λ) appearing in the flux F_λ scale, in which the shift measurements are made routinely. This last effect can be taken into account independently.

Pressure shifts of the hydrogen line profiles calculated in WD atmospheres were derived from the residual flux (r_λ) profiles in the same way as that applied by an observer. We followed the calculation scheme of Shipman and Mehan (1976) to obtain the shifts expressed in velocity units. We found that the pressure redshift increases with the distance $\Delta\lambda$ from the line center (except of the Hγ line in models of $T_{ef} \gtrsim 20{,}000$ K).

The theoretical model for the PS calculations used in this paper predicts the following regularities: The pressure shift is more pronounced in the case of even Balmer lines, and its importance increases with the order number of the even or odd lines as well. Griem's calculations (Griem 1983) likewise give the increasing shift; however, they do not distinguish between odd and even lines. In our WD line profile calculations the Hα line turned out incontrovertibly to be slightly sensitive to the pressure shift, irrespective of the PS data used (see Fig. 4). Therefore, this line should be recommended to observers as a reliable one for gravitational redshift measurements in WD spectra.

As compared with Griem's (1983) data, we give priority to the conclusions based on our PS data as being already partly checked in the laboratory with respect to N_e and T variations. This checking concerns the Hα and Hβ lines. Our PS data for the Hγ line are more uncertain. We note also that far from the Hβ line center we obtain only an upper limit of the pressure shift expected in a WD atmosphere (because our PS data apply strictly to the central dip, which is more sensitive to the PS effect than other points in the central and middle parts of the Hβ line profile).

Figure 4 shows representative behavior of the first WD Balmer lines. Solid lines represent the pressure shifts resulting from our PS data; the dashed lines and primed Greek letters, those from Griem's. (Recall that the former results are reliable in the central line region; the latter are related to ELC and have coherent meaning only far from the line center.) The pressure redshifts for the Hβ line are given at two effective temperatures: 16,000 K and 25,000 K (β_{16} and β_{25} respectively); for other lines, only at the lower value of T_{ef}. All the results refer to the surface gravity log $g = 8.0$. The temperature dependences exhibited in Figure 4 for the Hβ line are typical also for the other lines being examined.

The calculations were carried out using the PS data described in § III. Figures 5–7 exhibit pressure shifts of the first Balmer lines at various values of the distance $\Delta\lambda$ from the line center (numbers at the curves), versus the effective temperature of a WD atmosphere, all of them with log $g = 8.0$. In Figure 5 only, the dotted curve refers to log $g = 9.0$. In this case we intended to demonstrate that the pressure shift of the Hα line is small—practically beyond the present level of observational precision—even in relatively far wings and at large surface gravities. The behavior of the Hγ line is particularly interesting. Figure 7 shows that at $T_{ef} \approx 20{,}000$ K the profile of the Hγ line is hardly influenced by the pressure shift. At still higher temperatures the pressure shift becomes negative, and at the same time the farther the wings, the larger the blueshift.

Figures 8–10 give a recapitulating review of the behavior of the pressure shift as a function of assumed surface gravity, in model atmospheres of $T_{ef} = 20{,}000$ K and 10,000 K. We see that the pressure redshift is most significant, as compared with gravitational redshift, in white dwarf stars with moderate surface gravities (log g = 7–8). The contribution of the pressure redshift to the total observed redshift is especially important in cool white dwarfs. Particularly, in this case the observed excess of the gravitational redshift, as mentioned in § I, can be explained fully by the PS effect. The dashed lines in Figures 8–10 exhibit a pressure shift appearing in the middle wings of the Hβ and Hγ lines, when Griem's PS data are used in the calculations.

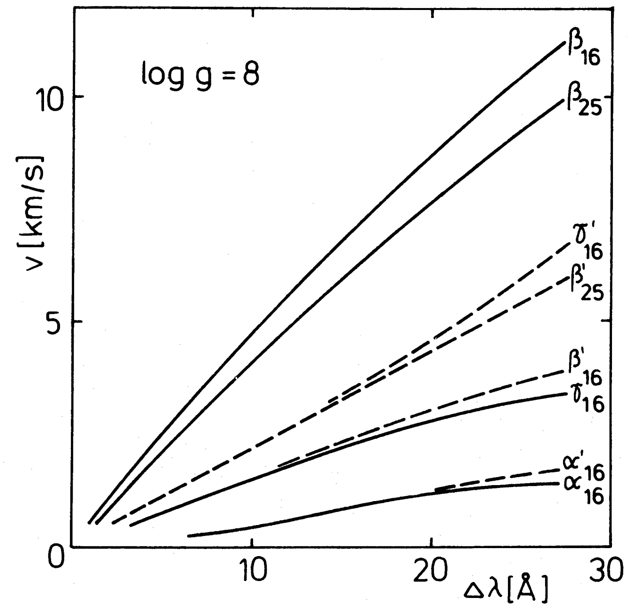

FIG. 4.—Behavior of the pressure shift (in velocity units) as a function of distance from the line center, given for the Hα, Hβ, and Hγ lines in a few representative models. The label β_{16} (e.g.) means Hβ line, T_{ef} = 16,000 K. *Solid lines*, our PS calculations; *dashed lines*, Griem's. Note that our calculations predict decreasing PS with T, whereas Griem's data imply increasing PS. The Hα line is nearly insensitive to PS effect.

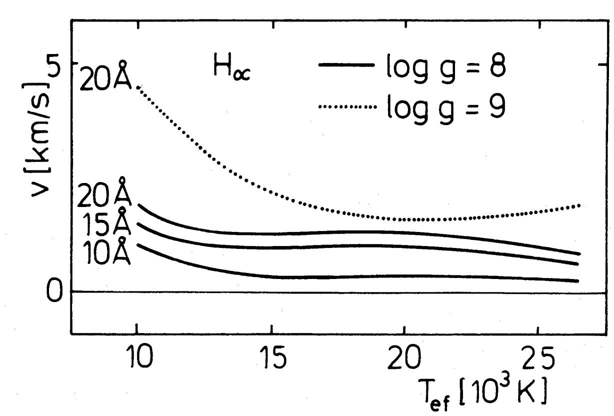

FIG. 5.—Pressure shift of the Hα line as a function of WD effective temperature, computed at some $\Delta\lambda$.

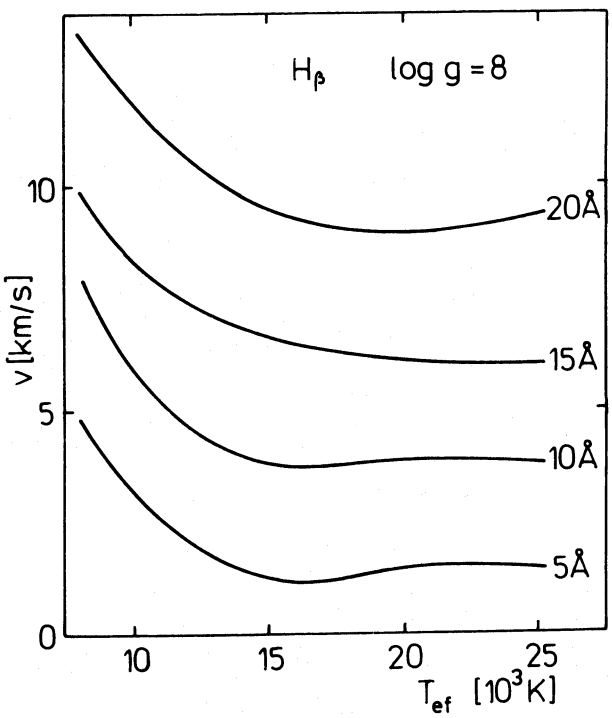

FIG. 6.—Same as Fig. 5, for the Hβ line

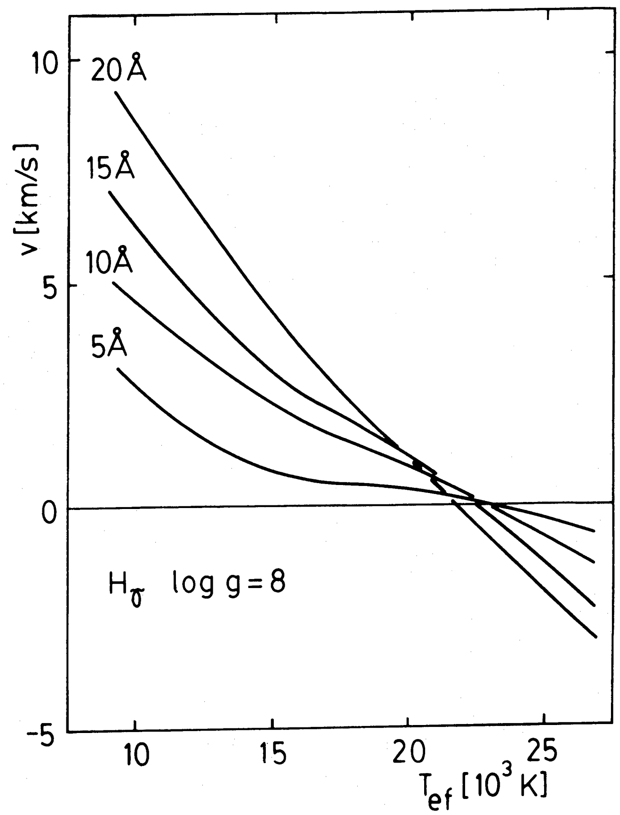

FIG. 7.—Same as Fig. 5, for the Hγ line

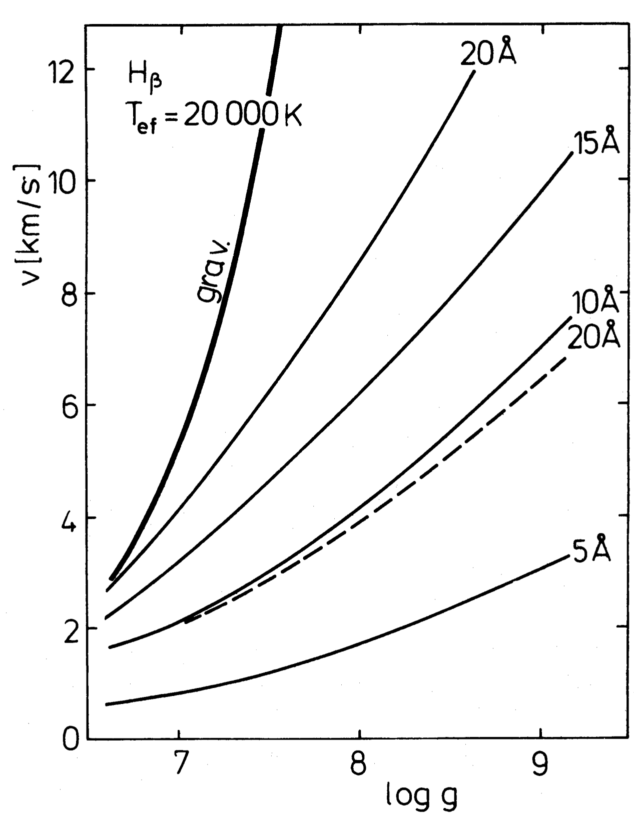

FIG. 8

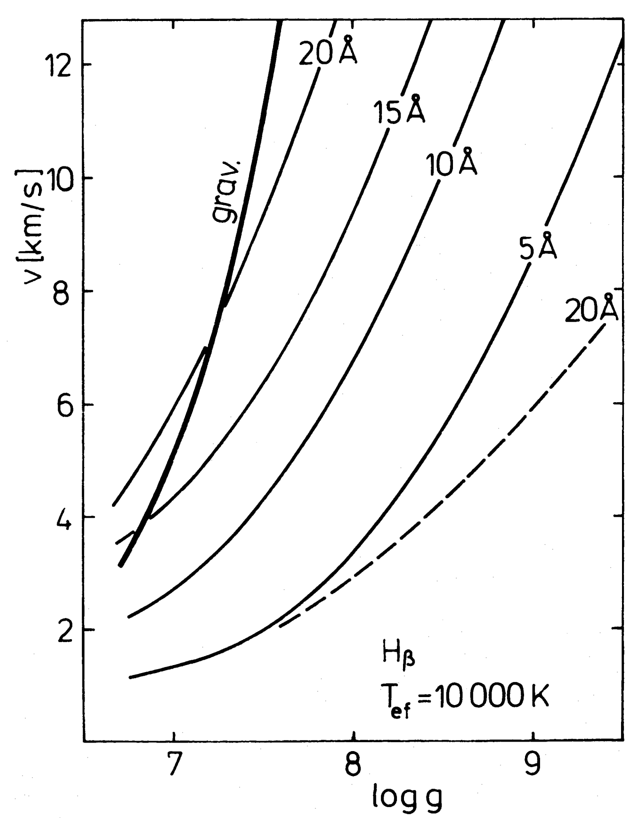

FIG. 9

FIG. 8.—Pressure shift of the Hβ line at selected values of $\Delta\lambda$ as a function of the surface gravity at T_{ef} = 20,000 K. *Dashed line*, Griem's result.
FIG. 9.—Same as Fig. 8, at T_{ef} = 10,000 K

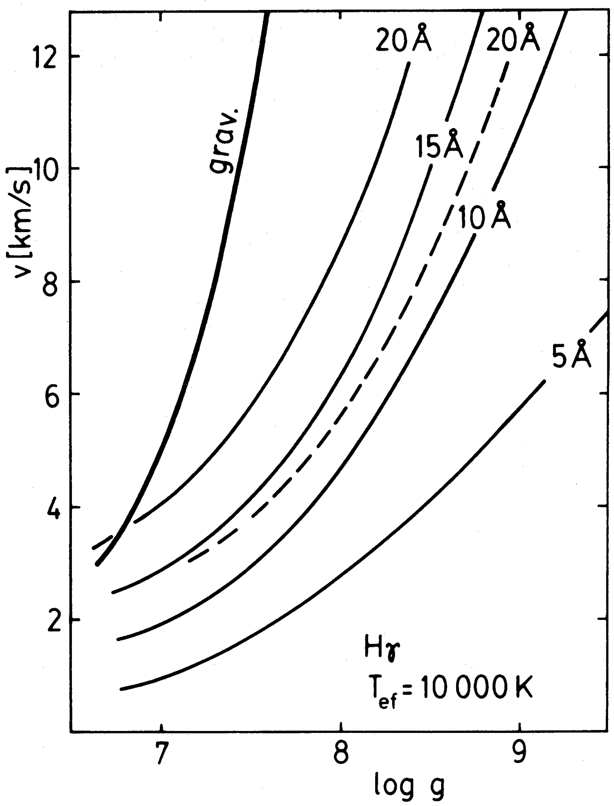

FIG. 10.—Same as Fig. 8, for Hγ line at T_{ef} = 10,000 K

Theoretical predictions regarding the Hγ line are important, since the basic measurements of Balmer line shifts in WD spectra by Trimble and Greenstein (1972) were performed mostly for this line. Our results suggest that the Hγ line is not sensitive to the PS effect at high T_{ef} ($T_{ef} \gtrsim$ 20,000 K; see Fig. 7). Therefore we do not expect discrepancies between the "relativistic" and "astrophysical" masses of hot WD stars (40 Eri B and Sirius B, for example), if the shift of the Hγ line is measured. On the other hand, the predicted pressure shift of this line increases with decreasing T_{ef}. Following Shipman (1986) we note that the excess of the observed redshifts in WD spectra above "residual" redshifts amounts to 13 km s^{-1} in cooler stars (see also Table 3 of Shipman and Sass 1980), and that the larger excesses reported in earlier papers should be attributed to observational errors. The values of PS of the Hγ line predicted in this paper are of the same order of magnitude at lower T_{ef} and can at least partially (or completely) explain this discrepancy (cf. also Fig. 10).

This paper gives a semi-quantitative solution of the problem formulated by Greenstein and Trimble (1967) long ago in their pioneer work in the context of Weidemann's suggestion of a possible strong sensitivity of the Hγ line to the pressure shifts in WD atmospheres: "This possibility needs detailed computations of the core and wings, and a study of what is really measured, what weight is given to the core and to the inner parts of the wings."

We describe here the expected behavior of the pressure shift in the first Balmer lines in WD spectra, as well as possible given current knowledge in this field. We expect that the PS data described in § III will be helpful in interpreting actual observational data. A complete investigation of the pressure shift effects in the Balmer lines, directly applicable to reduction of the measured redshift in WD spectra, will be a program for the future.

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