Final Technical Report

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Observations of the Ultraviolet Spectra of Helium (DB) White Dwarfs and A Study of the Ultraviolet Spectra of White Dwarfs Containing Carbon

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Abstract

Strong ultraviolet carbon lines have been detected in the spectrum of the southern DC white dwarf BPM 11668. Observations of a number of hotter DB white dwarfs with IUE do not show any evidence for carbon features. Two additional DA white dwarfs have been observed that have the strong unidentified absorption near λ1400 which now seems to be identified with another lower temperature feature as satellite lines to Ly α .

I. Introduction

Observations of the white dwarfs summarized in Table I were obtained with the International Ultraviolet Explorer (IUE) through support from NASA grant NAG5-287. Some of the results have been presented at the "Third Delaware Workshop on White Dwarf Stars," held June 9-10, 1983 in Montreal (Wegner 1983a, b). In addition papers have been published describing a strong carbonline white dwarf and DA stars (Wegner 1983c, 1984a, b, two more presented at the 164th American Astronomical meeting in Baltimore (Wegner and Nelan 1984; Nelan and Wegner 1984a) for which final versions are in preparation or preprint.

II. Observational Results

Although throughout most of the observing sessions, the DB white dwarfs were primarily concentrated on, one relatively faint southern DC white dwarf BPM 11668 was observed which shows the strong ultraviolet lines of neutral carbon (Wegner 1983c). The somewhat noisy spectrum of this faint object is shown in Fig. 1.

After the discovery of an unidentified absorption near λ1400 in the DA white dwarf LB3303 (Wegner 1982), two additional objects were observed. As shown in Fig. 2, the cooler, G231-40 definitely shows this feature, while the hotter GD140 does not. At the time of writing this report, several other objects have been studied. This subject will be pursued further in the forthcoming year of IUE operation.

Recent model atmosphere calculations made by E.P. Nelan at Dartmouth have included the 1400 Å and 1600 Å satellite lines of Ly α in DA model atmospheres. As Figure 3 shows, this gives quite good fits to the data. At present, we are evaluating the temperature and gravity dependance of these spectral features which promise to be highly sensitive indicators for the DA stars (Nelan and Wegner 1984b).

An additional object, GD323 has been observed in colaboration with other researchers (Liebert et al. 1983; Wesemael et al. 1983). Both IUE and ground based data have been combined and a spectrum synthesis carried out. Visual spectra of this unusual object showed He I and weak H I, and the IUE spectra revealed Lyα. Using the relative strengths of these lines, their profiles, at present

the best explanation for the star seems to be that it has a He-rich atmosphere with a layer of hydrogen floating on top.

The results for the DB stars are displayed in Fig. 4. This compares the SWP spectra of these objects with the well known cooler He-rich star LDS 678B which has strong ultraviolet carbon lines. It should be noted that all the DB stars show none of the carbon lines. This data is being analyzed in collaboration with graduate student E.P. Nelan and it has been found that carbon abundances are of order C:He $\leq 10^{-6}$ (Wegner and Nelan 1984), which appears to confirm the downturn in carbon abundance predicted by theories that the carbon is brought to the surface by dredging (Fontaine et al. 1984).

References

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Nelan, E.P. and Wegner, G. 1984a, "Ultraviolet Features in the Spectra of Cool DA White Dwarfs," Bull. A.A.S., 16, 510.

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Wegner, G. 1983b, "IUE Observations of DB Stars," paper presented June 10, 1983 at the 3rd Delaware Workshop on White Dwarfs, Montreal.

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Wegner, G. 1984a "The Absorption Near 1400 Å in the Spectra of Additional DA White Dwarfs," A.J., 89, 1050.

Wegner, G. 1984b "The Discontinuity Near 1600 Å in the Spectra of DA White Dwarfs," Ap. J. (Letters), 284 in press.

Wegner, G. and Nelan, E.P. 1984, "Ultraviolet and Visual Spectroscopy of DB White Dwarfs," Bull. A. A. S., 16, 510.

Wesemael, F., Liebert, J., Sion, E.M., and Wegner, G. 1983, "The Peculiar DAB White Dwarf GD323,: paper presented at the 162nd Meeting A.A.S., June 19-22, 1983, Minneapolis, Minn.

Table I

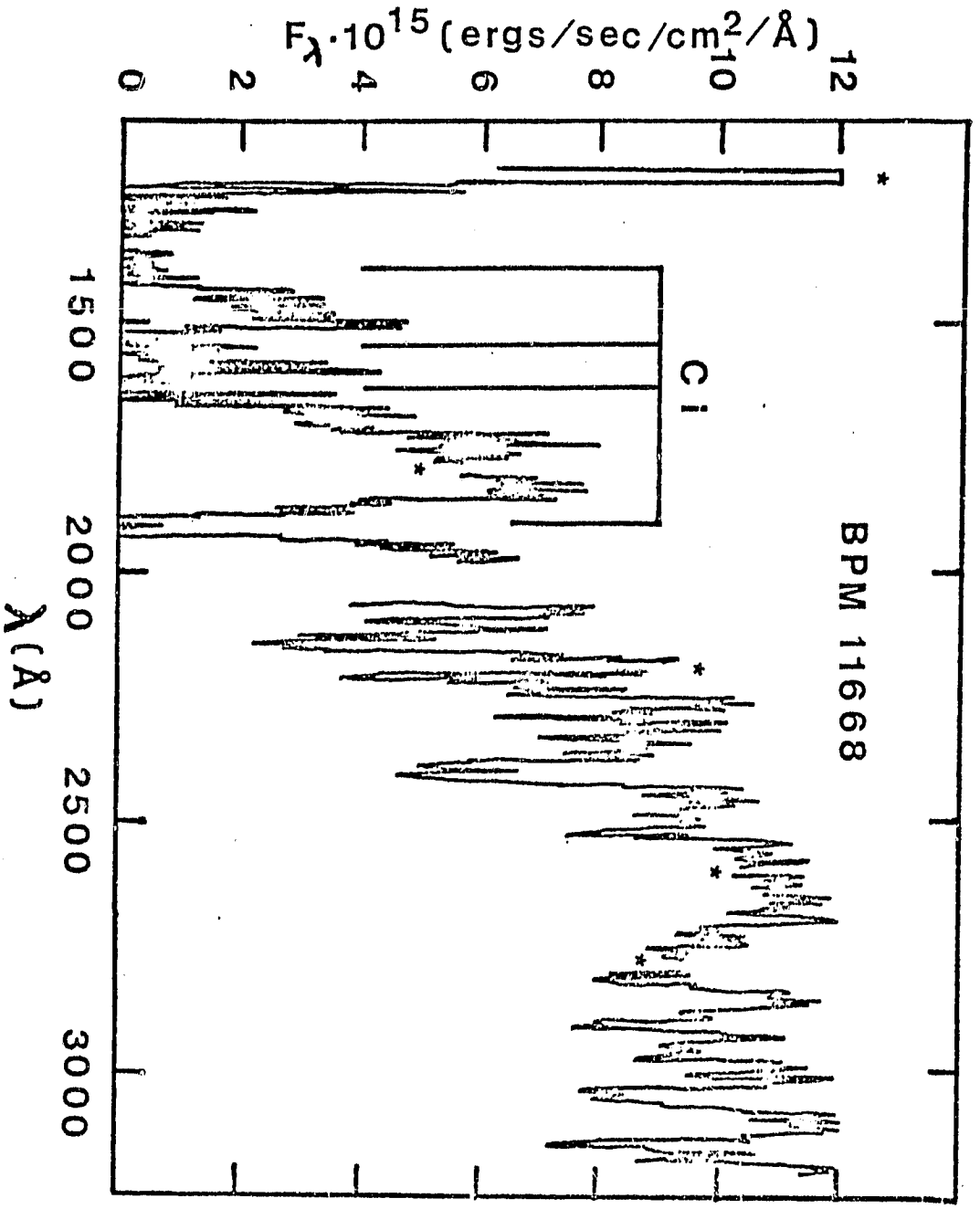
Objects Observed with IUE under the Auspices of Grant NAG5-287.

White Dwarf/ Coordinates	Date of IUE Observation	Image No.	Remarks or Spectral Type
GD303	Jan. 13, 1983	SWP 18994	DB
GD303	Jan. 13, 1983	LWR 15047	DB
G195-19	Jan. 13, 1983	LWR 15048	magnetic
PG1411+21	Jan. 13, 1983	SWP 18995	DB
PG1411+21	Jan. 13, 1983	LWR 15049	DB
GD140	Jan. 13, 1983	SWP 18996	DA
LTT11	Jan. 15, 1983	SWP 19005	DB
LTT11	Jan. 15, 1983	LWR 15057	DB
GD408	Jan. 15, 1983	SWR 19006	DB
GD408	Jan. 15, 1983	LWR 15058	DB
BPM11668	Mar. 24, 1983	SWP 19531	Strong CI
BPM11668	Mar. 24, 1983	LWR 15569	DC
G231-40	Mar. 24, 1983	LWR 19532	λ1400
G231-40	Mar. 24, 1983	LWR 15570	DA
G231-40	Mar. 24, 1983	SWP 19533	DA
GD140	Mar. 24, 1983	LWR 15572	DA
PG1346+08	Mar. 24, 1983	SWP 19534	DB pec
PG1346+08	Mar. 24, 1983	LWR 15571	DB pec
PG1346+08	Mar. 24, 1983	SWP 19535	DB pec
PG1346+08	Mar. 24, 1983	SWP 19536	DB pec
G256-18	Mar. 25, 1983	LWR 15577	DB
G256-18	Mar. 25, 1983	SWP 19540	DB

Table 1 (continued)

GD378	Mar. 25, 1983	LWR 15578	DB
GD 378	Mar. 25, 1983	SWP 19549	DB
PG1445+15	Mar. 26, 1983	LWR 15584	DB
PG1445+15	Mar. 26, 1983	SWP 19548	DB
T0N10	Mar. 27, 1983	SWP 19559	DB
T0N10	Mar. 27, 1983	LWR 15592	DB

Figure 1: The ultraviolet portion of the spectrum of the DC white dwarf BPM 11668. Both the long- and short-wavelength IUE spectra have been combined. Asterisks denote positions of known defects in the data, e.g. a defective pixel and reseau marks, that have been suppressed. The influence of the strong geocoronal Lyα line near λ1215 can be seen and the positions of strong carbon features are marked.



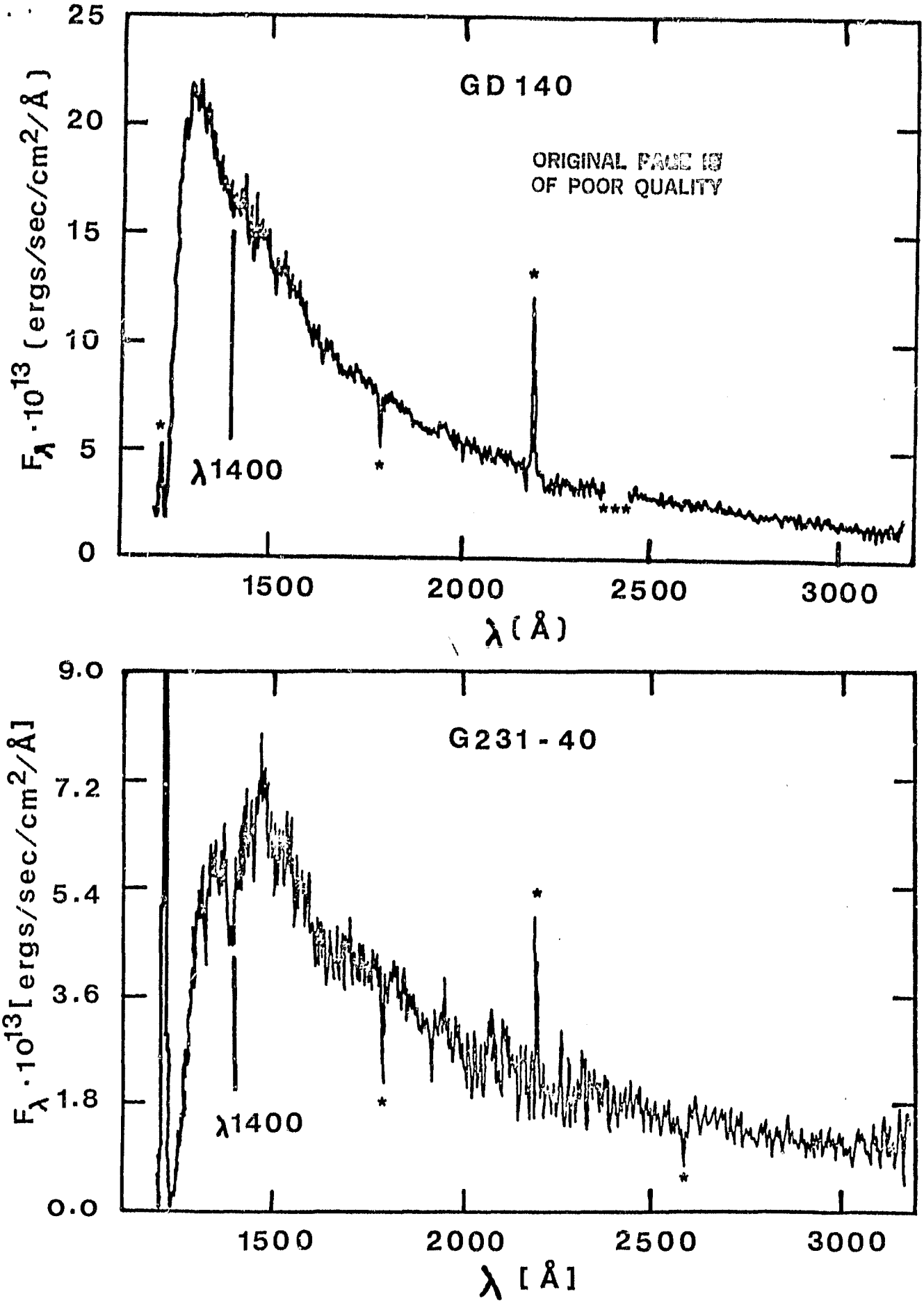


Fig. 2 - Ultraviolet spectra of two DA white dwarfs. The λ1400 can be seen in the cooler (G231-40) star, while it is very weak or absent in the hotter (GD140).

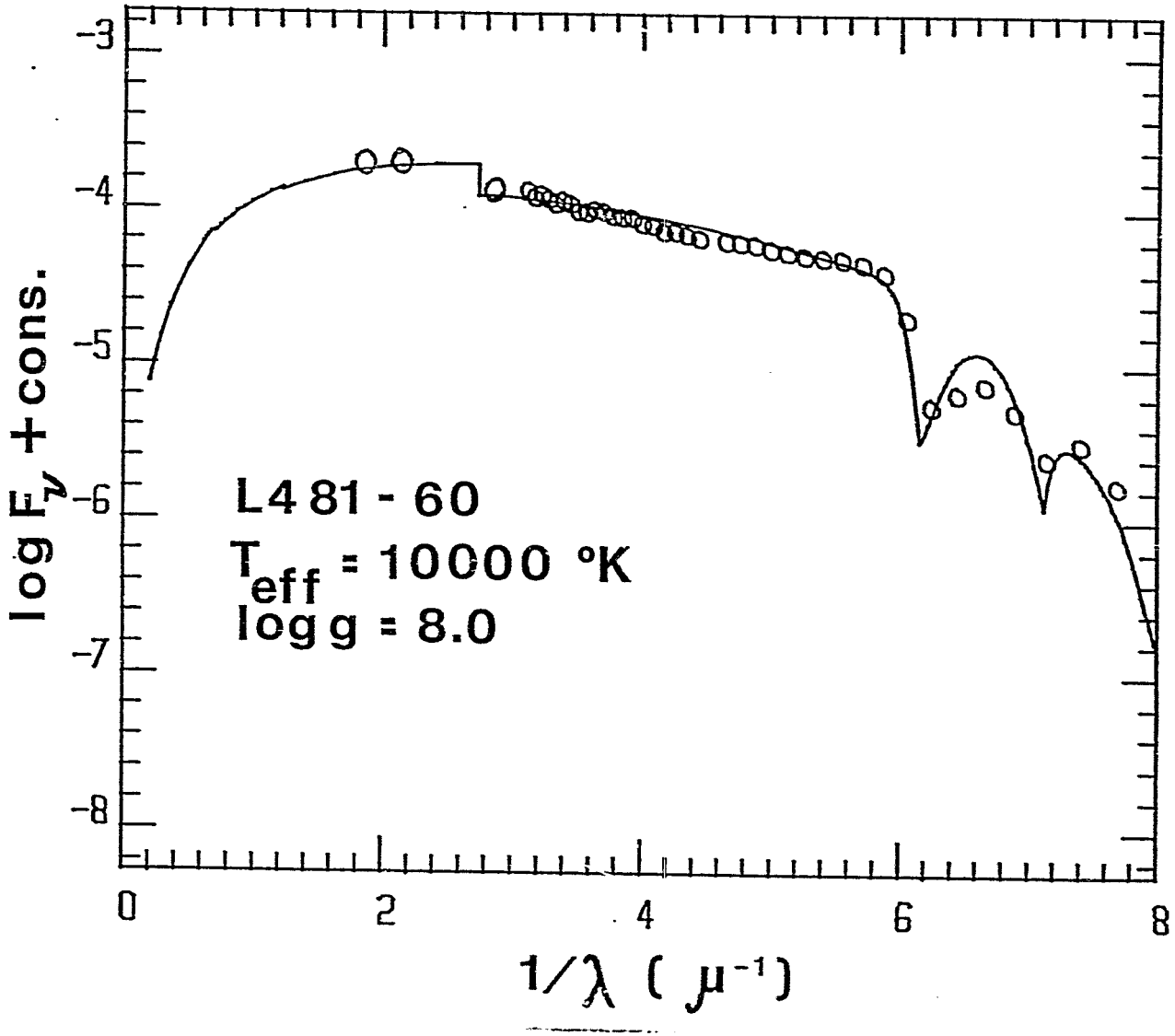
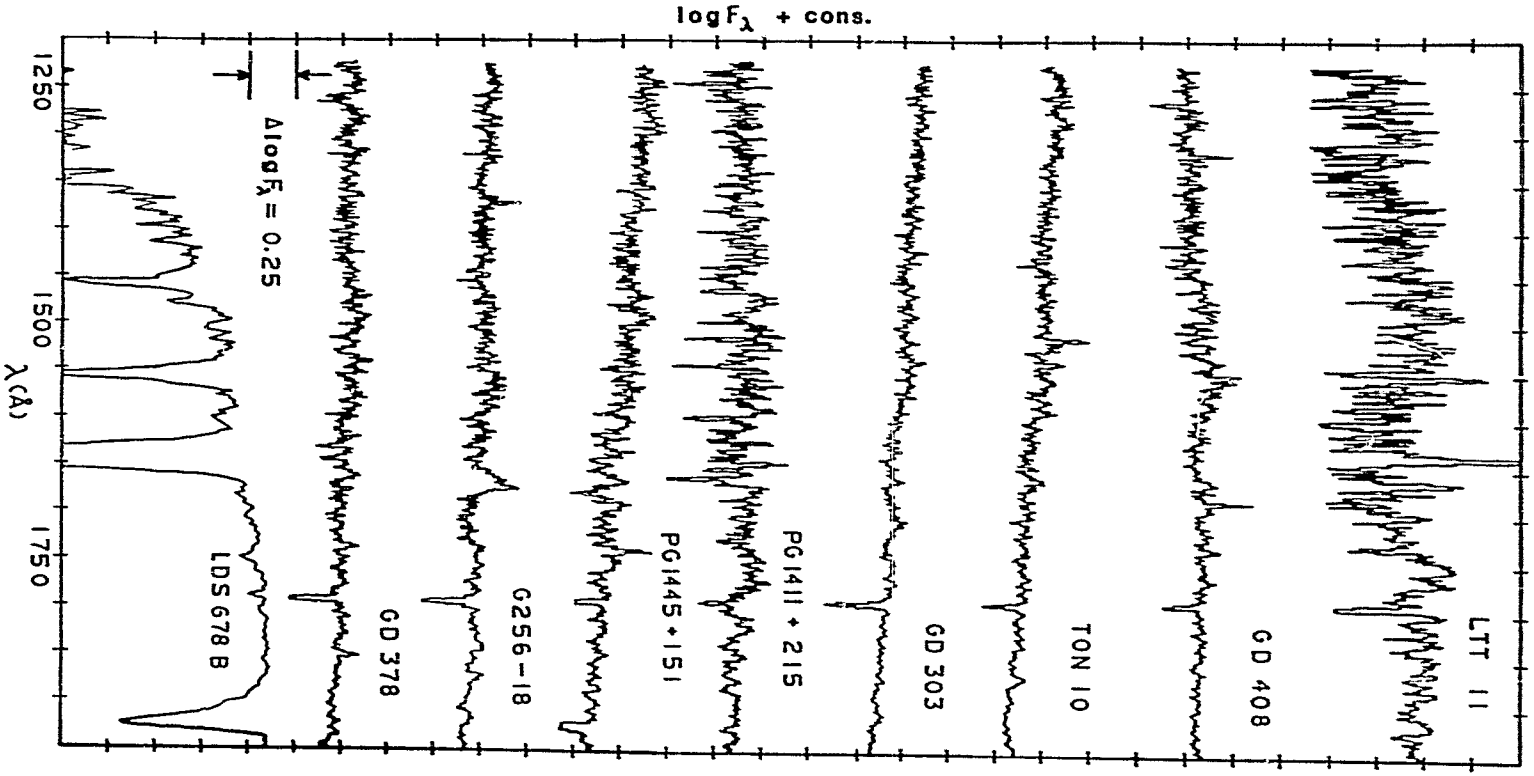


FIG. 3. Comparsion between the computed spectral energy distribution (solid line) for a log(g) = 8.0 pure hydrogen model with T_{eff} = 10000 K and the observed energy distribution of the white dwarf L481-60 (WD1544-37) reported in Wegner (1984b) (open circles).

Fig. 4 - The SWP spectra of DB white dwarfs taken for this project with IUE. The bottom most registration is of the slightly cooler DC white dwarf LDS 678B which shows strong neutral carbon lines.



APPENDIX

Recent Preprint and Reprint based on IUE data.