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A Study of the Ultraviolet Absorptions
in the Spectra of DA White Dwarfs

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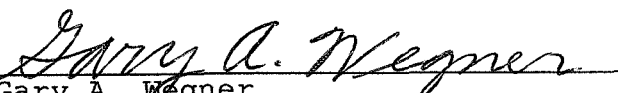
Ultraviolet Spectra of the Star HR6560

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ABSTRACT

During the last semi-annual period, the research work connected with Grant NAG5-287 from the National Aeronautics and Space Administration has been to carry out two projects in conjunction with the *International Ultraviolet Explorer Satellite*. These are: (1) to study the properties of the H_2 and H_2^+ quasi-molecular absorption features at $\lambda\lambda 1600$ and 1400 in the ultraviolet spectra of the hydrogen-rich DA white dwarfs and to search for additional spectroscopic features in the spectra of these stars, and (2) use the ultraviolet portion of the spectrum of the peculiar rare earth-rich late F type star, HR6560 (HD159870), to establish whether or not the element abundance anomalies are produced in conjunction with its having a white dwarf binary companion. The data show that HR6560 is probably not associated with any hot subluminous or degenerate star.

INTRODUCTION

The purpose of the DA white dwarf research being reported here has been to complete systematic observations of the ultraviolet spectra of the hydrogen-rich DA white dwarfs with the *International Ultraviolet Explorer (IUE)*. This was originally proposed as a follow up on the work reported in Nelan and Wegner (1985) that the strong lines found near $\lambda\lambda 1600$ and 1400 in the spectra of the cooler examples of the DA white dwarfs are absorptions produced by the H_2 and H_2^+ quasi-molecules. The observations of additional DA white dwarfs progressed well and were completed during the period covered by this report and the new observations obtained with the *IUE* under the auspices of NASA Grant NAG5-287 are summarized in Table I.

Observations of the ultraviolet spectrum of the peculiar star HR6560 (HD159870) were also completed. These along with measurements of the comparison star, HD141004 are summarized in Table 2. The optical spectra of HR6560, studied in collaboration with C. R. Cowley who had obtained ground based spectra of the object, showed that this star was of late spectral type, about F8, but has a spectrum rich in rare earth lines, similar to the Ap stars. One then asks the question as to whether the abundance anomalies are due to intrinsic stellar phenomena or arise from material from an evolved star being dumped onto the outer layers of HR6560 as in some objects, e.g. the barium stars.

II. OBSERVATIONAL RESULTS

The *IUE* ultraviolet spectra of the DA white dwarfs have continued to reveal the presence of the $\lambda\lambda 1600$ and 1400 absorptions in the cooler examples of this class of stars. Some of the newer spectra are shown in Figure 1 where the spectra of the stars are arranged approximately in order of effective temperature according to $(B-V)$. There it can be seen that the ultraviolet absorptions are fairly ubiquitous in the spectra of the DA white dwarfs and that there is a marked temperature dependence.

At present, progress is being made towards systematically modelling all of the DA spectra obtained for this project collaboratively with Dr. E. P. Nelan of the Computer Sciences Corporation at the Space Telescope Science Institute. Earlier work on model atmospheres and the subsequent fitting of the spectra of a few objects has been described in previous reports and in Nelan and Wegner (1985). Briefly, this work makes use of a computer code specifically developed by Nelan to study white dwarf atmospheres and employs the absorption coefficients derived by Sando & Wormhoudt (1973) and Stewart, Peek, and Cooper (1973) to model the ultraviolet quasi-molecular features near $\lambda\lambda 1600$ and 1400 . This work should be completed during the upcoming year of 1987. One of the primary questions to be answered is whether or not the ultraviolet absorptions define a simple sequence that only depends on the temperature of the star.

The ultraviolet portion of the continuum spectral energy distribution of HR6560 is shown in Figure 2. This is based on the

recently obtained low resolution LWP and SWP images. It is possible to compare this with the images of the G0 star HD141004 used for comparison and with other stars of spectral type in the range F0 to G0, published in the *IUE Ultraviolet Spectral Atlas* by Wu et al. (1983). The overlap in the LWP and SWP spectra are not particularly good for HR6560, but from this, it can be seen that the energy distribution of HR6560 matches well with objects of spectral class near F8. This is somewhat hotter than the spectral type of F8 determined by Cowley (1976) and Cowley & Bidelman (1979), but certainly within the range admissible as the spectrum of the object is complicated by the presence of rare earth lines and has led to somewhat different possible hypotheses about their formation. With the present data, it appears that HR6560 is not a composite object with a hot subluminous companion. The absence of this companion will have important implications on the origin of its peculiar metallic line spectrum. With the presently available information, a cause intrinsic to the star itself seems a more likely explanation.

III. CONCLUSIONS

During the last half of 1986, work has continued to be conducted on white dwarf stars. The basic results of these investigations can be summarized briefly as follows:

- 1) Observations have been completed on the cool DA white dwarfs and they all show the presence of the $\lambda\lambda 1400$ and 1600 absorptions.

2) The ultraviolet spectrum of the peculiar late F type metallic line star HR6560 do not show any evidence for the presence of a hot subluminoous companion.

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Table I

DA White Dwarfs Observed with IUE under the auspices of Grant
NAG5-287

(October 1, 1985 - April 30, 1986)

White Dwarf or name	Date of IUE Observation	Image No.	Spectral Type
BPM6082	Nov. 22, 1985	SWP27161	DA
BPM6082	Nov. 22, 1985	LWP7171	DA
G210-36	Nov. 22, 1985	SWP27162	DA
G210-36	Nov. 22, 1985	LWP7172	DA
LP550-5	Nov. 23, 1985	SWP27163	DA
G116-52	Nov. 23, 1985	LWP7176	DA
G116-52	Nov. 23, 1985	SWP27167	DA
LP550-5	Nov. 23, 1986	LWP7177	DA
LTT7987	Apr. 16, 1986	LWP8041	DA
LTT7987	Apr. 16, 1986	SWP28181	DA
G185-32	Apr. 16, 1986	LWP8042	DA
LHS2333	Apr. 16, 1986	LWP8043	DA
LHS2333	Apr. 16, 1986	SWP28182	DA
L970-30	Apr. 17, 1986	SWP28184	DA
L970-30	Apr. 17, 1986	LWP8046	DA
G148-7	Apr. 17, 1986	SWP28185	DA
LHS3254	Apr. 17, 1986	LWP8047	DA

Table II

IUE Observations Obtained of HR6560 and Associated Objects for
Grant NAG5-287

(October 1, 1985 - April 30, 1986)

<u>Star</u>	<u>Date of IUE Observation</u>	<u>Image No.</u>	<u>Spectral Type</u>	<u>Res. Model</u>
HD159870	Nov. 23, 1985	LWP7173	F8	Low
HD159870	Nov. 23, 1985	SWP27164	F8	Low
HD159870	Nov. 23, 1985	LWP7174	F8	High
HD159870	Nov. 23, 1985	SWP27165	F8	Low
HD141004	April 17, 1985	SWP28187	G0	Low
HD141004	April 17, 1985	LWP8049	G0	Low

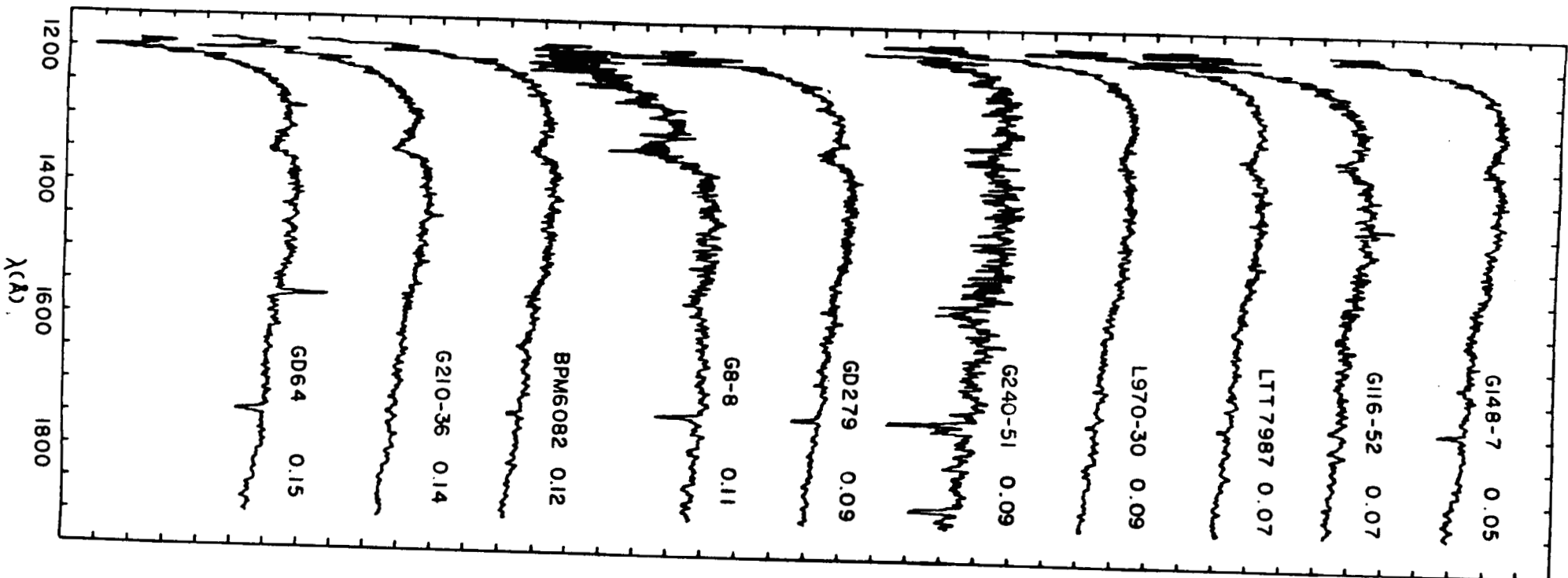


FIGURE 1 - Examples of the SWP spectra of several recently observed DA white dwarfs. The number to the right of the star's name is the published (B-V) color index.

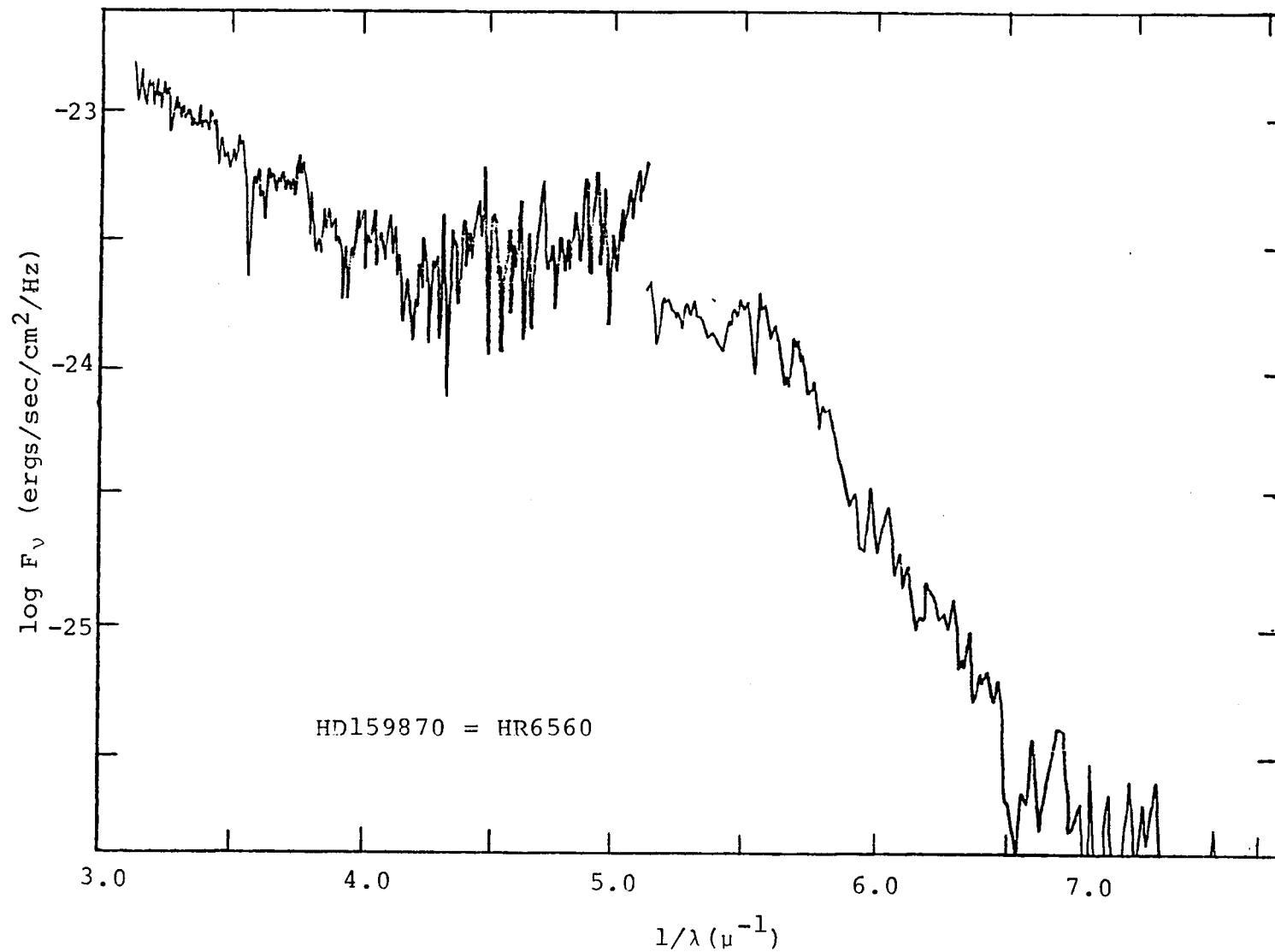


FIGURE 2 - The combined LWP and SWP Spectra of the peculiar star HD159870