UV spectrum of λ Boo

M. Gerbaldi

CNRS, Institut d' Astrophysique, 98bis Bd. Arago, 75014 Paris France

R. K. Gulati

IUCAA, Post Bag 4, Ganeshkhind, Pune 411007, India

R. Faraggiana

Dipartimento di Astronomia, Via Tiepolo 11, 34131 Trieste Italy

R. L. Kurucz

Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA

Abstract. By using stellar computed atmospheric models with ATLAS9 and ATLAS12 codes, we compare fluxes in the ultra-violet domain with the one observed in low dispersion mode of the IUE satellite for the star λ Boo . We derive the chemical abundance of zinc and chromium from high dispersion IUE data by applying spectrum synthesis technique.

1. Introduction

The λ Boo stars are A-type stars characterized by a deficiency of most elements with respect to the solar composition while carbon, nitrogen and oxygen have approximately the solar abundance. In the recent past, the interest in these objects has been increased since the pattern of their abundances reflect their evolutionary stage and not the structure of their atmosphere as for the other Ap stars. No theoretical models fit well the anomalous abundance behavior of these stars (Charbonneau, 1993). Detailed abundance analyses have been performed by Venn and Lambert (1990) and by Stürenburg (1993); these analyses are based on high resolution optical data and spectrum synthesis technique. In the ultraviolet domain, Baschek and Slettebak (1988) have done a study based on IUE spectra by using a differential analysis technique. As an application of Kurucz (1995) recent models based on ATLAS9 and ATLAS12 codes, we determine the abundances of zinc and chromium for λ Boo by comparing the IUE spectra to the computed ones. The selected wavelength domains for this study are : 202–203 *nm* and 205.3–207.0 *nm*. These elements have been chosen for the comparison of the Zn abundance with that of the ISM where this element is not depleted (Roth and Blades, 1995); both the resonance lines of ZnII being blended with Cr lines, the abundance of Cr is computed as well.

2. Input Data

IUE spectra available from the archives are used as an input for the current study. Of the several images for the λ Boo star , we selected well exposed images in the region of our interest. IUE/RDAF package was used to calibrate the images: low dispersion spectra were calibrated in wavelength and absolute fluxes, while the high dispersion calibrated spectra were normalized following the IUE/RDAF interactive normalization procedure.

3. Analysis

3.1. Model Parameters

Model atmospheric parameters for the λ Boo star were adopted from Venn and Lambert (1990).

- T_{eff} (K) 8650
- log g (cm/sec^2) 4.0
- Overall Abundance [M/H] ....−2.0
- ξ (km/s) 2.0

The model atmospheres was generated with the above parameters by using Kurucz ATLAS9 code. (**Model 1**)

High resolution observations in the optical domain show that carbon, nitrogen and oxygen are not as underabundant as other elements. As an experiment, we changed the abundances as given in Venn and Lambert (1990) and with C, N, O abundances equal to [-0.37], [0.06] and [-0.45] respectively and generated a new model with ATLAS9 code. (**Model 2**)

In principle, the model based on ATLAS12 code which takes into account the depth dependence of abundances should better represent the observed spectrum. We also generated the ATLAS12 model with the above parameters. (**Model 3**)

In Figure ??, we show the comparison among model fluxes in the wavelength region $\lambda\lambda$ 120–200 nm based on the above three models. The effect of changes in abundances of C, N and O in Model 2 and Model 3 is reflected in the wavelength region 130-150 nm, where the flux is depressed compared to the Model 1. However, the fluxes derived from Model 2 and Model 3 are not significantly different from each other.

3.2. Spectrum Synthesis

The resolution of computed fluxes available on Kurucz CDROM13 is not sufficient for a comparison with the IUE low dispersion spectra, so we computed the synthetic absolute fluxes with Model 2 and Model 3 with the following parameters in SPECTRUM SYNTHESIS:

- Resolving power 500,000

Figure 1. Flux distribution for three models

Figure 2. Flux distribution based on Model 2 plotted with the one observed at low resolution mode for λ Boo

- v *sini* .... 110 *km/s*
- Line List .... Kurucz CDROM18
- Instrumental resolution 300

Figure ?? and Figure ?? show the comparison between the observed and synthetic absolute fluxes for the Model 1 and Model 2 respectively. Since no noticeable differences were found in the fluxes predicted by Model 2 and Model 3, hence in the following analysis we used Model 2.

Spectrum synthesis parameters for abundance analysis:

- Input Model .... Model 2
- Resolving power 500,000
- Wavelength range (Fig. 4) .... 202–203 *nm*
- Wavelength range (Fig. 5) .... 205–207 *nm*
- v *sini* .... 110 *km/s*

Figure 3. Same as in Figure 2, but based on Model 3

Figure 4. The Zn II 202.5483 nm region of λ boo (thick line) plotted with the synthetic spectrum (thin line) based on Model 2

- Line List .... Kurucz CDROM18
- Instrumental resolution 10,500

In Figure ?? and Figure fig-5, we show the comparison of the observed spectrum with the one generated with Model 2. After fixing the abundance of other elements to those obtained by Venn and Lambert (1990), we modified the abundances of Zn and Cr until we get a good match between the observed and theoretical profiles in the region of Zn lines. Abundances of Zn and Cr thus derived from matching the line profiles are [-0.50] and [-1.00] respectively. The Zn abundance does not contradict the mechanism of gas, but not dust accretion proposed by Waters et al. (1992).

4. Conclusions

- Model fluxes based on ATLAS9 code mimic the behavior of the one based on ATLAS 12 in the wavelength region $135 - 180nm$.

Figure 5. Same as in Figure 4, but for the Zn II 206.2004 nm region

- In general both these models reproduce the observed flux behavior except for the absence of H-satellite depressions around $\lambda 140$ nm and $\lambda 160$ nm, but, even if we take these into account, some discrepancy still remains around $\lambda 145$ nm between the observed and computed fluxes.
- Abundances of Zn is lower than the solar one, but within the limits of ISM.

References

Baschek B., & Slettebak A. 1988, A&A, 207, 112

Charbonneau P. 1993, ApJ, 405, 720

Gerbaldi M.,& Faraggiana R. 1993 , in Peculiar Versus Normal Phenomena in A-Type and Related Stars, M.M. Dworetsky, F. Castelli, & R. Faraggiana, ASP Conference Series, 44, 368

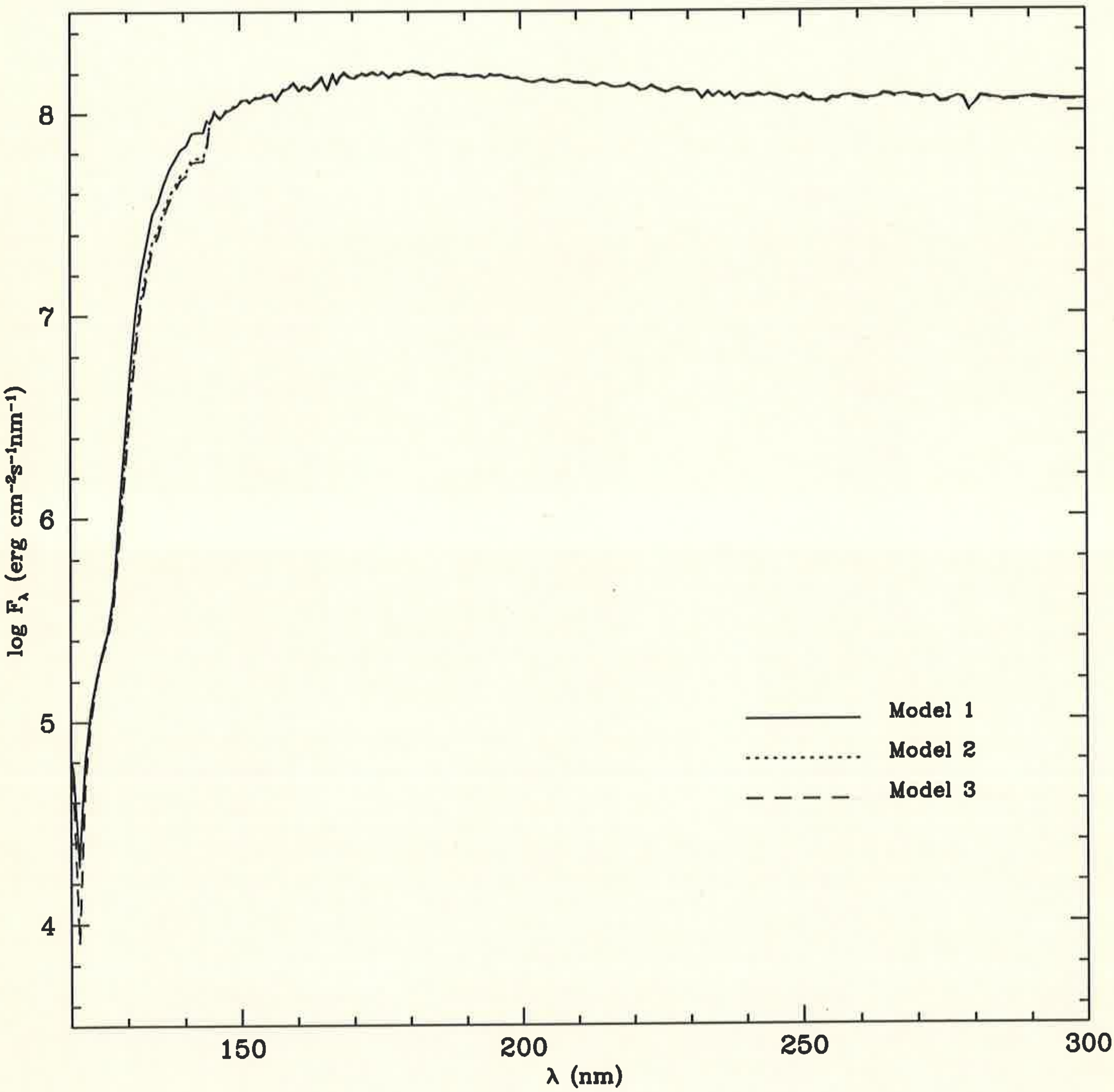
Roth K. C., & Blades J. C. 1995, ApJ, 445, L95

Stürenburg S. 1993, A.A., 277, 139

Venn K. A., Lambert D. L. 1990, ApJ, 363, 234

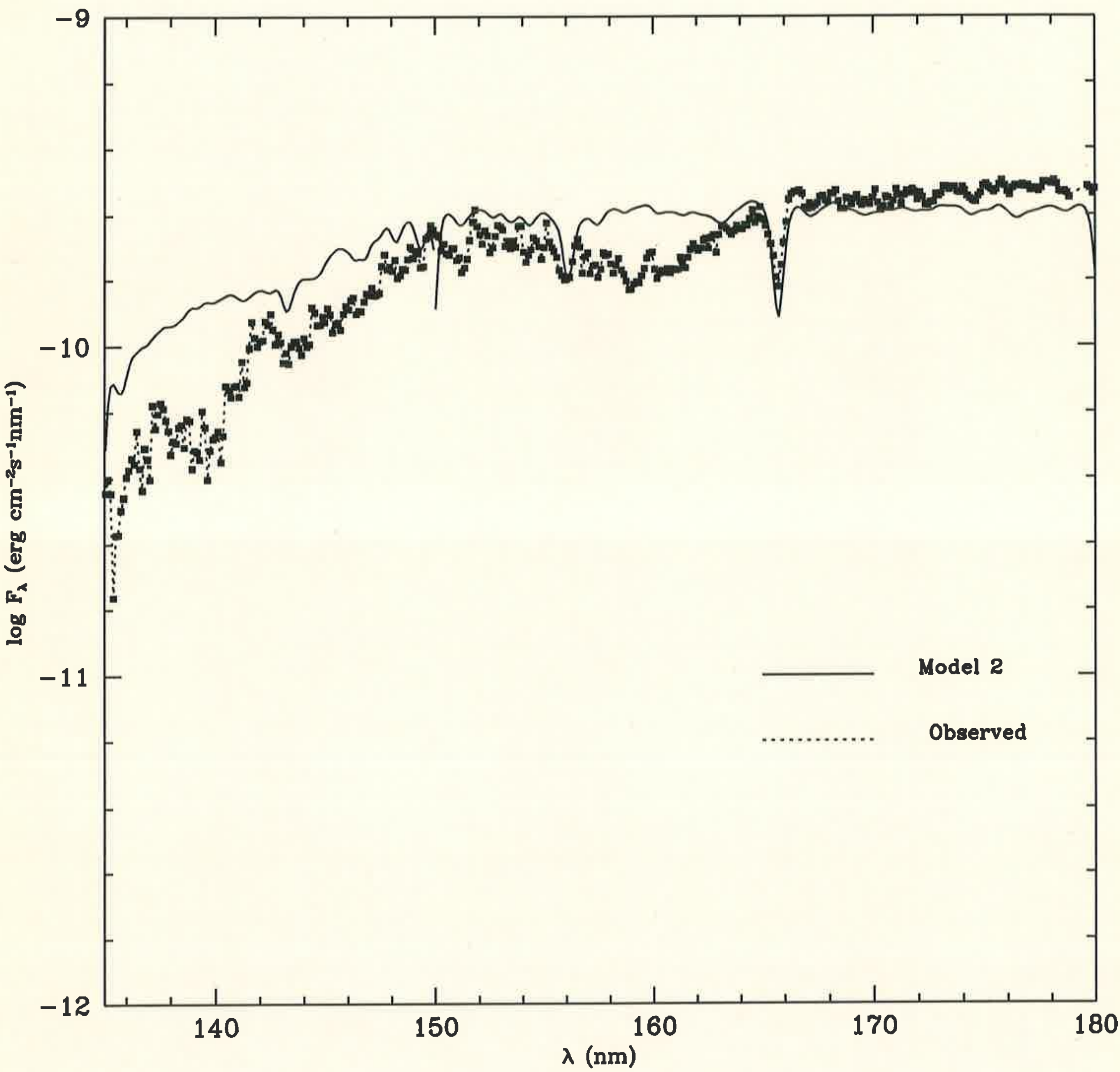
Waters L. B. F. M., Trams N. R., Waelkens C. 1992, A&A, 262, L37

FIGURE 1



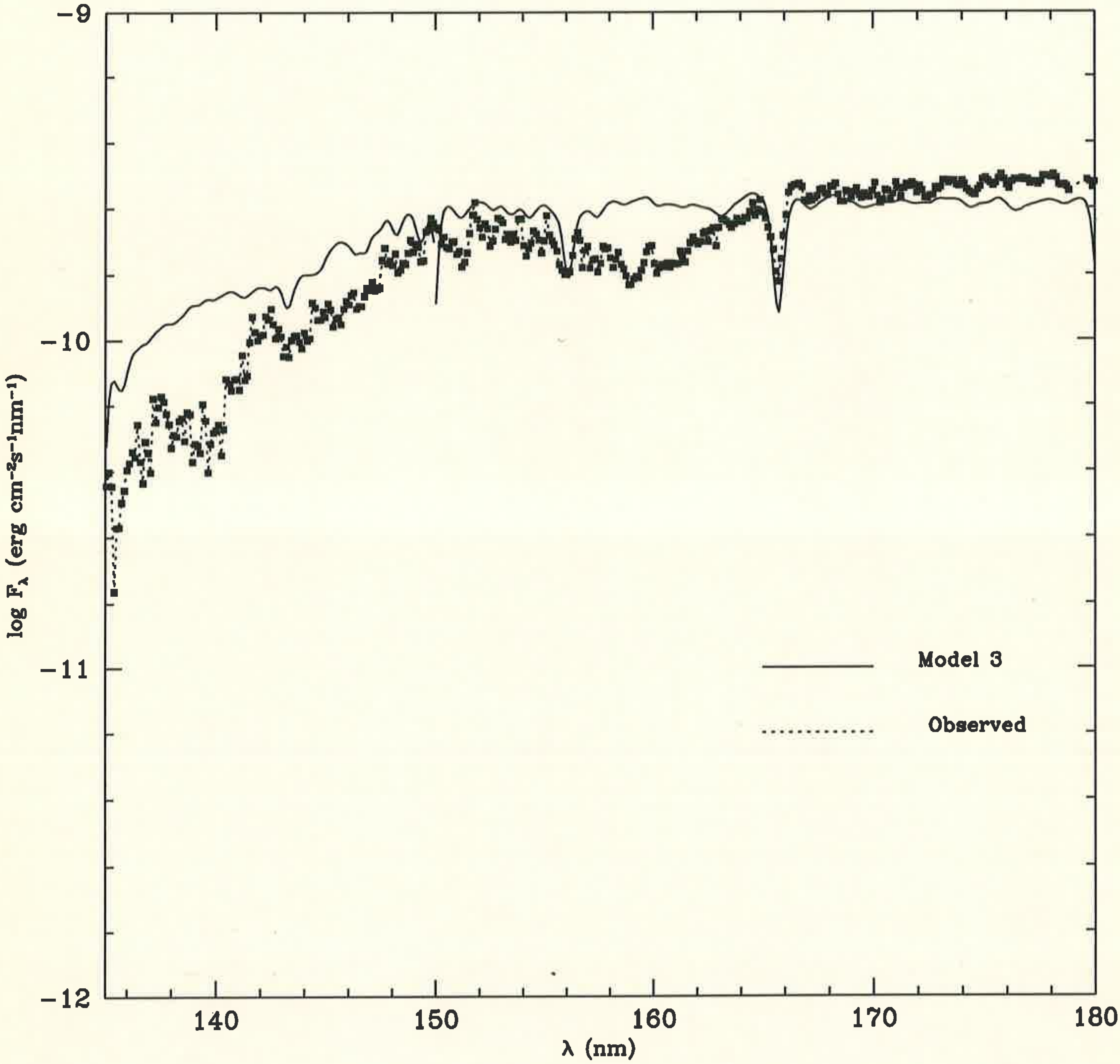
8
7
6
5
4
log F$_\lambda$ (erg cm^{-2}s^{-1}nm^{-1})
150
200
250
300
λ (nm)
Model 1
Model 2
Model 3

FIGURE 2



-9
-10
-11
-12
140
150
160
170
180
λ (nm)
log F_λ (erg cm^-2 s^-1 nm^-1)
Model 2
Observed

FIGURE 3



-9
-10
-11
-12
log F_λ (erg cm^-2 s^-1 nm^-1)
140
150
160
170
180
λ (nm)
Model 3
Observed

202.3

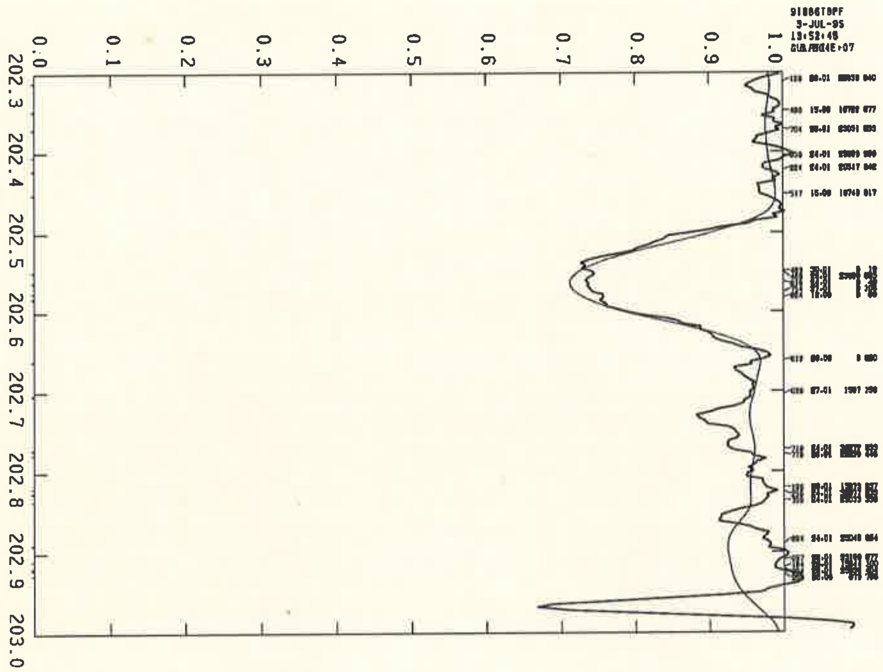


FIGURE-4

TEST RUN OF SYNTHE PROGRAMS

LAMBDA BOO MODEL (CNO VL)

2 KM/S ROTATION VELOCITY
1.5 KM/S MACROTURBULENT VELOCITY
21000 INSTRUMENTAL RESOLUTION

202.3

205.3

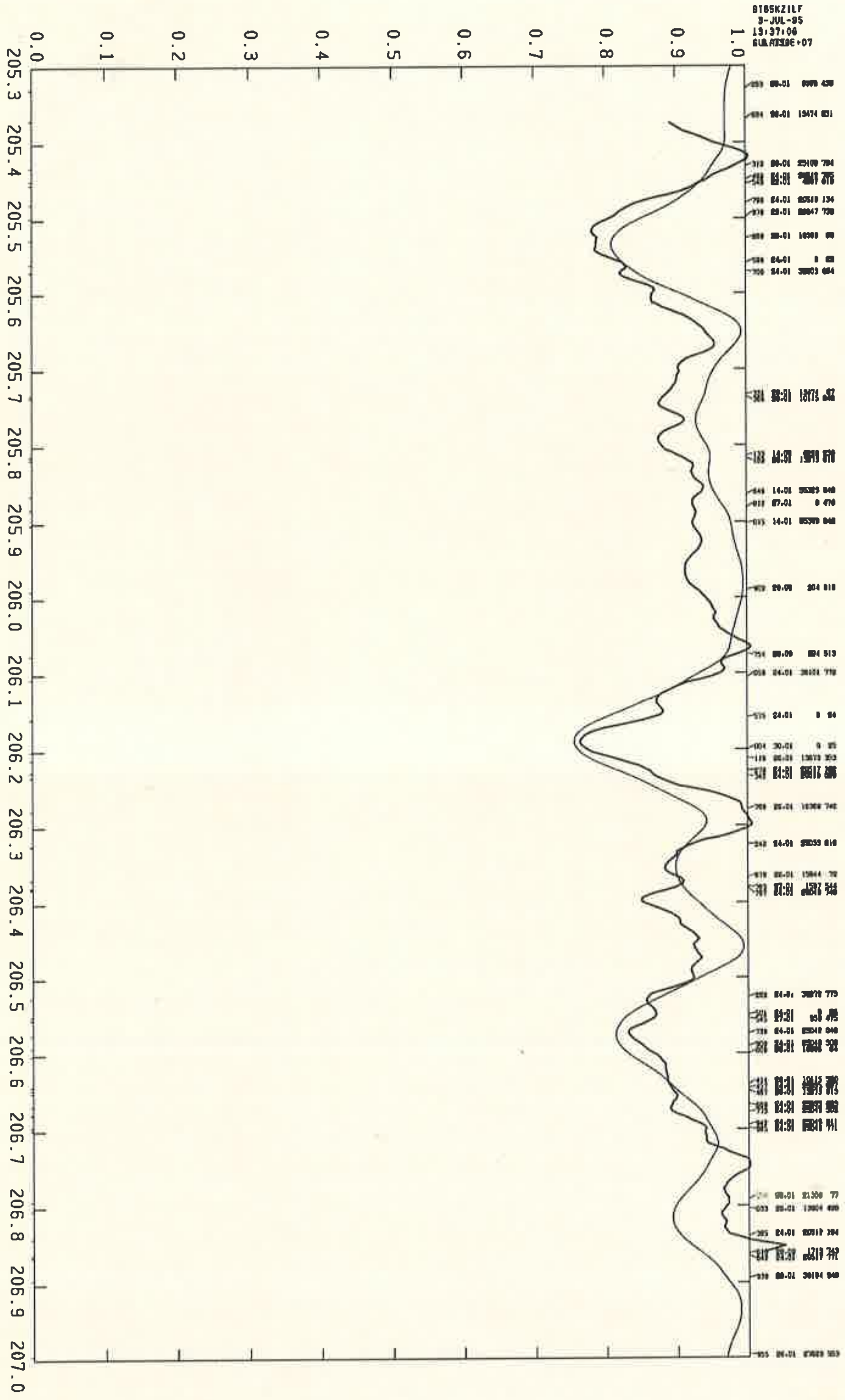


FIGURE 5

TEST RUN OF SYNTHE PROGRAMS

LAMBDA BOO MODEL (CNO VL)

2 KM/S ROTATION VELOCITY
1.5 KM/S MACROTURBULENT VELOCITY
21000 INSTRUMENTAL RESOLUTION

205.3