A preliminary analysis of the F3 III star 20 CVn

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ABSTRACT

We are performing a detailed spectral analysis of the F3 III star 20 CVn. Our 2.4 Å mm^{-1} spectrograms obtained with the 1.22-m telescope of the Dominion Astrophysical Observatory and CCD detectors cover λλ3825-4940. Our preliminary atmospheric parameters are T_{eff} = 6900 K and log g = 3.0. We calculated ATLAS9 (Kurucz 1993) model atmospheres and synthesized the spectrum using SYNTHE (Avrett & Kurucz 1981). We compared the observed fluxes and Hγ line profile with calculated values to obtain our results.

1. Introduction

Our elemental abundance study of the δ Scuti star 20 CVn (AO CVn, HD 115604, HR 5017, BD+41° 2380, SAO 44549, HIP 64844) is being performed in a manner consistent with the "Elemental Abundance Analyses with DAO Spectrograms" series of Adelman and his associates (see, e.g., Adelman et al. (2000) for the superficially normal stars 28 And (A7III, δ Scuti) and 99 Her (F7 V)). Other consistent analyses include those of two B and A type supergiants (Yüce 2005). The classical variability strip crosses the Main Sequence between A2 V and F0 V (Wolff 1983). The instability strip is a very interesting laboratory of astrophysics and asteroseismology. 20 CVn is close to the red-side of the instability strip in the H-R diagram.

Danziger & Dickens (1967) suspected that this star was a member of the Hyades-Moving-Group. Dickens et al. (1971) found the metallicity of 20 CVn is similar to Hyades stars and suggested this might be evidence of Hyades membership. Hauck et al. (1985) using S/N = 60 spectra found that [Fe/H] value of 20 CVn is greater than that of the Hyades group from a curve-of-growth analysis of its Fe I lines. They also derived T_{eff} = 7200 K, log g = 3.0 and ξ = 0.9 km s^{-1}.

2. Observations and Reductions

Adelman obtained 2.4 Å mm^{-1} spectrograms of 20 CVn at the Dominion Astrophysical Observatory (DAO) using the SITe2 and SITe4 CCDs with a typical signal-to-noise ratio of at least 200 and a wavelength coverage of 64 and 144 Å, respectively. The observed spectral range is λλ3825-4940. They were rectified with the interactive computer graphics program REDUCE (Hill & Fisher 1986). A 3.5% correction was used to correct scattered light in the dispersion direction for most SITe2 spectrograms. For the later SITe2 and SITe4 spectrograms a scattered light correction was incorporated into the program CCDRED (Gulliver, Hill & Adelman 1996).

3. Measurements and Identifications

We normalized all 15 spectrograms of 20 CVn (see Figure 1). Then the spectral lines were measured using the program VLINE (Hill & Fisher 1986). We derived $v \sin i$ = 5.6 ± 0.3 km s^{-1} by fitting the clean weak lines with Gaussian profiles. For approximately 5000 lines, the equivalent widths, the central wavelengths, the line depths and the FWHMs (full width at half maximum) were measured (see Figure 2). In this process, the fixed parameter feature was used to better determine the parameters of weak and closely blended lines. Gaussian profiles were fit through the stellar metal lines of 20 CVn. In this preliminary study we measured the radial velocity (see Table 1) from the Doppler shift of unblended lines. These were used to determine the rest wavelengths of all of the lines in the section. Then we identified them by means of standard lists of atomic lines especially Moore (1945).

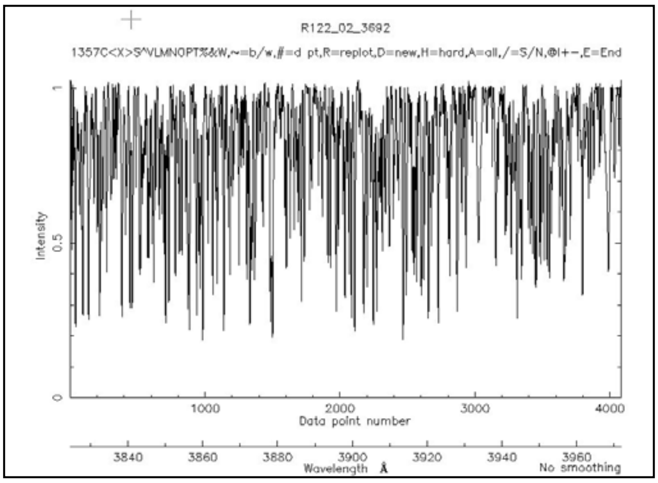

Figure 1. Normalization of the λλ 3825 – 3970 section of the 20 CVn spectrum

4. Atmospheric Parameters and Microturbulent Velocity

To get initial estimates of the atmospheric parameters T_{eff} and log g from the homogeneous uvbyβ data of Hauck & Mermilliod (1998), we used the computer program of Napiwotzki et al. (1993). The uncertainties are about ±200 K and ±0.2 dex (Lemke 1989). The results for 20 CVn are 7452 K and 3.66.

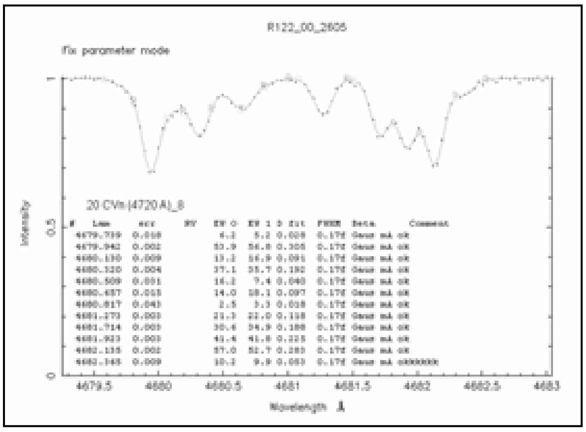

Figure 2. Measuring the spectrum of 20 CVn with VLINE

Table 1. Radial velocities for measured spectra in this study.

Spectra	Wavelength (Å)	Radial velocity (km s^{-1})
R122_02_3692	3825-3970	8.5 ± 0.2
R122_99_6088	3883-3944	7.2 ± 0.2
R122_99_1495	3938-3999	9.0 ± 0.3
R122_98_5370	3994-4056	7.7 ± 0.2
R122_98_5296	4103-4164	8.6 ± 0.5
R122_98_5567	4158-4218	8.8 ± 0.6
R122_00_1680	4213-4274	9.5 ± 0.6
R122_00_6679	4239-4381	9.6 ± 0.6
R122_98_7118	4323-4382	8.6 ± 0.5
R122_98_5471	4379-4440	8.4 ± 0.2
20CVn4450	4403-4521	8.3 ± 0.4
R122_02_3494	4516-4660	7.1 ± 0.6
R122_98_5774	4544-4604	8.4 ± 0.4
R122_00_2605	4660-4798	9.6 ± 0.4
20CVn4864	4792-4940	8.7 ± 0.5

With these values of effective temperature and log g, we computed a model atmosphere using ATLAS9 (Kurucz 1993) with [m/H] = 0.0 (solar abundances). We measured the Hγ profile from our DAO spectra and used the spectrophotometry of 20 CVn from Breger (1976) who corrected the values of Danziger & Dickens (1967). By matching theoretical calculations of the Hγ profile and fluxes with the observations, we found T_{eff} = 6900 K and log g = 3.0.

Now we determined the microturbulent velocity using WIDTH9 (Kurucz 1993) and as criteria: i) The abundances are independent of equivalent width and ii) The scatter of abundances about their mean is a minimum. Our first results are below

From 104 Fe I lines we found that the microturbulence based on the abundances being independent of equivalent width was 2.8 km s^{-1} and from the scatter about their mean was 2.7 km s^{-1}. For 29 Fe II lines both criteria for microturbulence was 2.6 km s^{-1}.

When we average the microturbulences we find 2.7 km/s. For these microturbulences, the log Fe/N(Total) values are Fe I -4.667 ± 0.190 and Fe II -4.340 ± 0.191.

The average is -4.50 ± 0.19 dex. Converting to log Fe/H, we obtain -4.46 ± 0.19. Thus the abundances of 20 CVn might be close to solar. However, T_{eff} and log g need to be adjusted.

5. Summary

Our preliminary Fe abundance shows that the abundances of 20 CVn might be solar. Fe I and Fe II are sufficiently different that our effective temperature and surface gravity need to be adjusted. We will try to keep the fits of the model's predictions for the energy distribution and the Hγ profile close to the observations. A higher temperature and/or a smaller log g are needed to achieve ionization equilibrium. For this determination, many more lines need to be measured.

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