DETAILED ANALYSES OF FOUR SOLAR ANALOGS ANALYSED ON HIGH S/N CFH AND ESO SPECTRA

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ABSTRACT. Four solar type G stars claimed to be photometrically very similar to the Sun have been analyzed in detail on high resolution, high S/N spectra. Their atmospheric parameters : effective temperature, spectroscopic gravity, microturbulence and iron abundance, [Fe/H], have been determined.

1. INTRODUCTION

The search for solar analogs has been very active during these last ten years. At the present time, this research bears a special interest between astronomers interested in discovering planetary systems. A very large list of solar analogs is given in Hardorp (1978). His search has been done by means of photoelectrical observations. Other authors have also looked for stars having the same physical and chemical characteristics than the Sun. Cayrel de Strobel et al. (1981) and M.N. Perrin and M. Spite (1981) tryed to complete the search using quantitative spectral analyses of some of these objects. They were not completely successful, in the sense that at least one physical parameter was different between the Sun and the solar analogs.
Here we present a new analysis of four solar analogs based on high S/N spectra.

2. THE SELECTION OF CANDIDATES FOR SOLAR ANALOGS

Table I contains some catalog data of the four stars we have selected for this study. The first three, HD44594, HD76151 and HD20630 have been taken from Table I in Hardorp's (1978) paper: "The Sun among the stars". The star HD44594 is contained in section 1 of this table headed : "spectra indistinguishable from solar". HD76151 and HD20630 are contained in Section 3 which contains stars headed : "Spectra very close to solar". Our attention has been called on the star HD81809 by D. Mihalas (private communication). In his letter of May 6, 1981 to one of the authors, Mihalas said that : "O.C. Wilson's CaII data reveal that HD81809 has an

G. Cayrel de Strobel and M. Spite (eds.), The Impact of Very High S/N Spectroscopy on Stellar Physics, 429–432.

activity cycle that looks identical to the Sun's" : (1) same mean Ca index; (2) same amplitude of Ca index; (3) same period. After such statements : HD81809 seemed to us an attractive solar twin candidate, and we added it to our list.

Table I

Catalogue Data

	HD 44594	HD 76151	HD 20630	HD 81809
V	6.60	6.00	4.83	5.38
B–V	0.66	0.67	0.68	0.64
Sp	G3V	G3V	G5V	G2V
π (0".001)	41	90	106	37
R_V (kms^{-1})	+60	+28	+20	+54
U (kms^{-1})	+29	−32	−23	−35
V (kms^{-1})	−73	−19	− 4	−46
W (kms^{-1})	− 5	− 5	− 5	+ 9

3. OBSERVATIONS AND DATA REDUCTIONS

The four stars have been observed with the CFH Telescope using the coudé spectrograph and a cooled Reticon array of 1872 photodiodes. The average S/N ratio was about 250, and the resolution about 0.2 Å (35000). HD44594, which is a southern hemisphere star, has been observed also at ESO, using the Coudé Echelle Spectrograph fed by the 1.4m Coudé Auxiliary Telescope.
In this paper we discuss only results for iron lines falling in the spectral intervals centered at Hα (6563 Å) and at ≈6750. The equivalent widths of the chosen Fe-lines have been obtained with a profile fitting technique that account for blends, following Cayrel et al. (1985).

4. DETAILED SPECTRAL ANALYSES OF THE STARS

The method is the same as the one followed by Cayrel et al. (1981). We remember that no abundance can be determined unless the three physical parameters T_{eff}, log g and ζ_t have been obtained. The effective temperatures have been derived from the wings of the Hα lines, the gravities from the ionisation equilibrium, the microturbulence was relatively unimportant: the analyzed lines were all sufficiently weak, so that a common curve of growth could be used.
The iron abundance of each program star has been obtained by comparing the observed FeI equivalent widths with those of appropriate models

https://doi.org/10.1017/S0074180900035403 Published online by Cambridge University Press

interpolated in a grid of model atmospheres (Gustafsson, 1981). The results from the detailed spectral analyses are contained in Table II.

Table II

Atmospheric parameters of the stars

	HD 44594	HD 76151	HD 20630	HD 81809
T_{eff} (K)	5770 ± 30	5710 ± 40	5630 ± 50	5630 ± 50
logg (cms^{-2})	4.50	4.50	4.50	3.75
ξ_t (kms^{-1})	1.0	1.0	1.0	1.0
$[Fe/H]^*_\odot$	+0.13 ± .06	+0.13 ±.06	+0.03 ±.05	−0.28 ± .09

5. DISCUSSION OF THE RESULTS

From Table I we see that the B−V's of the stars are higher than 0.64 with the exception of HD81809, and that, again, at the exception of HD81809 the spectral types of the stars are more advanced than that of the Sun. The space velocities of the stars with the exception of HD20630 seem to indicate that they are belonging to the old disk population.
Keeping in mind that Gustaffson's solar model has been computed with T_{eff}=5770 K, logg=4.50, $[A/A_\odot]$=0.0 and ξ_t=1.0 kms^{-1}, we see from Table II that the best candidate for a solar twin is HD44594: it has the same effective temperature, gravity and microturbulence as the Sun, the star has however a slight overabundance of Fe, which could be responsible for its spectral type, one unit more advanced than that of the Sun and for its relatively high B−V value.
HD76151 is cooler and slightly overabundant in iron.
HD20630 is very much cooler than the Sun but its iron abundance is normal.
The detailed analysis of HD81809 has revealed that its T_{eff}, logg and [Fe/H] values differ strongly from those of the Sun. Following the BS Catalog the star is also a spectroscopic binary. It is difficult to understand why its activity cycle is "identical" to the Sun.

6. CONCLUSION

First of all, let us recall that the CFH and ESO observations of the four solar analogs, we have analysed, have produced results being by almost an order of magnitude more accurate than those of Cayrel de Strobel et al. (1981) and Perrin and M. Spite (1981). Nevertheless our conclusion is the same as in Cayrel et al. (1981): none of the four solar analogs we have presented here is a "real solar twin".

https://doi.org/10.1017/S0074180900035403 Published online by Cambridge University Press

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https://doi.org/10.1017/S0074180900035403 Published online by Cambridge University Press