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# The $\alpha$ Cen A and Solar FUV Spectra

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**Abstract.**

We present a comparison of the high-resolution FUV spectrum of $\alpha$ Cen A (G2 V) acquired by STIS on HST with the solar FUV spectra acquired by SUMER on SOHO, and by UVSP on SMM, respectively. We compare the line properties of the strongest lines, and discuss the main peculiarities of the FUV emission of both stars.

## 1. Introduction

We have obtained a very high S/N spectrum of the star $\alpha$ Centauri A with the STIS instrument on HST (Woodgate et al. 1998). The resolution is about 100,000 and the spectrum covers the range 1130–3100 Å. $\alpha$ Cen is a near (d=1.34 pc) twin of the Sun with the same spectral type, and nearly the same effective temperature and gravity. With respect to the Sun, $\alpha$ Cen A is older (its age is estimated in the range 6.8-7.6 Gyr), and is more metal-rich (cf. Guenther & Demarque 2000).

This STIS high resolution spectrum of $\alpha$ Cen A can be considered the new "reference spectrum" for the Sun as a star, because it is a full disk average, has excellent wavelength and flux calibration, covers the whole UV range at one time, and is of high S/N.

## 2. The STIS Spectrum of $\alpha$ Cen A

Information on the $\alpha$ Cen A STIS data acquisition and reduction can be found in Linsky et al. (2000). In this spectrum we have measured 665 emission features, of which 74 are due to blending of two or more lines, 58 are due to not identified transitions, and 533 are identified as due to single emission lines. Most of these features are due to Fe II, C I, and Si I (140, 135, and 123 lines, respectively).

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Other abundant lines are from S I, Ni II, and Si II (54, 31, and 15 lines, respectively). The whole atlas, as well as details on the spectrum analysis, and on the characteristics of the strongest lines will be given in a forthcoming paper (Pagano et al. 2002).

## 3. The Solar SUMER/SOHO and UVSP/SMM Spectra

We use here the SUMER/SOHO spectrum of the Sun given by Curdt et al. (2001)[1]. These data were acquired with a dispersion of 41.2 mÅ/pixel (1st order) at 1500 Å, which mean 8.2 km $s^{-1}$, respectively. The wavelengths are typically accurated to 10 mÅ, i.e. 2 to 5 km $s^{-1}$. The data represent the average radiance (mW $sr^{-1}m^{-2}$Å$^{-1}$) for the quiet sun at disk center, a coronal hole, and a solar spot.

We also use the UVSP/SMM spectrum acquired with a $1'' \times 180''$ slit, oriented north-south at or near solar disk center. This spectrum covers the 1290–1772 Å spectral range, and has a spectral resolution of ∼100,000. According to Shine (private communication), this spectrum was calibrated using Rottman's quiet sun data from rocket flights which were flux unresolved measurements with low spectral resolution. The wavelength scale of the solar spectrum was corrected by using the $\alpha$ Cen A STIS spectrum, by performing a cross correlation between the two spectra in many selected wavelength intervals.

To be comparable with the $\alpha$ Cen A spectrum, from the solar radiance we have computed the solar irradiance at the $\alpha$ Cen distance by multiplying for $\pi\ R^2_\odot/d^2_{\alpha Cen}$ (cf. Wilhelm et al. 1998) for both the two solar spectra.

## 4. Comparison between the $\alpha$ Cen A/STIS and Sun/SUMER Spectra

The comparison between the $\alpha$ Cen A STIS and Sun SUMER spectra can be done in the 1170-1610 Å spectral range. The SUMER spectrum has a best photon statistic, therefore faint lines can be easily seen in the solar spectrum than in the $\alpha$ Cen STIS spectrum. On the other hand, the STIS spectrum has a better resolution, thus can be useful to resolve line blending and study line reversal due to optical thickness effects better than with the solar spectrum. In Table 1 we give a summary of how many lines we found in common to the two spectra. Many of the lines present in the solar spectrum but not in the $\alpha$ Cen A one are below about 1500 Å. On the contrary, many of the lines detected in the STIS spectrum only are above 1500 Å. This is probably a S/N and resolution effect. The emission lines in the $\alpha$ Cen A spectrum are much stronger than in the Solar quiet sun spectrum. Mostly this is because the solar spectrum is an average quiet sun (disk-center) spectrum. When comparing disk center radiance data with full disk irradiance data one should consider center-to-limb variation. For most of the lines, the full disk irradiance is almost a factor of two as compared to the irradiance derived from disk-center radiance data (cf.,

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[1] see also the Curdt's contribution in these proceedings

Wilhelm et al. 1999), while there is no difference for the continuum. Therefore, because of this effect, a radiometric comparison between the SUMER and STIS spectra appears not obvious.

Table 1. Measured features in the $\alpha$ Cen A/STIS and Sun/SUMER spectra in the 1170-1610 Å spectral range

| | | Total Features | With ID$^a$ | Without ID$^a$ |
|---|---|---|---|---|
| $\alpha$ Cen A/STIS | | 562 | 505 | 57 |
| | of which not in the Sun spectrum | 172 | 127 | 45 |
| Sun/SUMER | | 516 | 458 | 58 |
| | of which not in the $\alpha$ Cen A spectrum | 126 | 80 | 46 |
| Lines common to both spectra | | 390 | 378 | 12 |

$^a$ ID = Identification

## 5. Comparison between $\alpha$ Cen A and Sun UVSP

The comparison between the $\alpha$ Cen A STIS and Sun UVSP spectra can be done in the 1192-1688 Å spectral range. Since, the UVSP data are "mean intensity over the disk" data, it was possible to perform a radiometric comparison with the $\alpha$ Cen A spectrum. We have compared line fluxes and line widths of the emission lines whose integrated flux in the STIS spectrum exceed $5\times 10^{-14}$ erg $\mathrm{s}^{-1}$ $\mathrm{cm}^{-2}$.

We find that the line widths are almost comparable for most of the chromospheric lines, while transition region lines are typically larger for $\alpha$ Cen A with respect to the Sun. We show in Figure 1 the FWHM ratios versus the temperatures of line formation $\log T$. A linear fit to these data suggests that the two quantities are correlated with a correlation coefficient of 0.8.

As far as concern line fluxes, typically the $\alpha$ Cen A lines are stronger than those of the Sun (see e.g. the C I, O I, S I, Fe II, Si II, Si IV, C IV, N IV lines). On the contrary, the He II 1640 Å and the Al II 1671 Å lines are stronger in the Sun than in $\alpha$ Cen A. Since the Al II line in the $\alpha$ Cen A spectrum shows ISM absorption, the stellar flux in this line can be easily underestimated. Instead, the He II is really weaker on $\alpha$ Cen A than on the Sun. Since the He II line is extremely sensitive to the coronal activity, a flux ratio of 1.8 could suggest that the Sun is more active than $\alpha$ Cen A. However, the effect can be also due to limb darkening instead of limb brightening in this line.

Can the differences of equivalent widths of the $\alpha$ Cen A and solar lines be due to abundance differences? Actually, assuming that the temperature-density structure in the photosphere and chromosphere of $\alpha$ Cen A and the Sun are similar, the relative equivalent widths of lines for the Sun and $\alpha$ Cen A would measure the abundances. There are indeed some studies of the $\alpha$ Cen A photosphere (cf. Guenther & Demarque 2000 and references therein) supporting that $\alpha$ Cen A is metal rich compared to the Sun. However, there are many assumptions that can go wrong. For example, the thermal-density

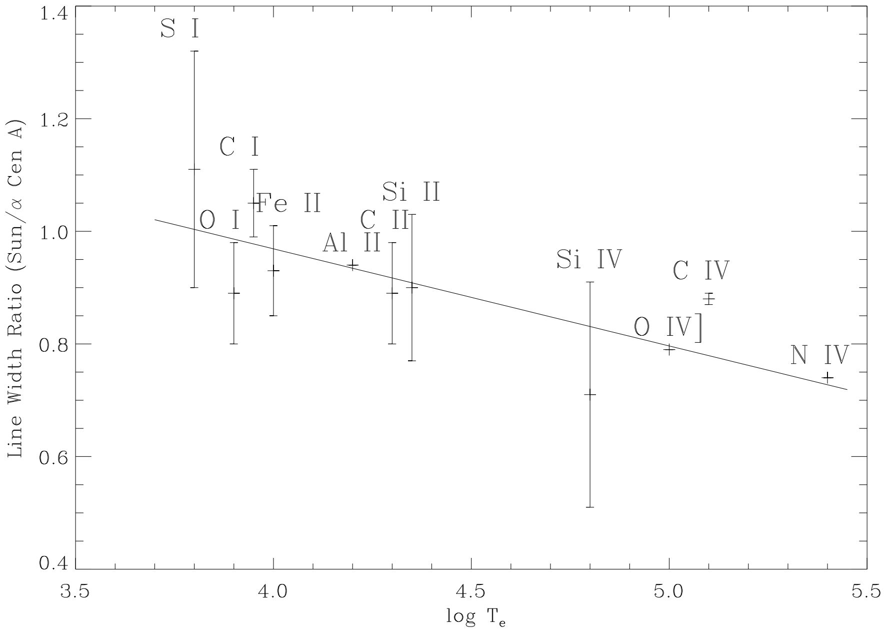

Figure 1. The ratio between the solar and $\alpha$ Cen A line widths versus the temperature of line formation.

structures may be significantly different and the disk averaging of the UVSP spectrum may not be an accurate disk average. A detailed model atmosphere analysis of $\alpha$ Cen A is beyond the scope of the present analysis, but it is worth noting that a simple computation of the expected abundances of C, O, and Fe in $\alpha$ Cen A from the FUV line flux ratios, assuming an identical temperature-density structure for the two stars, yields to 0.22 solar in logarithm, in excellent agreement with Guenther & Demarque (2000).

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