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Observed and Synthetic Spectra of Super-Metal Rich Stars: A progress report

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ABSTRACT

In this report we present recent work and progress in the determination of the metallicity scale for super-metal rich (SMR) stars. This calibration is intended to be done by quantitatively comparing observed and synthetic spectra of a selected sample of stars. Characteristics of the observational material collected so far is given and details on the atomic and molecular line list used to compute synthetic spectra are illustrated.

1. Introduction

For the analysis of integrated spectra of stellar systems it is fundamental to understand the behavior of relevant spectral features in terms of stellar atmospheric parameters: effective temperature, surface gravity and metallicity. Over the years, line strengths-atmospheric parameters calibration has been done either empirically or theoretically. Empirical calibrations (Faber et al. 1985; Buzzoni, Gariboldi & Mantegazza 1992; Worthey et al. 1994, Jones & Worthey 1995) have been built by acquiring large observational data bases, and labelling individual stellar spectra with atmospheric parameters found in the literature or derived from available observable quantities. Despite the large amount of material, the high metallicity edge of the available data bases is very poor and the metallicity scale of these stars is still uncertain, thus, limiting our understanding of stellar populations in old stellar systems where metal-rich populations are thought to be present: globulars, spiral bulges and giant ellipticals. Theoretical calibrations (see Gulati, Malagnini & Morossi 1993 and references therein) provide an alternative approach with the advantage that theoretical spectra can be computed for almost any set of atmospheric parameters.

In this work we show the recent results obtained within a project that has the following goals in mind: i) identify true SMR stars to complement current empirical data bases; ii) establish the metallicity scale of super-solar stars and iii) create a grid of synthetic spectra to complement existing stellar spectral libraries. To accomplish these goals we plan to compare high quality observed spectra (section 2) with theoretical spectra computed from improved model atmospheres and numerical codes and an *ad hoc* derived list of atomic and molecular data (section 3).

2. Observations

We have selected 201 stars of spectral types F to M that are catalogued in Taylor (1991) or in Cayrel de Strobel et al. (1992) or in Worthey et al. (1994) as having super-solar abundances ([Fe/H]$\geq$ 0.10).

The observations were carried out in March 1994 using a Boller & Chivens Cassegrain Spectrograph coupled with the 2.1m telescope at the Guillermo Haro Observatory, México. A total of 91 stars were observed in two overlapping spectral intervals that cover the region 3750-5300 Å . The spectra were reduced using the MIDAS reduction package (version 1992). The shape of the observed spectra was recovered by dividing them by a response function derived from the spectrophotometric information of 6 standard stars. We have estimated the resolution in the two spectral ranges, 3750-4650 Å and 4450-5300 Å , to be 3.2$\pm$0.2 and 2.5$\pm$0.1 Å , respectively, and a S/N $\geq$ 50.

Figure 1 shows the distribution of the observed stars in terms of the three atmospheric parameters. The number written at the top left of each panel indicates the total number of determinations of the corresponding parameter. Note that some of the determinations are below the metallicity limit we imposed to select our stars. These determinations correspond to stars from Worthey et al. (1994) that in the other two sources appear to have [Fe/H] < 0.10. In this diagram we have included all determinations available in the three sources.

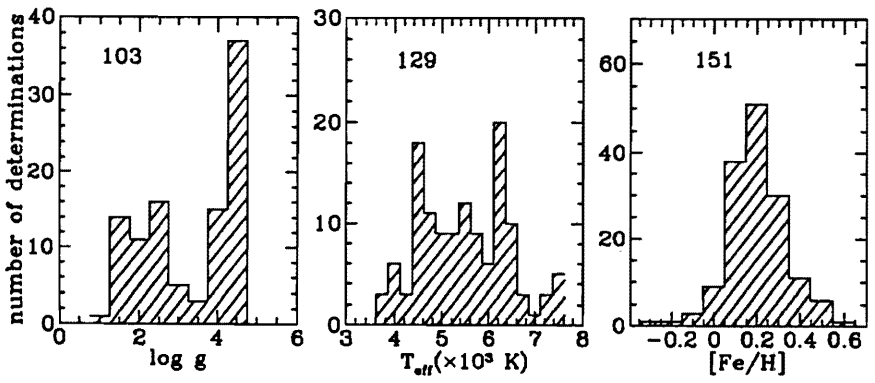

Fig. 1.— Distribution of the observed stars in terms of the atmospheric parameters.

For many of the stars more than one determination, for at least one of the atmospheric parameters, is available, in particular for [Fe/H]. To proper label the observed spectra, we will choose the best literature set of parameters by comparing the observed spectra with the computed ones. With this aim, theoretical spectra will be computed at high resolution using the most recent collection of model atmospheres and set of numerical codes developed by Kurucz (1993). Chavez et al. (1995) briefly list the main changes and improvements of these codes and models with respect to previous versions.

3. Synthetic Spectra:Atomic and Molecular Data

The line list included in our computations has been extracted from the most updated atomic and molecular line lists by Kurucz. Over 45000 lines for the 4850-5400 Å spectral interval have been taken into account. Molecules considered in our computations are CN, C_2, MgH, SiH and CH, and account approximately for 90% of the lines. In order to check the reliability of the theoretical material, we have computed the solar central intensity spectrum and carried out a line by line comparison with the Atlas of Delbouille, Roland & Neven (1973). About 2000 modifications were performed to the main parameters governing the line strength and profiles, in particular *gf* values and Van der Waals damping constants. This modifications were done in order to get an agreement between the synthetic and the observed spectra to within 5%.

In order to illustrate the importance of these corrections, in figure 2 we show two histograms of the differences, computed minus observed spectra (both normalized to the continum), before and after making the modifications. The spectra were rebinned and degraded to the resolution of the observational material described in section 2.

A more quantitative comparison showed that the differences between the spectral indices of magnesium and iron: Mg_2, Mg_1, Mg_b, Fe5270 and Fe5335 (Faber et al. 1985)

computed from the observed and synthetic solar spectra are, in general, twice as large as the rms error reported by Worthey et al. (1994) if the unmodified line list is used. When corrections are included in the line list these differences decrease to about one third of Worthey et al's errors.

It is worthwhile to mention that there is little room for further improvement in our line list because the largest differences displayed on the modified line list histogram correspond to lines which are unidentified in the solar spectrum.

4. Future work

We are now in position of carrying out the comparison between model atmophere predictions and observations. After a good match is obtained we will proceed to analyze the relationship atmospheric parameters-spectral index that we expect to give insight on the metallicity scale of the super solar stars. The material, empirical and theoretical, will complement existing stellar libraries. More observations are planned for the near future to cover the complete selected sample of stars and also to extend the spectral coverage to longer wavelengths.

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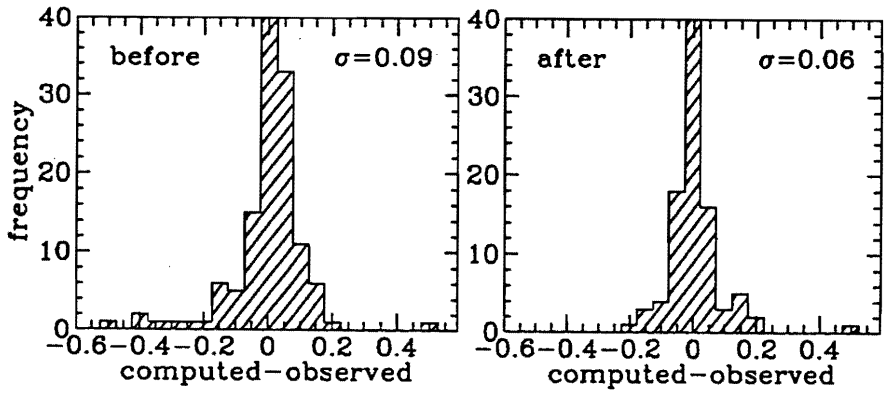

Fig. 2.— Histograms of the differences between the computed and observed solar central intensity spectra before and after performing the modifications to spectral line parameters.

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