Supersolar metallicity in G0–G3 main-sequence stars with V < 15

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We present the results of the analysis of a magnitude-limited sample of solar-like stars (spectral types G0–G3 and luminosity class V). Through spectroscopic observations, conducted in the Observatorio Astrofísico Guillermo Haro, and (Lick-like) spectroscopic indices, defined in the spectral range of 3800–4800 Å, we have determined the fundamental stellar parameters (effective temperature, surface gravity, and global metalicity) for 233 stars. We have identified a set of super metal-rich solar analogs, which are potential targets for giant planet searches. Besides to this study, we have started high-resolution observations ($R \sim 82000$), using the Cananea High resolution Spectrograph (CanHiS), in order to study chemical abundances in the stars of our sample.

OVERVIEW

The precise determination of the leading atmospheric parameters in stars: effective temperature, surface gravity and chemical composition ($T_{\rm eff}$,$\log g$,[M/H]) has a strong impact in studies of a number of astrophysical scenarios. Metallicity, for instance, has long been used in studies of the chemical evolution of the Milky Way, where very metal poor stars are expected to carry on the records of the early stages of the Galaxy. Stars with metallicities in the super-solar regime (Spinrad & Taylor, 1969; Rich, 1988), on the other side, provide clues on the impact of evolved stars in the enrichment of the interstellar medium, not only in the Galaxy, but also in the bulges of other spiral galaxies, and the stellar content of giant ellipticals. More recently, the well established correlation between the high stellar metal content and the presence of giant exoplanets (e.g. Gonzalez, 1997; Santos, Israelian & Mayor, 2001; Fischer & Valenti, 2005), has strongly motivated detailed abundance studies of the super-metal rich (SMR) stars and their impact in planet formation theories (Ida & Lin, 2004; Boss, 1997). In this work, we present the results of the spectroscopic analysis of a sample of stars with spectral types G0–G3, luminosity class V, and closer than ∼1 Kpc (V<15). The study is based on intermediate resolution (FWHM = 2.5 Å) spectra and a set spectroscopic indices that are used to simultaneously derive the photospheric parameters of the target stars and to identify a new sample of SMR stars as potential targets for planet searches.

SAMPLE AND OBSERVATIONS

The observed sample includes so far 233 stars (about 80% lack of previously reported atmospheric parameters), which were observed with the Böller & Chivens spectrograph at the 2.12m telescope at the Observatorio Astrofísico Guillermo Haro, Cananea, Mexico. A grating of 600 l/mm and a slit of 200 μm of width were used, covering the spectral range 3800–4800 Å with a spectral resolution of 2.5 Å of FWHM. For comparison purposes, we also observed the asteroids Vesta and Ceres (Fig. 1), and they were used as a template to calibrate our method. Additionally, we observed a sample of 29 *reference stars* from the PASTEL catalog (Soubiran et al., 2010) complemented with 35 objects of Liu et al. (2008). This reference sample will serve to test the adequacy of the theoretical spectra.

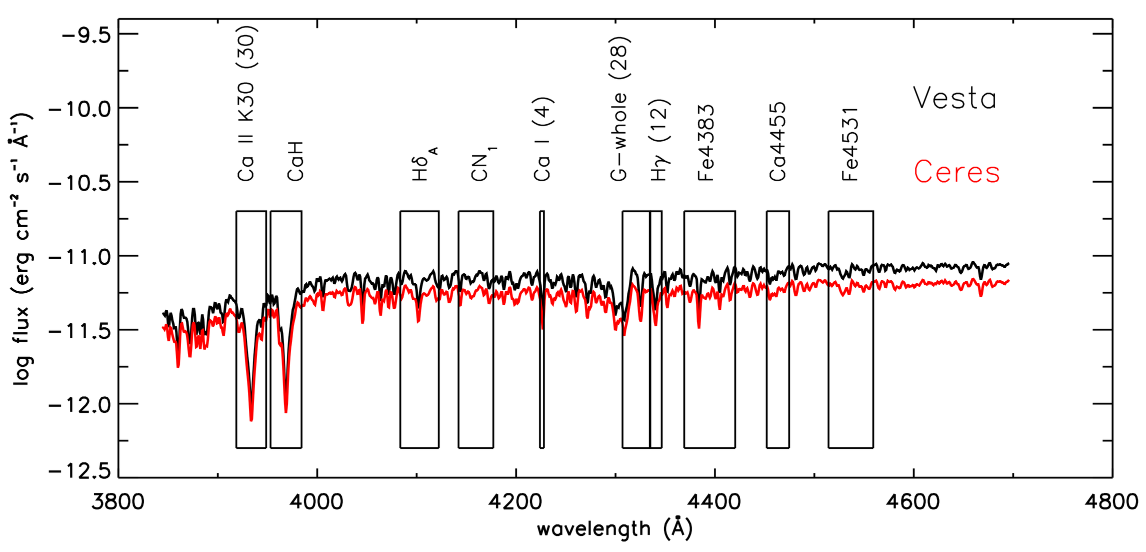

Figure 1: Solar spectrum reflected by the asteroids Vesta and Ceres. The vertical bands show the regions included in the central bands of the indices used in this work.

SPECTROSCOPIC INDICES

We identified 10 indices defined in different works (Trager et al., 1998; Worthey & Ottaviani, 1997; Lee et al., 2008; Carretero, 2007) that maximize the orthogonality in the atmospheric parameters space and that better reproduce the solar parameters. For the index calculation, we adopted the definition of Trager et al. (1998), which consists in three spectral bands: a central one that includes the spectral feature to be measured and two adjacent bands that are using to calculate, through linear interpolation, a pseudo-continuum flux. An index is computed by comparing the pseudo-continuum flux with the flux measured in the spectrum at the central band.

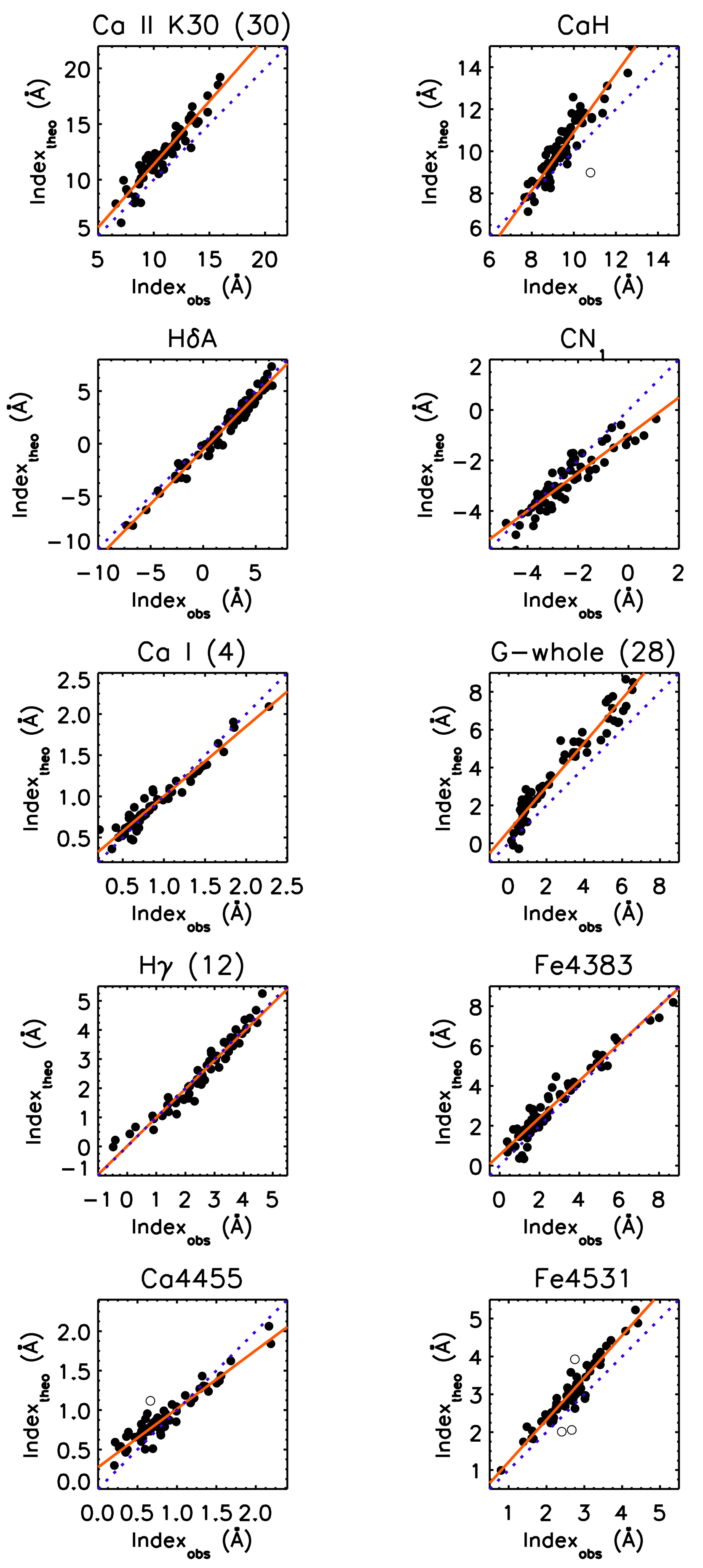

Figure 2: Theoretical versus observed indices for the set of reference stars for the selected indices. The dotted line indicates the bisector of the plane, while solid line shows the best linear fit of the data. The open dots are the data rejected by 3σ clipping.

DETERMINATION OF ATMOSPHERIC PARAMETERS

We computed the selected indices in a set of theoretical spectra of Munari et al. (2005) within the ranges of $T_{\rm eff}$, $\log g$ and [M/H] adequate for our sample, in order to generate a theoretical grid of spectroscopic indices. These indices were transformed to the observational system using the coefficients of the linear regression show in Fig. 2 (red line), which is constructed with the observed and theoretical indices of the PASTEL catalog's selected stars. Since the space of parameters of the Munari et al. library is too coarse, we decided to perform a trilinear interpolation of the grid of calibrated indices in order to reduce the steps to smaller values: 5 K in $T_{\rm eff}$, 0.05 dex in $\log g$ and 0.02 dex in [M/H]. With the purpose of determining the stellar parameters of our sample, we adopted a least squares method, by minimizing the χ^2 statistic. A critical point in this procedure is a correct estimation of the error in the index value, which play an important role in minimizing the χ^2, since there is no wavelength interval, at a resolution of FWHM=2.5 Å, free of absorption lines, where the noise can be safely measured on the observed spectra. Therefore, we devised an iterative Montecarlo method to determine the errors (see for more details López-Valdivia et al., 2014). To estimate the error on the stellar parameters, we followed Avni (1976). We found an average 1σ errors of 55 K for $T_{\rm eff}$, 0.26 dex and 0.056 dex for $\log g$ and [M/H], respectively.

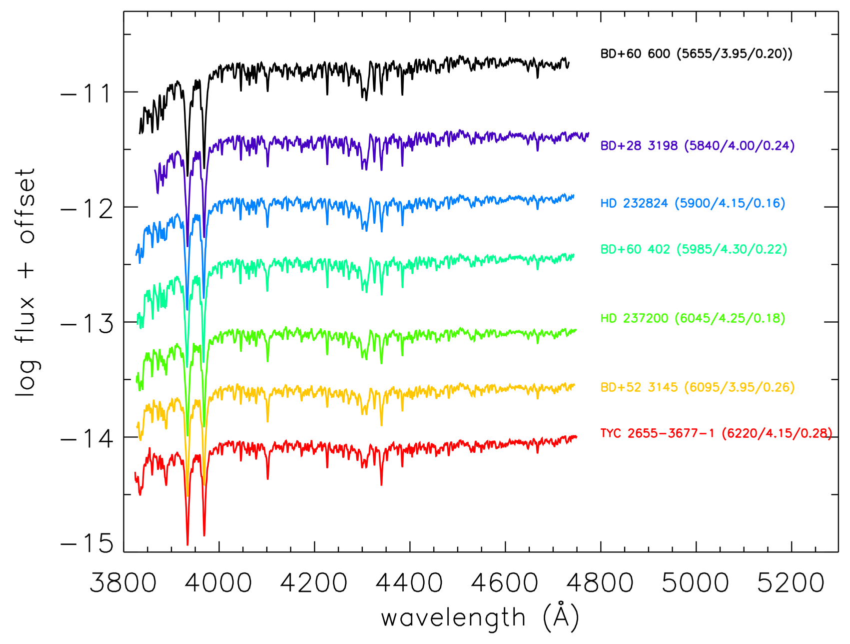

Figure 3: Some spectra of the SMR stars found in this work

Object	$T_{\rm eff}$ (K)	$\sigma_{T_{\rm eff}}$ (K) +	$\sigma_{T_{\rm eff}}$ (K) -	$\log g$ (dex)	$\sigma_{\log g}$ (dex) +	$\sigma_{\log g}$ (dex) -	[M/H] (dex)	$\sigma_{[M/H]}$ (dex) +	$\sigma_{[M/H]}$ (dex) -
TYC 1759-462-1	**6140**	80	75	**3.65**	0.45	0.40	**0.20**	0.12	0.12
BD+60 402	**5985**	75	70	**4.30**	0.40	0.40	**0.22**	0.08	0.10
TYC 1230-576-1	**5665**	85	75	**4.40**	0.35	0.30	**0.16**	0.10	0.08
HD 232824	**5900**	50	85	**4.15**	0.25	0.45	**0.16**	0.06	0.10
HD 237200	**6045**	40	70	**4.25**	0.25	0.40	**0.18**	0.04	0.06
HD 135633	**6095**	65	70	**4.25**	0.35	0.45	**0.22**	0.06	0.06
BD+28 3198	**5840**	25	45	**4.00**	0.10	0.25	**0.24**	0.04	0.06
Cl* NGC 6779 CB 471	**5790**	70	65	**3.80**	0.35	0.35	**0.20**	0.10	0.10
TYC 2655-3677-1	**6220**	45	50	**4.15**	0.30	0.25	**0.28**	0.04	0.06
HD 228356	**6055**	55	20	**4.00**	0.30	0.10	**0.16**	0.06	0.04
BD+47 3218	**6050**	45	60	**4.05**	0.25	0.35	**0.16**	0.04	0.08
[M96a] SS Cyg star 14	**6195**	35	40	**4.00**	0.25	0.25	**0.24**	0.04	0.06
TYC 3973-1584-1	**6000**	35	55	**4.45**	0.20	0.30	**0.20**	0.04	0.06
BD+52 3145	**6095**	35	50	**3.95**	0.20	0.25	**0.26**	0.06	0.06
TYC 3986-3381-1	**5855**	55	60	**4.15**	0.25	0.25	**0.26**	0.08	0.06
TYC 3982-2812-1	**5895**	60	50	**4.30**	0.30	0.25	**0.18**	0.06	0.06
TYC 3618-1191-1	**5940**	60	60	**4.40**	0.35	0.30	**0.24**	0.08	0.08
TYC 3986-758-1	**5845**	55	65	**4.05**	0.30	0.35	**0.16**	0.06	0.08
BD+60 600	**5655**	35	60	**3.95**	0.10	0.30	**0.20**	0.06	0.08
HD 283538	**6005**	25	40	**4.00**	0.10	0.25	**0.16**	0.04	0.06
HD 137510	**5875**	70	20	**4.00**	0.35	0.05	**0.16**	0.08	0.04
HD 212809	**5975**	60	50	**4.55**	0.30	0.25	**0.16**	0.04	0.06

Table 1: Atmospheric parameters of SMR stars.

RESULTS

We determined in a homogeneous way the three leading atmospheric parameters, $T_{\rm eff}$, $\log g$ and [M/H], for 233 solar analogs (see the results on López-Valdivia et al., 2014); we found a new sample of 20 SMR stars (Table 1) and we confirmed the metal-rich nature of HD 135633 and HD 137510. The distribution of the objects in the parameters space is depicted in Fig. 4.

Our group has started a complementary observational program at high spectral resolution ($R > 80000$) whose goal is to corroborate the global chemical composition through an analysis of individual chemical species.Particular emphasis is given to the abundance of Lithium since it appears to trace the presence of planets (e.g., Israelian et al., 2009) and conforms a valuable age diagnostics in main sequence stars.

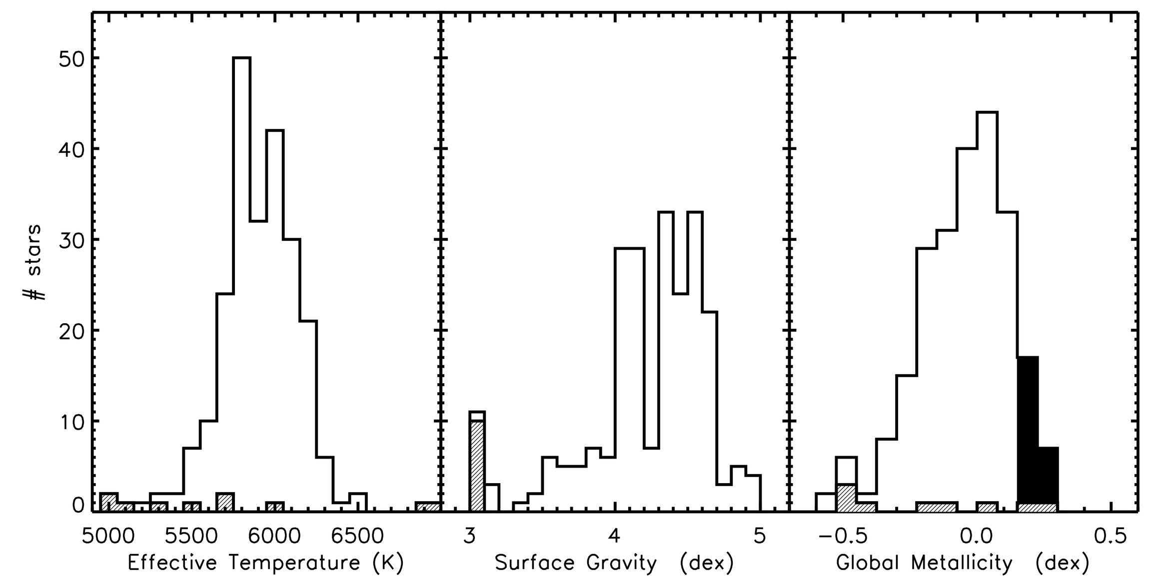

Figure 4: Atmospheric parameter distributions of our sample. The shaded area shows some outliers, while the black area shows the SMR stars found in this work.

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