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The Abundance Distribution of Stars with Planets

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ABSTRACT

We present the results of a uniform, high-precision spectroscopic metallicity study of 136 G-type stars from the Anglo-Australian Planet Search, 20 of which are known to harbour extrasolar planets (as at July 2005). Abundances in Fe, C, Na, Al, Si, Ca, Ti and Ni are presented, along with Strömgen photometric metallicities. This study is one of several recent studies examining the metallicities of a sample of planet-host and non-planet-host stars that were obtained from a single sample, and analysed in an identical manner, providing an unbiased estimate of the metallicity trends for planet bearing stars. We find that non-parametric tests of the distribution of metallicities for planet-host and non-planet-host stars are significantly different at a level of 99.4% confidence. We confirm the previously observed trend for planet-host stars to have higher mean metallicities than non-planet-host stars, with a mean metallicity for planet-host stars of [Fe/H]=0.06±0.03 dex compared with [Fe/H]=−0.09±0.01 dex for non-host-stars in our sample. This enrichment is also seen in the other elements studied. Based on our findings, we suggest that this observed enhancement is more likely a relic of the original gas cloud from which the star and its planets formed, rather than being due to "pollution" of the stellar photosphere.

Key words: stars: abundances – stars: chemical peculiar – stars: planetary systems

1 INTRODUCTION

The discovery of the first extra-solar planets (Mayor & Queloz 1995; Marcy & Butler 1996) has triggered an explosion of new planet discoveries and also served to create the entirely new astronomical discipline of exo-planetary science. Studies are being performed not only of the properties of the planets themselves, but also of the stars harbouring these planets. Chemical analyses of extra-solar planetary host stars have suggested that they appear to be metal enriched compared to the sample of "average" F, G and K stars not known to harbour planets. This effect was first identified by Gonzalez (1997) and has since been repeatedly observed by others (Gonzalez 1998; Gonzalez & Vanture 1998; Gonzalez, Wallerstein & Saar 1999; Gonzalez & Laws 2000; Santos et al. 2000, 2001, 2004; Butler et al. 2000; Gonzalez et al. 2001; Smith et al. 2001; Reid 2002; Fischer & Valenti 2005). At present, this observed chemical anomaly is the *only* externally observable connection between the properties of a star and the presence of a planetary companion. There are also suggestions of similar anomalies in the abundances of Li, C, N (Gonzalez & Laws 2000; Israelian et al. 2004), Na, Mg and Al (Berião et al. 2005). It must be noted though, that these effects are yet to be seen in a wide selection of planetary hosts and have been subject to dispute (e.g. Ryan 2000).

The uniformity of metallicity studies is an issue that is now being addressed (e.g. Santos et al. 2001, 2005; Fischer & Valenti 2005; Valenti & Fischer 2005). Most published surveys have utilised abundances for local field stars previously published by other authors (e.g. Favata et al. 1997) as their comparison non-planet-host sample. The use of different samples is of concern, as different metallicity estimation processes can produce systematically different results (eg. are the spectral line lists used the same? Have the spectra been processed in the same way to measure equivalent

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widths? Have the same model atmospheres been used to turn equivalent widths into abundances?) Even where both samples have metallicities measured in the same way (eg. Santos et al. 2004), different sample selection criteria can lead to systematic effects (eg. are the samples volume-limited or magnitude-limited? Are the samples differently culled based on age, or binarity?). Clearly the ideal experiment would be to measure abundances using a single process, for *all* the objects in a planet search sample, and then compare the matallicities of the objects with, and without, planets in that one sample.

It is just this test which we perform here. We have used the spectra of stars from the Anglo-Australian Planet Search (AAPS) to determine their metallicity (ie. iron abundance), as well as their abundances in seven other elements. We then compare these measured abundances for stars from the AAPS sample which have been found to harbour planets, to those not found to harbour planets, to obtain one of the most "differential" experiments yet performed on planet-host star metallicities. A similar independent analysis of the metallicities of the AAPS target stars (along with the target stars of the Lick and Keck planet searches) has been performed in parallel to this work, and is presented in Fischer & Valenti (2005) and Valenti & Fischer (2005).

2 DATA

2.1 Target Stars

We concentrate on the 136 G-type (Solar-type) stars, observed as part of the AAPS program (Butler et al. 2001, 2002; Tinney et al. 2001, 2002, 2003; Jones et al. 2002, 2003; Carter et al. 2004; McCarthy et al. 2004). As at July 2005, twenty of these stars were known to be planet hosts. AAPS target stars were selected to have $\delta < -20$ deg and V<7.5. Stars known to be young (age < 3 Gyr), active (logR'_{HK}> -4.5) or with other stars within $5''$ (as they contaminate the spectrograph slit) are rejected from the AAPS search. A small sub-sample of 19 fainter (V > 7.5) metal-rich stars (based on published *uvby* photometry) were also included in 1999. Since this additional sample obviously biases our overall sample, we consider the V > 7.5 and V < 7.5 samples seperately throughout. Of the 136 target G-type stars studied, 127 (including 19 planetary host stars) have been included in similar chemical studies by other authors (primarily that of Fischer & Valenti (2005) and Valenti & Fischer (2005)).

2.2 Spectroscopic Data

Spectroscopic observations of the target stars were obtained at the 3.9m Anglo-Australian Telescope (AAT) between January 1998 and November 2000 as part of the AAPS. All of the spectra used were obtained with the University College London Echelle Spectrograph (UCLES) using the 31.6 line/mm echelle grating. The spectra used for this study were all "template" spectra. That is, spectra observed without an I_2 absorption cell in the beam, and with a narrow 0.5-0.75$''$ slit, for the purposes of defining a reference spectrum against which observations obtained with an I_2 cell can be registered. The spectra encompass the entire visible spectrum from 4820 to 8420Å with a signal-to-noise ratio (S/N) between 200 and 300 per spectral pixel at resolution $\lambda/\Delta\lambda \approx 80000$. The raw data were reduced in IDL as part of the standard AAPS processing (ie. bias-subtracted, flat-fielded and extracted) to provide one-dimensional spectra, suitable for spectral analysis. Subsequent analysis was performed within the IRAF data reduction environment. In particular, the radial velocities of all targets stars were determined by cross-correlation against a template (HD10700, v_{rad}=16.4±0.9km/s), and all stars were shifted to zero-velocity.

Metallicity analyses often proceed by measuring equivalent widths for absorption lines assuming Gaussian fits (commonly using the IRAF task `splot` in the package `noao.onedspec`). There are two drawbacks with this method: (1) it relies on the spectral line being well modeled by a Gaussian function, and (2) the fitting of the profile is an interactive process (usually requiring user definition of continuum regions and the edges of the spectral line) and is potentially subject to subjective variation between stars. Moreover, due to the high S/N ratio and spectral resolution of these data, functional fitting is really not necessary – there are more than enough photons available to obtain good equivalent width estimates by simply integrating the observed line profiles. A small perl script was therefore written to obtain equivalent width estimates in an automated manner via direct integration – ie. by summing over predefined rest wavelength intervals the difference between the observed spectra line and the continuum flux level, as defined by fitting a linear continuum between two predefined rest wavelength ranges for each line.

These equivalent widths were then analysed using a procedure similar to that adopted by previous studies (see Santos et al. 2000; Gonzalez et al. 2001; Santos et al. 2001). The line list utilised in this study is shown in Table 1 and was selected from Edvardsson et al (1993) and Santos et al. (2000). Log gf and excitation energies for each line were obtained from the NIST Atomic Spectra Database, Version 2.0. Standard local thermodynamic equilibrium analysis was employed to determine the elemental abundances and atmospheric parameters. Solar abundances were obtained from Anders & Grevesse (1989). $T_{\rm eff}$ was obtained from the stellar colours listed in the Hipparcos catalogue via equation 8.9 from Smith (1995) (B - V = 7000/$T_{\rm eff}$ - 0.56). This method of temperature determination differs from that utilised by other similar studies which have utilised the spectra for a temperature value and resulted in a mean $T_{\rm eff}$ uncertainty of ± 100 K. A revised version of Sneden's (1973) MOOG abundance code entitled `width6` (Ryan 2001) was used to obtain a final set of abundances, in conjunction with a grid of Kurucz (1993) ATLAS9 atmospheres. Stellar log g values and Fe abundances were obtained by iterating until the [Fe/H] value from both Fe I and Fe II was the same. In this study, the values of the microturbulence parameter, ξ_t, that were sampled were 1.0, 1.25 and 1.5, as for Solar-type stars, ξ_t usually lies between 1.0 and 1.5. The value which produced the smallest correlation between abundance and equivalent width (i.e. minimised the correlation coefficient between log ξ(Fe I) and log (W_λ/λ)) was selected as being the stellar ξ_t value, resulting in uncertainties for ξ_t of ± 0.25.

Table 1. Line list used for chemical abundance analysis

λ (Å)	Log gf	χ_l (eV)	λ (Å)	Log gf	χ_l (eV)
Fe I:			**Fe II:**		
5044.21	-2.15	2.85	6084.11	-3.97	3.20
5088.15	-1.78	4.15	6149.23	-2.90	3.89
5104.44	-1.70	4.28	6247.57	-2.52	3.89
5109.65	-0.98	4.30	6369.47	-4.36	2.89
5247.05	-4.95	0.09	6416.93	-2.85	3.89
5322.05	-3.04	2.28	6432.68	-3.74	2.89
5806.73	-1.05	4.61	**Ni I:**		
5852.22	-1.34	4.55	6175.36	-0.54	4.09
5855.08	-1.75	4.61	6176.80	-0.53	4.09
5856.09	-1.64	4.29	6177.25	-3.51	1.82
5858.78	-2.26	4.22	**Ca I:**		
5862.36	-0.60	4.55	6166.44	-0.90	2.52
6027.06	-1.22	4.07	6169.05	-0.54	2.52
6079.01	-1.13	4.65	6471.66	-0.59	2.53
6151.62	-3.30	2.17	6499.65	-0.59	2.52
6157.73	-1.25	4.07	**Ti I:**		
6159.38	-1.97	4.61	5113.45	-0.78	1.44
6165.36	-1.55	4.14	5426.25	-3.00	0.20
6173.32	-2.88	2.22	5866.46	-0.84	1.07
6180.21	-2.78	2.73	5965.84	-0.41	1.88
6200.32	-2.44	2.61	6126.22	-1.42	1.07
6226.74	-2.20	3.88	6261.11	-0.48	1.43
6229.23	-2.97	2.85	**Ti II:**		
6240.56	-3.39	2.22	5336.78	-1.70	1.58
6265.14	-2.55	2.18	**C I:**		
6380.75	-1.40	4.19	5380.32	-1.61	7.68
6392.54	-4.03	2.28	6587.62	-1.00	8.54
6498.95	-4.70	0.96	**Si I:**		
6608.04	-4.04	2.28	5665.56	-1.73	4.92
6627.56	-1.68	4.55	6721.86	-0.94	5.86
6646.93	-3.99	2.61	**Na I:**		
6703.58	-3.15	2.76	6154.23	-1.53	2.10
6710.31	-1.87	1.48	6160.75	-1.23	2.10
6725.36	-2.30	4.10	**Al I:**		
6733.15	-1.58	4.64	7835.32	-0.50	4.02
6745.11	-2.17	4.58	7836.13	-1.64	4.02
6750.15	-2.62	2.42			
6752.72	-1.37	2.42			
6786.86	-2.06	4.19			

2.3 Photometric Data

This spectroscopic process is not the only way to obtain abunance estimates. Stellar metallicity can also determined using Strömgen *uvby* photometry as initially outlined by Strömgen (1966) and recently utilised by Reid (2002). Such photometry measures stellar metallicity via differential line blanketing, as determined by two colour indices:

$$c_1 = (u - v) - (v - b)$$

and

$$m_1 = (v - b) - (b - y).$$

Several calibrations between these indices and metallicity have been developed. We follow the calibration outlined by Schuster & Nissen (1988) and used by Reid (2002):

$$\begin{aligned}[\mathrm{Fe/H}]_{\mathrm{uvby}} = 1.052 - 73.21\mathrm{m}_1 + 280.9\mathrm{m}_1(b-y) \\ +333.95{\mathrm{m}_1}^2(b-y) - 595.5\mathrm{m}_1(b-y)^2 \\ +[5.486 - 41.61\mathrm{m}_1 - 7.963(b-y)] \\ \times\log\{\mathrm{m}_1 - [0.6322 - 3.58(b-y) \\ +5.20(b-y)^2]\}\end{aligned}$$

for F-type stars ($0.22 \leqslant (b - y) < 0.375$, $0.03 \leqslant m_1 \leqslant 0.21$, $0.17 \leqslant c_1 \leqslant 0.58$ and $-3.5 \leqslant [\mathrm{Fe/H}] \leqslant 0.2$) and

$$\begin{aligned}[\mathrm{Fe/H}]_{\mathrm{uvby}} = -2.0695 + 22.45\mathrm{m}_1 - 53.8{\mathrm{m}_1}^2 \\ -62.04\mathrm{m}_1(b-y) + 5145.5{\mathrm{m}_1}^2(b-y) \\ +(85.1\mathrm{m}_1 - 13.8\mathrm{c}_1 - 137.2{\mathrm{m}_1}^2)\mathrm{c}_1\end{aligned}$$

for G-type stars ($0.375 \leqslant (b - y) < 0.59$, $0.03 \leqslant m_1 \leqslant 0.57$, $0.10 \leqslant c_1 \leqslant 0.47$ and $-2.6 \leqslant [\mathrm{Fe/H}] \leqslant 0.4$).

Using this calibration, photometric metallicities were estimated for nearly all of our target stars using Strömgen photometry from the Hauck & Mermilliod (1998) catalogue.

2.4 Results

The metallicity results from both the spectroscopic and photometric analyses can be seen summarised in Tables 2 (stellar atmospheric and metallicity values) and 3 (all other elemental abundances). Figure 1 plots the differences between the photometric and spectroscopic metallicities against several stellar parameters. We define Δ[Fe/H] in the sense

$$\Delta[\mathrm{Fe/H}] = [\mathrm{Fe/H}]_{uvby} - [\mathrm{Fe/H}]_{\mathrm{spec}},$$

No obvious trends are apparent in these data. The mean difference between the two techniques is $\Delta[\mathrm{Fe/H}] = 0.02 \pm 0.01$ This difference is smaller than that obtained by Reid (2002) when comparing spectroscopic and photometric metallicities ($<\Delta[\mathrm{Fe/H}]> \sim -0.10$), though considering the smaller samples of Reid (22 and 40 stars) the difference is probably not significant. The difference obtained here is also smaller than that obtained by Gratton et al. (1997) ($<\Delta[\mathrm{Fe/H}]> = -0.102 \pm 0.151$ from 152 stars), though it is consistent within uncertainties.

Several of the stars studied here, including all but one of the planet-host stars, have been included in previous studies such as Edvardsson et al (1993); Gonzalez et al. (2001); Santos et al. (2000); Reid (2002); Santos et al. (2004); Fischer & Valenti (2005) and Valenti & Fischer (2005). One study with which we have significant overlap is that of Santos et al. (2004) where nine non-planet-host stars and 17 planet-host stars are common to both studies. For almost all of these common stars, the metallicity measured in this study is less than that cited by Santos et al. (2004), often well outside of errors. The mean difference is 0.10 ± 0.02 dex. The systematic difference in metallicity between this study and that of Santos et al. (2004) is attributed to the use of different methods for determining T_{eff} and ξ_t and different atomic parameters for the spectral lines. We also overlap greatly with the studies of Fischer & Valenti (2005) and Valenti & Fischer (2005) where 108 non-host and 19 planet-host stars are in common. Approximately half of these common stars have metallicities determined here to be different to and outside of the errors reported by Fischer & Valenti (2005). These differences in abundance are attributed to the different methods used, since Valenti & Fischer (2005) and Fischer & Valenti (2005) fit the observed spectrum directly (rather than by matching equivalent widths) and also determine T_{eff} directly from the spectrum (rather than adopt-

Table 2. Atmospheric Parameters and Metallicities for all target stars

HD	T_{eff} (K)	Log g	ξ_t (km/s)	[Fe/H] Spec	[Fe/H] Phot	HD	T_{eff} (K)	Log g	ξ_t (km/s)	[Fe/H] Spec	[Fe/H] Phot
Non-Host Stars:											
1581	5969±102	4.49±0.18	1.50	−0.22±0.07	−0.18	107692	5776±66	4.21±0.18	1.50	−0.04±0.08	0.25
3277	5523±67	4.50±0.19	1.00	−0.11±0.06	−0.20	108309	5673±86	3.99±0.17	1.25	0.04±0.08	0.09
3823	6007±52	4.31±0.20	1.50	−0.30±0.07	−0.42	114613	5617±49	3.87±0.17	1.50	0.06±0.08	0.11
4308	5729±138	4.61±0.21	1.25	−0.32±0.07	−0.25	114853	5764±73	4.59±0.18	1.00	−0.18±0.07	−0.12
7570	5985±122	4.21±0.20	1.50	0.07±0.07	−0.10	120690	5589±105	4.26±0.20	1.00	−0.10±0.06	−0.04
9280	5429±86	3.81±0.19	1.25	0.13±0.07	0.14	121384	5375±108	4.01±0.19	1.25	−0.40±0.07	−0.42
10180	5807±94	4.29±0.21	1.25	−0.01±0.05	0.07	122862	5954±19	4.24±0.14	1.50	−0.15±0.07	−0.27
10700	5520±98	4.90±0.24	1.00	−0.42±0.06	−0.37	128620	5569±112	3.89±0.19	1.25	0.03±0.08	0.17
11112	5782±124	4.05±0.19	1.50	0.07±0.08	0.02	131923	5574±100	4.12±0.21	1.25	−0.05±0.08	−0.03
12387	5734±117	4.50±0.20	1.25	−0.25±0.09	−0.21	134060	5825±99	4.27±0.16	1.25	0.03±0.08	0.04
16417	5374±57	4.05±0.19	1.50	0.03±0.08	0.03	134330	5540±42	4.23±0.15	1.25	−0.02±0.07	0.22
18709	5926±85	4.47±0.18	1.25	−0.23±0.07	−0.31	134331	5837±108	4.41±0.21	1.50	−0.07±0.08	–
18907	5338±65	4.37±0.21	1.50	−0.50±0.07	−0.48	134606	5484±105	4.13±0.20	1.25	0.13±0.07	0.15
19632	5661±68	4.26±0.19	1.50	−0.09±0.09	0.00	136352	5776±102	4.66±0.21	1.25	−0.31±0.07	−0.27
20201	5944±17	4.31±0.20	1.50	0.02±0.07	−0.08	140901	5554±17	4.43±0.20	1.00	0.05±0.07	0.09
20766	5770±25	4.58±0.21	1.25	−0.22±0.08	−0.22	143114	5877±21	4.54±0.21	1.50	−0.40±0.08	−0.37
20782	5803±98	4.55±0.19	1.25	−0.07±0.07	−0.13	145825	5755±78	4.44±0.29	1.25	−0.04±0.07	0.19
20794	5566±134	4.81±0.18	1.00	−0.32±0.07	−0.22	147722	5819±365	4.01±0.19	1.50	−0.04±0.08	–
20807	5895±28	4.64±0.19	1.50	−0.25±0.07	−0.23	150248	5735±84	4.50±0.18	1.25	−0.11±0.07	−0.20
22104	5658±41	3.97±0.21	1.50	0.15±0.09	0.18	155974	6282±440	4.19±0.16	1.50	−0.20±0.07	−0.39
23127	5626±69	4.00±0.19	1.50	−0.06±0.07	−0.29	158783	5693±99	4.09±0.19	1.50	−0.05±0.07	−0.03
26491	5785±85	4.43±0.18	1.00	−0.08±0.07	−0.13	161050	5914±62	4.04±0.21	1.50	−0.14±0.07	−0.20
30295	5291±76	4.08±0.21	1.00	0.15±0.07	0.18	161612	5462±398	4.20±0.17	1.00	0.06±0.07	0.19
31827	5402±59	3.84±0.20	1.25	0.20±0.08	0.30	162255	5726±137	4.05±0.19	1.25	0.01±0.08	0.07
33811	5416±96	3.95±0.20	1.25	0.15±0.07	0.28	168871	5917±101	4.32±0.20	1.50	−0.18± 0.08	−0.10
36108	5926±52	4.37±0.18	1.50	−0.24±0.07	−0.30	177565	5583±276	4.40±0.17	1.50	−0.07±0.11	0.10
38283	5945±104	4.19±0.20	1.50	−0.24±0.01	−0.23	183877	5670±164	4.64±0.14	1.00	−0.18±0.07	−0.12
38382	5945±106	4.33±0.21	1.50	−0.09±0.07	0.00	187805	5976±102	4.14±0.21	1.50	−0.01±0.07	–
38973	5914±106	4.29±0.20	1.50	−0.07±0.07	–	189567	5749±87	4.46±0.12	1.25	−0.25±0.07	−0.24
39213	5288±59	4.00±0.21	1.00	0.20±0.07	–	190248	5454±92	4.03±0.17	1.25	0.20±0.07	0.25
42902	5824±54	4.23±0.20	1.50	0.17±0.07	0.10	192865	6026±204	3.76±0.20	1.50	−0.03±0.08	−0.04
43834	5557±42	4.43±0.20	1.25	0.06±0.06	0.15	193193	5913±70	4.37±0.16	1.25	−0.09±0.07	−0.12
44120	5917±46	4.05±0.19	1.50	0.01±0.07	−0.06	193307	6055±211	4.34±0.14	1.50	−0.27±0.07	−0.49
44594	5723±110	4.31±0.21	1.25	0.04±0.07	0.10	194640	5529±329	4.41±0.21	1.00	−0.05±0.07	0.04
45289	5675±82	4.29±0.19	1.00	−0.06±0.08	0.00	196068	5773±90	3.98±0.20	1.50	0.17±0.07	0.00
45701	5714±90	3.94±0.19	1.25	0.07±0.07	0.21	196800	5873±30	4.25±0.20	1.50	0.05±0.07	0.07
52447	5879±43	3.96±0.18	1.50	0.08±0.08	−0.14	199190	5812±27	4.12±0.19	1.50	0.04±0.07	0.03
53705	5822±87	4.49±0.11	1.25	−0.23±0.08	−0.23	199288	5935±79	4.67±0.21	1.50	−0.54±0.08	−0.68
53706	5378±53	4.60±0.16	1.00	−0.25±0.07	−0.12	199509	5837±39	4.69±0.19	1.25	−0.29±0.08	−0.39
55720	5583±93	4.70±0.15	1.00	−0.27±0.07	−0.14	202628	5782±39	4.44±0.18	1.50	−0.11±0.07	−0.11
59468	5626±140	4.40±0.17	1.00	0.05±0.07	0.06	204385	5907±76	4.23±0.18	1.50	−0.05±0.08	0.01
64184	5729±39	4.44±0.20	1.25	−0.23±0.07	−0.12	205536	5443±381	4.45±0.15	1.00	−0.08±0.07	0.00
69655	5960±22	4.48±0.20	1.50	−0.22±0.08	−0.19	207129	5892±64	4.41±0.17	1.25	−0.04±0.08	−0.04
72769	5470±138	4.01±0.19	1.25	0.14±0.07	–	207700	5609±224	4.21±0.15	1.00	0.03±0.07	0.01
73121	5963±19	4.11±0.18	1.50	−0.02±0.07	−0.17	208998	5982±129	4.57±0.19	1.50	−0.34±0.07	−0.44
73524	5901±112	4.44±0.20	1.25	0.09±0.06	0.08	209653	5941±104	4.24±0.20	1.50	−0.15±0.08	−0.09
78429	5702±112	4.27±0.18	1.25	0.01±0.07	0.12	210918	5749±87	4.44±0.19	1.25	−0.12±0.07	−0.02
80635	5515±164	3.48±0.17	1.50	0.18±0.09	–	211317	5743±92	4.03±0.19	1.50	0.10±0.07	0.06
82082	5879±59	4.19±0.16	1.50	−0.03±0.07	0.18	212168	5898±73	4.26±0.20	1.50	−0.05±0.08	0.04
83529A	5945±104	4.51±0.20	1.25	−0.20±0.07	−0.22	212330	5699±155	4.13±0.20	1.25	0.00±0.08	−0.06
86819	5957±69	4.27±0.19	1.50	−0.09±0.07	0.03	212708	5512±309	4.18±0.19	1.25	0.13±0.07	0.16
88742	5920±87	4.46±0.16	1.25	−0.10±0.08	−0.11	214759	5351±94	4.27± 0.24	1.0	0.12±0.07	0.11
92987	5770±36	4.00±0.15	1.50	−0.08±0.08	0.05	214953	5945±117	4.27±0.17	1.50	−0.06±0.07	−0.21
93385	5910±22	4.34±0.14	1.50	−0.08±0.07	−0.25	217958	5711±149	3.97±0.14	1.50	0.09±0.09	0.05
96423	5655±116	4.36±0.18	1.25	0.01±0.07	0.04	219077	5357±473	3.98±0.13	1.25	−0.21±0.07	−0.10
102365	5702±102	4.69±0.19	1.00	−0.28±0.07	−0.23	220507	5620±92	4.22±0.21	1.25	−0.08±0.07	−0.02
105328	5855±69	4.03±0.18	1.50	0.05±0.08	0.16	221420	5652±172	3.72±0.15	1.50	0.17±0.08	0.14
106453	5566±76	4.38±0.17	1.25	−0.01±0.08	–	223171	5717±111	4.09±0.18	1.25	0.01±0.07	0.02

Table 2 – *continued* Atmospheric Parameters and Metallicities for all target stars

HD	T_{eff} (K)	Log g	ξ_t (km/s)	[Fe/H] Spec	Phot	HD	T_{eff} (K)	Log g	ξ_t (km/s)	[Fe/H] Spec	Phot
Planetary Host Stars:											
142	6150±35	4.21±0.20	1.50	−0.02±0.07	−0.07	83443	5294±10	4.12±0.15	1.00	0.23±0.05	–
2039	5726±58	3.96±0.21	1.25	0.16±0.07	0.12	102117	5537±125	4.14±0.20	1.25	0.18±0.07	0.11
17051	6017±22	4.32±0.16	1.50	0.01±0.07	0.06	117618	5886±81	4.19±0.16	1.25	−0.04±0.08	0.01
23079	5947±28	4.49±0.20	1.50	−0.20±0.07	−0.16	134987	5623±57	4.16±0.15	1.25	0.17±0.07	0.25
30177	5394±40	4.00±0.18	1.25	0.20±0.07	0.22	160691	5614±247	3.96±0.18	1.25	0.18±0.06	0.23
39091	5895±52	4.21±0.21	1.25	0.03±0.08	0.02	164427	5822±42	3.96±0.14	1.50	−0.01±0.07	0.05
70642	5620±112	4.35±0.22	1.25	0.08±0.06	0.17	196050	5693±155	3.86±0.14	1.25	0.09±0.08	0.11
73526	5493±14	3.93±0.12	1.25	0.11±0.07	0.13	213240	5886±52	4.20±0.16	1.50	0.09±0.09	0.00
75289	5963±10	4.13±0.19	1.50	0.12±0.07	0.08	216435	5831±36	3.98±0.15	1.50	0.09±0.07	−0.03
76700	5470±27	3.87±0.17	1.50	0.10±0.08	0.16	216437	5714±108	4.06±0.21	1.25	0.13±0.07	0.13

ing values based on measured photometry). Our abundances along with those of Fischer & Valenti (2005) and Santos et al. (2004) are listed in Table 4. For the remaining metallicity studies with overlap, the abundances we determine agree to within the uncertainties (which are typically ±0.10 dex).

Significant overlap also occurred with the other elements studied.Na, Si, Ti and Ni were studied in 19 common host stars by Fischer & Valenti (2005) and Valenti & Fischer (2005) (along with 108 non-host stars), Na and Al were studied in 17 common host stars by Berião et al. (2005), Si, Ca, Ni and Ti were studied in 14 common host stars by Bodaghee et al. (2003) and C was studied in 16 common host stars by Ecuvillon et al. (2004), whilst two common host stars had C, Ca, Ti and Si abundances determined by Santos et al. (2000) and all elements were studied in one common host star by Sadakane et al. (2002). We obtained a good agreement (within uncertainties) between the vast majority of our results and those previously published for Si, Ca, Ni, Na, Si and C, whilst Ti and Al abundances deviated significantly from those published by other authors. This deviation is likely to be due to the use of different line lists (for Ti) and the smaller number of lines utilised in determining the abundances (for both Ti and Al).

In any case, it is worth re-stating that the main aim of this study is to compare "like with like". That is to compare the metallicities of planet-host and non-host stars, rather than to obtain the best possible abundances for our target stars.

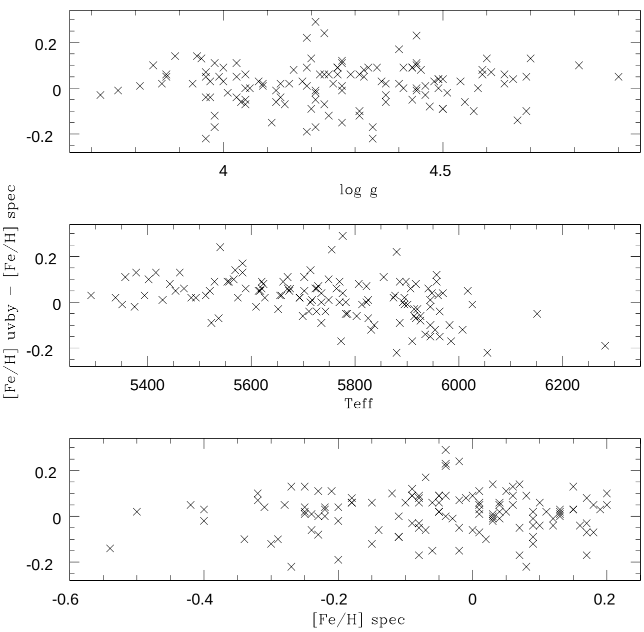

Figure 1. Distributions of the difference Δ[Fe/H] = $[Fe/H]_{uvby}$ − $[Fe/H]_{spec}$ versus log g *(top)*, T_{eff} *(middle)*, and $[Fe/H]_{spec}$ *(bottom)*.

3 ABUNDANCE TRENDS

3.1 Iron

The metallicity distributions for our two samples (V < 7.5 and V > 7.5) are shown in Figure 2. This simple visual comparison suggests that the planetary host stars are somewhat biased towards higher metallicities. Table 5 compares the mean and median of the two samples, with the quoted uncertainties being the standard error in the mean, and the median uncertainty from the algorithm of Kendall, Stuart & Ord (1987)[1]. The data indicates that there is indeed evidence that planetary hosts are somewhat biased towards higher metallicities, compared to the larger sample of stars not known to host planets. The stars with V > 7.5 do not reflect this trend, which is entirely unsurprising as this sample was selected based on its high metallicity.

However, it should be noted that the "planetary host stars have higher metallicity" effect is not a strong one. The difference between the median spectroscopic metallicities of the two samples is only 0.16 dex, while the photometric metallicity difference is only 0.11 dex. It is also reassuring

[1] For a distribution with N values, the error in the median is the range in values on either side of the median which contains $(\sqrt{N})/2$ values

Table 3. Stellar Abundances for all target stars

HD	[C/H]	[Na/H]	[Al/H]	[Si/H]	[Ca/H]	[Ti I/H]	[Ti II/H]	[Ni/H]
Non-Host Stars:								
1581	−0.28 ± 0.10	−0.16 ± 0.09	−0.34 ± 0.14	−0.14 ± 0.07	−0.18 ± 0.10	−0.10 ± 0.11	−0.20 ± 0.04	−0.26 ± 0.12
3277	0.02 ± 0.08	−0.04 ± 0.09	−0.29 ± 0.05	−0.05 ± 0.06	−0.14 ± 0.13	−0.03 ± 0.12	−0.12 ± 0.06	−0.13 ± 0.09
3823	−0.22 ± 0.08	−0.28 ± 0.8	−0.40 ± 0.10	−0.22 ± 0.15	−0.19 ± 0.11	−0.24 ± 0.12	−0.25 ± 0.04	−0.30 ± 0.08
4308	−0.16 ± 0.08	−0.21 ± 0.06	−0.30 ± 0.05	−0.15 ± 0.06	−0.22 ± 0.13	−0.02 ± 0.13	−0.16 ± 0.06	−0.27 ± 0.12
7570	0.20 ± 0.14	0.11 ± 0.09	−0.08 ± 0.05	0.18 ± 0.10	0.11 ± 0.12	0.03 ± 0.09	0.00 ± 0.06	0.09 ± 0.08
9280	0.38 ± 0.19	0.22 ± 0.17	0.21 ± 0.16	0.28 ± 0.12	0.20 ± 0.12	0.09 ± 0.13	0.07 ± 0.06	0.11 ± 0.05
10180	0.06 ± 0.11	0.07 ± 0.07	−0.10 ± 0.09	0.06 ± 0.04	0.01 ± 0.10	0.02 ± 0.05	−0.01 ± 0.09	0.04 ± 0.08
10700	−0.18 ± 0.10	−0.35 ± 0.08	−0.42 ± 0.06	−0.29 ± 0.06	−0.38 ± 0.13	−0.09 ± 0.14	−0.25 ± 0.05	−0.43 ± 0.07
11112	0.18 ± 0.09	0.21 ± 0.08	0.01 ± 0.06	0.20 ± 0.07	0.10 ± 0.11	0.08 ± 0.12	0.02 ± 0.08	0.09 ± 0.10
12387	−0.05 ± 0.09	−0.17 ± 0.09	−0.24 ± 0.10	−0.08 ± 0.05	−0.18 ± 0.12	−0.04 ± 0.11	−0.11 ± 0.05	−0.26 ± 0.13
16417	0.07 ± 0.09	0.04 ± 0.06	−0.06 ± 0.06	0.10 ± 0.06	0.03 ± 0.07	0.05 ± 0.06	−0.01 ± 0.04	0.03 ± 0.08
18709	−0.26 ± 0.09	−0.32 ± 0.07	−0.38 ± 0.05	−0.18 ± 0.05	−0.13 ± 0.08	−0.11 ± 0.15	−0.12 ± 0.06	−0.25 ± 0.05
18907	−0.31 ± 0.14	−0.41 ± 0.17	−0.49 ± 0.19	−0.31 ± 0.16	−0.42 ± 0.14	−0.08 ± 0.09	−0.27 ± 0.06	−0.51 ± 0.08
19632	−0.03 ± 0.09	0.03 ± 0.04	−0.18 ± 0.09	0.05 ± 0.04	0.02 ± 0.13	0.05 ± 0.10	−0.17 ± 0.08	−0.02 ± 0.11
20201	−0.04 ± 0.12	−0.06 ± 0.08	−0.10 ± 0.08	0.09 ± 0.05	0.08 ± 0.10	0.06 ± 0.09	−0.02 ± 0.05	0.05 ± 0.12
20766	−0.19 ± 0.11	−0.18 ± 0.11	−0.37 ± 0.05	−0.16 ± 0.09	−0.17 ± 0.08	−0.11 ± 0.16	−0.23 ± 0.07	−0.27 ± 0.11
20782	0.01 ± 0.12	−0.15 ± 0.09	−0.27 ± 0.10	−0.03 ± 0.05	−0.10 ± 0.12	0.01 ± 0.16	−0.08 ± 0.07	−0.17 ± 0.09
20794	−0.08 ± 0.09	−0.21 ± 0.06	−0.31 ± 0.05	−0.16 ± 0.07	−0.27 ± 0.15	0.09 ± 0.10	−0.10 ± 0.06	−0.27 ± 0.11
20807	−0.19 ± 0.12	−0.22 ± 0.07	−0.43 ± 0.06	−0.18 ± 0.08	−0.29 ± 0.13	−0.16 ± 0.11	−0.24 ± 0.07	−0.34 ± 0.05
22104	0.19 ± 0.09	0.45 ± 0.15	0.19 ± 0.10	0.34 ± 0.07	0.15 ± 0.12	0.21 ± 0.14	0.16 ± 0.06	0.40 ± 0.06
23127	0.07 ± 0.12	−0.01 ± 0.06	−0.19 ± 0.06	0.05 ± 0.06	0.01 ± 0.09	−0.02 ± 0.11	−0.04 ± 0.07	−0.02 ± 0.05
26491	0.04 ± 0.03	−0.09 ± 0.10	−0.28 ± 0.07	−0.04 ± 0.02	−0.07 ± 0.11	−0.05 ± 0.10	−0.04 ± 0.06	−0.15 ± 0.09
30295	–	0.49 ± 0.18	0.12 ± 0.14	0.32 ± 0.16	0.12 ± 0.10	0.27 ± 0.14	0.16 ± 0.07	0.24 ± 0.14
31827	0.37 ± 0.12	0.50 ± 0.15	0.39 ± 0.13	0.52 ± 0.14	0.27 ± 0.13	0.25 ± 0.11	0.07 ± 0.08	0.37 ± 0.09
33811	0.03 ± 0.11	0.36 ± 0.07	0.20 ± 0.09	0.30 ± 0.06	−0.17 ± 0.11	−0.21 ± 0.12	−0.09 ± 0.04	0.20 ± 0.08
36108	−0.13 ± 0.06	−0.28 ± 0.11	−0.38 ± 0.17	−0.19 ± 0.05	−0.19 ± 0.08	−0.13 ± 0.10	−0.20 ± 0.08	−0.29 ± 0.12
38283	−0.07 ± 0.03	−0.16 ± 0.08	−0.35 ± 0.12	−0.15 ± 0.03	−0.18 ± 0.09	−0.13 ± 0.08	−0.20 ± 0.13	−0.27 ± 0.05
38382	0.03 ± 0.05	−0.08 ± 0.09	−0.27 ± 0.11	−0.01 ± 0.04	−0.06 ± 0.10	−0.04 ± 0.09	−0.10 ± 0.08	−0.17 ± 0.07
38973	−0.01 ± 0.06	−0.02 ± 0.06	−0.24 ± 0.10	0.01 ± 0.09	−0.05 ± 0.08	−0.10 ± 0.05	−0.18 ± 0.11	−0.04 ± 0.05
39213	–	0.65 ± 0.18	0.27 ± 0.12	0.33 ± 0.10	0.17 ± 0.15	0.28 ± 0.16	0.16 ± 0.08	0.24 ± 0.10
42902	0.30 ± 0.13	0.29 ± 0.11	0.11 ± 0.08	0.32 ± 0.08	0.14 ± 0.13	0.17 ± 0.12	0.01 ± 0.06	0.03 ± 0.08
43884	0.04 ± 0.09	0.12 ± 0.08	−0.08 ± 0.07	0.13 ± 0.09	0.06 ± 0.10	0.06 ± 0.09	−0.04 ± 0.06	0.06 ± 0.11
44120	0.13 ± 0.10	0.09 ± 0.06	−0.12 ± 0.06	0.09 ± 0.07	0.08 ± 0.12	0.01 ± 0.10	−0.01 ± 0.05	−0.01 ± 0.07
44594	0.08 ± 0.05	0.11 ± 0.09	−0.05 ± 0.04	0.15 ± 0.09	0.06 ± 0.05	0.08 ± 0.10	0.05 ± 0.06	–
45289	0.12 ± 0.13	−0.04 ± 0.07	−0.10 ± 0.08	0.04 ± 0.05	−0.03 ± 0.09	0.05 ± 0.09	0.05 ± 0.07	−0.08 ± 0.10
45701	0.24 ± 0.13	0.21 ± 0.06	0.03 ± 0.06	0.18 ± 0.07	0.13 ± 0.12	0.04 ± 0.11	0.04 ± 0.07	0.08 ± 0.13
52447	0.30 ± 0.18	0.18 ± 0.07	−0.11 ± 0.13	0.24 ± 0.13	0.12 ± 0.11	0.09 ± 0.15	0.04 ± 0.03	0.11 ± 0.08
53705	−0.08 ± 0.11	−0.16 ± 0.05	−0.29 ± 0.10	−0.12 ± 0.09	−0.15 ± 0.11	−0.11 ± 0.10	−0.11 ± 0.04	−0.26 ± 0.09
53706	−0.09 ± 0.08	−0.14 ± 0.07	−0.31 ± 0.08	−0.15 ± 0.08	−0.26 ± 0.10	0.02 ± 0.09	−0.22 ± 0.08	−0.26 ± 0.12
55720	−0.13 ± 0.14	−0.23 ± 0.013	−0.26 ± 0.06	−0.12 ± 0.09	−0.23 ± 0.10	0.00 ± 0.11	−0.16 ± 0.07	−0.27 ± 0.06
59468	0.07 ± 0.08	0.11 ± 0.08	−0.11 ± 0.06	0.08 ± 0.09	0.03 ± 0.11	0.10 ± 0.09	0.03 ± 0.07	0.02 ± 0.11
64184	0.01 ± 0.06	−0.12 ± 0.07	−0.25 ± 0.06	−0.07 ± 0.06	−0.17 ± 0.09	0.01 ± 0.10	−0.12 ± 0.09	−0.24 ± 0.09
69655	−0.12 ± 0.09	−0.12 ± 0.09	−0.41 ± 0.06	−0.14 ± 0.10	−0.20 ± 0.09	−0.15 ± 0.11	−0.25 ± 0.06	−0.24 ± 0.07
72769	–	0.33 ± 0.19	0.18 ± 0.16	0.34 ± 0.13	0.13 ± 0.13	0.16 ± 0.14	0.07 ± 0.04	0.19 ± 0.13
73121	0.11 ± 0.08	0.08 ± 0.09	−0.15 ± 0.10	0.05 ± 0.10	0.05 ± 0.09	0.03 ± 0.11	−0.01 ± 0.05	−0.06 ± 0.10
73524	0.11 ± 0.06	0.02 ± 0.07	−0.10 ± 0.12	0.12 ± 0.04	0.11 ± 0.08	0.05 ± 0.03	0.11 ± 0.08	0.11 ± 0.07
78429	0.02 ± 0.05	0.01 ± 0.09	−0.14 ± 0.11	0.08 ± 0.09	−0.02 ± 0.12	0.07 ± 0.11	0.03 ± 0.06	0.00 ± 0.12
80635	0.33 ± 0.19	0.41 ± 0.18	0.43 ± 0.15	0.44 ± 0.21	0.32 ± 0.15	0.21 ± 0.16	0.10 ± 0.06	0.39 ± 0.13
82082	0.02 ± 0.04	−0.01 ± 0.06	−0.11 ± 0.10	0.09 ± 0.06	0.05 ± 0.16	−0.01 ± 0.17	−0.16 ± 0.07	−0.03 ± 0.15
83529A	−0.20 ± 0.12	−0.28 ± 0.10	–	−0.20 ± 0.14	−0.12 ± 0.12	−0.12 ± 0.13	−0.09 ± 0.04	−0.28 ± 0.12
86819	0.01 ± 0.06	−0.05 ± 0.04	−0.25 ± 0.05	−0.01 ± 0.06	−0.05 ± 0.13	−0.07 ± 0.11	−0.11 ± 0.05	−0.14 ± 0.07
88742	0.00 ± 0.06	−0.12 ± 0.06	−0.34 ± 0.05	−0.04 ± 0.07	−0.07 ± 0.13	−0.10 ± 0.10	−0.12 ± 0.09	−0.17 ± 0.09
92987	–	0.02 ± 0.07	0.02 ± 0.07	0.07 ± 0.06	−0.03 ± 0.09	−0.04 ± 0.10	−0.13 ± 0.05	−0.09 ± 0.08
93385	0.03 ± 0.10	−0.01 ± 0.06	−0.22 ± 0.05	0.01 ± 0.07	−0.07 ± 0.11	−0.01 ± 0.12	−0.09 ± 0.06	−0.10 ± 0.11
96423	–	0.06 ± 0.05	−0.09 ± 0.07	0.12 ± 0.07	−0.03 ± 0.12	0.06 ± 0.10	−0.02 ± 0.04	0.02 ± 0.10
102365	−0.18 ± 0.15	−0.20 ± 0.16	–	−0.19 ± 0.12	−0.24 ± 0.11	−0.12 ± 0.13	−0.15 ± 0.09	−0.29 ± 0.12
105328	0.13 ± 0.08	0.12 ± 0.05	−0.08 ± 0.06	0.16 ± 0.09	0.11 ± 0.09	0.09 ± 0.12	0.01 ± 0.06	0.07 ± 0.13
106453	−0.10 ± 0.09	0.02 ± 0.08	−0.18 ± 0.07	0.07 ± 0.09	−0.01 ± 0.08	0.01 ± 0.11	−0.09 ± 0.04	−0.06 ± 0.13

Table 3 – *continued* Stellar Abundances for all target stars

HD	[C/H]	[Na/H]	[Al/H]	[Si/H]	[Ca/H]	[Ti I/H]	[Ti II/H]	[Ni/H]
107692	0.00 ± 0.05	0.05 ± 0.06	−0.09 ± 0.11	0.12 ± 0.08	0.05 ± 0.13	0.03 ± 0.10	−0.14 ± 0.04	−0.02 ± 0.11
108309	0.14 ± 0.06	0.13 ± 0.07	−0.02 ± 0.09	0.13 ± 0.05	0.10 ± 0.12	0.07 ± 0.11	0.00 ± 0.07	0.02 ± 0.13
114613	–	0.19 ± 0.07	−0.08 ± 0.06	0.19 ± 0.06	0.08 ± 0.10	0.12 ± 0.11	0.03 ± 0.06	0.08 ± 0.10
114853	−0.17 ± 0.09	−0.25 ± 0.10	−0.37 ± 0.12	−0.21 ± 0.09	−0.15 ± 0.11	−0.11 ± 0.06	−0.10 ± 0.10	−0.25 ± 0.12
120690	−0.12 ± 0.08	−0.07 ± 0.03	−0.22 ± 0.07	−0.04 ± 0.02	−0.06 ± 0.04	−0.13 ± 0.10	−0.13 ± 0.10	−0.13 ± 0.05
121384	−0.38 ± 0.06	−0.36 ± 0.12	–	−0.36 ± 0.14	−0.37 ± 0.10	−0.28 ± 0.12	–	−0.42 ± 0.12
122862	−0.08 ± 0.12	−0.15 ± 0.09	−0.29 ± 0.11	−0.09 ± 0.08	−0.13 ± 0.12	−0.12 ± 0.13	−0.12 ± 0.08	−0.20 ± 0.11
128620	–	0.22 ± 0.07	0.03 ± 0.05	0.23 ± 0.05	0.08 ± 0.09	0.04 ± 0.18	−0.01 ± 0.07	0.06 ± 0.19
131923	0.10 ± 0.06	0.03 ± 0.05	–	0.14 ± 0.05	−0.01 ± 0.08	0.01 ± 0.07	−0.05 ± 0.06	−0.07 ± 0.10
134060	0.05 ± 0.06	0.09 ± 0.09	−0.10 ± 0.12	0.10 ± 0.07	0.05 ± 0.10	0.04 ± 0.12	0.01 ± 0.04	0.07 ± 0.07
134330	−0.04 ± 0.13	0.04 ± 0.08	−0.13 ± 0.09	0.07 ± 0.05	0.04 ± 0.13	0.04 ± 0.13	−0.11 ± 0.05	−0.05 ± 0.12
134331	0.05 ± 0.06	−0.03 ± 0.11	–	0.02 ± 0.06	−0.07 ± 0.06	−0.06 ± 0.09	−0.08 ± 0.11	−0.03 ± 0.08
134606	0.27 ± 0.11	0.35 ± 0.09	0.12 ± 0.05	0.32 ± 0.08	0.12 ± 0.08	0.19 ± 0.09	0.07 ± 0.04	0.18 ± 0.07
136352	0.26 ± 0.10	−0.20 ± 0.09	−0.36 ± 0.09	−0.18 ± 0.07	−0.24 ± 0.13	−0.06 ± 0.04	−0.13 ± 0.07	−0.32 ± 0.11
140901	0.03 ± 0.05	0.10 ± 0.08	−0.11 ± 0.11	0.11 ± 0.09	0.04 ± 0.11	0.09 ± 0.12	0.01 ± 0.06	0.06 ± 0.05
143114	−0.18 ± 0.11	−0.30 ± 0.14	−0.41 ± 0.18	−0.26 ± 0.09	−0.26 ± 0.12	−0.14 ± 0.12	−0.24 ± 0.04	−0.41 ± 0.14
145825	0.01 ± 0.05	−0.01 ± 0.04	−0.19 ± 0.11	0.04 ± 0.06	−0.02 ± 0.11	0.00 ± 0.11	0.00 ± 0.07	−0.02 ± 0.09
147722	0.05 ± 0.08	0.02 ± 0.05	−0.13 ± 0.10	0.07 ± 0.08	0.05 ± 0.14	−0.01 ± 0.09	−0.10 ± 0.07	0.01 ± 0.09
150248	−0.12 ± 0.10	−0.08 ± 0.09	−0.24 ± 0.11	−0.04 ± 0.08	−0.12 ± 0.10	−0.01 ± 0.09	−0.10 ± 0.04	−0.09 ± 0.10
155974	−0.10 ± 0.12	−0.20 ± 0.09	−0.44 ± 0.06	−0.15 ± 0.07	−0.06 ± 0.13	−0.18 ± 0.09	−0.17 ± 0.09	−0.24 ± 0.09
158783	0.17 ± 0.10	−0.20 ± 0.08	–	0.07 ± 0.05	0.01 ± 0.07	0.03 ± 0.08	−0.12 ± 0.11	−0.02 ± 0.08
161050	−0.04 ± 0.08	−0.07 ± 0.09	−0.35 ± 0.12	−0.06 ± 0.04	−0.05 ± 0.04	−0.16 ± 0.05	−0.13 ± 0.09	−0.14 ± 0.09
161612	0.07 ± 0.09	0.13 ± 0.08	0.02 ± 0.05	0.17 ± 0.07	0.05 ± 0.08	0.08 ± 0.09	−0.01 ± 0.05	0.08 ± 0.13
162255	0.16 ± 0.07	0.13 ± 0.08	−0.08 ± 0.10	0.12 ± 0.05	0.06 ± 0.09	0.05 ± 0.09	−0.01 ± 0.09	−0.01 ± 0.04
168871	−0.04 ± 0.05	−0.07 ± 0.05	−0.28 ± 0.09	−0.08 ± 0.06	−0.14 ± 0.08	−0.13 ± 0.08	−0.17 ± 0.07	−0.17 ± 0.08
177565	0.09 ± 0.08	0.08 ± 0.07	−0.16 ± 0.06	0.07 ± 0.06	−0.09 ± 0.11	−0.03 ± 0.12	−0.15 ± 0.08	−0.08 ± 0.13
183877	−0.01 ± 0.08	−0.12 ± 0.08	−0.22 ± 0.05	−0.04 ± 0.05	−0.17 ± 0.08	0.05 ± 0.12	−0.02 ± 0.06	−0.17 ± 0.13
187805	0.08 ± 0.04	0.01 ± 0.03	−0.18 ± 0.08	0.05 ± 0.03	0.07 ± 0.05	−0.05 ± 0.03	−0.05 ± 0.05	0.00 ± 0.07
189567	−0.33 ± 0.13	−0.28 ± 0.10	−0.38 ± 0.06	−0.16 ± 0.09	−0.21 ± 0.15	−0.20 ± 0.16	−0.21 ± 0.08	−0.31 ± 0.12
190248	–	0.38 ± 0.10	0.16 ± 0.05	0.37 ± 0.05	0.10 ± 0.05	0.13 ± 0.04	0.03 ± 0.05	0.17 ± 0.06
192865	0.06 ± 0.15	0.03 ± 0.05	−0.18 ± 0.13	0.03 ± 0.11	0.10 ± 0.13	−0.04 ± 0.12	−0.07 ± 0.04	−0.29 ± 0.11
193193	−0.07 ± 0.11	−0.05 ± 0.10	−0.28 ± 0.14	−0.05 ± 0.09	−0.70 ± 0.12	−0.12 ± 0.13	−0.02 ± 0.06	−0.16 ± 0.13
193307	−0.33 ± 0.19	−0.28 ± 0.07	−0.45 ± 0.12	−0.33 ± 0.05	−0.14 ± 0.12	−0.21 ± 0.13	−0.17 ± 0.06	−0.29 ± 0.12
194640	–	0.02 ± 0.10	−0.19 ± 0.06	0.01 ± 0.08	−0.08 ± 0.11	−0.02 ± 0.12	−0.08 ± 0.05	−0.03 ± 0.12
196068	0.16 ± 0.09	0.24 ± 0.15	0.16 ± 0.13	0.31 ± 0.14	0.18 ± 0.12	0.14 ± 0.13	0.04 ± 0.05	0.22 ± 0.14
196800	0.36 ± 0.21	0.14 ± 0.17	−0.05 ± 0.13	0.15 ± 0.14	0.01 ± 0.10	0.06 ± 0.12	0.01 ± 0.06	0.14 ± 0.12
199190	0.21 ± 0.13	0.14 ± 0.09	−0.03 ± 0.10	0.15 ± 0.08	0.03 ± 0.11	0.01 ± 0.12	−0.04 ± 0.06	0.03 ± 0.12
199288	−0.41 ± 0.15	−0.50 ± 0.14	−0.30 ± 0.10	−0.44 ± 0.10	−0.39 ± 0.14	−0.25 ± 0.16	−0.39 ± 0.06	−0.62 ± 0.11
199509	–	−0.24 ± 0.14	−0.53 ± 0.19	−0.24 ± 0.10	−0.26 ± 0.10	−0.19 ± 0.14	−0.26 ± 0.05	−0.38 ± 0.13
202628	−0.15 ± 0.10	−0.12 ± 0.09	−0.30 ± 0.14	−0.04 ± 0.09	−0.07 ± 0.12	−0.06 ± 0.13	−0.18 ± 0.06	−0.21 ± 0.11
204385	0.07 ± 0.13	0.01 ± 0.05	−0.15 ± 0.10	0.03 ± 0.07	−0.03 ± 0.13	0.00 ± 0.12	−0.10 ± 0.04	−0.04 ± 0.13
205536	−0.03 ± 0.08	−0.02 ± 0.07	−0.17 ± 0.10	0.03 ± 0.06	−0.11 ± 0.13	0.06 ± 0.12	−0.09 ± 0.07	−0.10 ± 0.11
207129	−0.16 ± 0.14	−0.07 ± 0.06	−0.24 ± 0.14	−0.01 ± 0.04	0.00 ± 0.13	−0.04 ± 0.12	−0.04 ± 0.04	−0.10 ± 0.13
207700	0.13 ± 0.11	0.08 ± 0.11	−0.01 ± 0.08	0.15 ± 0.012	0.05 ± 0.10	0.15 ± 0.14	0.11 ± 0.04	0.04 ± 0.10
208998	−0.08 ± 0.06	−0.27 ± 0.13	−0.31 ± 0.05	−0.16 ± 0.11	−0.21 ± 0.12	−0.05 ± 0.11	−0.14 ± 0.07	−0.32 ± 0.13
209653	−0.08 ± 0.13	−0.11 ± 0.09	−0.33 ± 0.10	−0.08 ± 0.07	−0.10 ± 0.14	−0.09 ± 0.15	−0.13 ± 0.08	−0.28 ± 0.13
210918	−0.02 ± 0.08	−0.14 ± 0.08	−0.19 ± 0.10	−0.06 ± 0.05	−0.10 ± 0.10	−0.03 ± 0.12	−0.06 ± 0.07	−0.17 ± 0.08
211317	0.25 ± 0.09	0.29 ± 0.09	0.08 ± 0.05	0.25 ± 0.08	0.10 ± 0.07	0.13 ± 0.06	0.03 ± 0.09	0.17 ± 0.08
212168	−0.19 ± 0.12	−0.04 ± 0.09	−0.20 ± 0.10	0.00 ± 0.07	−0.02 ± 0.12	0.01 ± 0.11	−0.11 ± 0.05	−0.09 ± 0.10
212330	–	−0.04 ± 0.06	−0.16 ± 0.11	0.03 ± 0.06	0.04 ± 0.11	−0.03 ± 0.09	−0.02 ± 0.04	−0.08 ± 0.12
212708	0.27 ± 0.14	0.23 ± 0.09	0.08 ± 0.04	0.28 ± 0.08	0.03 ± 0.10	0.06 ± 0.13	–	−0.11 ± 0.08
214759	–	0.26 ± 0.07	0.07 ± 0.04	0.26 ± 0.11	0.00 ± 0.05	0.17 ± 0.07	0.06 ± 0.08	0.19 ± 0.08
214953	0.09 ± 0.06	−0.04 ± 0.07	−0.20 ± 0.08	0.02 ± 0.07	−0.02 ± 0.16	−0.09 ± 0.17	−0.01 ± 0.09	0.00 ± 0.11
217958	–	0.36 ± 0.10	0.09 ± 0.05	0.32 ± 0.07	0.12 ± 0.15	0.15 ± 0.14	0.05 ± 0.06	0.10 ± 0.12
219077	–	−0.19 ± 0.10	−0.28 ± 0.11	−0.09 ± 0.06	−0.16 ± 0.13	0.00 ± 0.09	–	−0.19 ± 0.12
220507	0.15 ± 0.09	0.00 ± 0.11	−0.09 ± 0.12	0.04 ± 0.08	−0.04 ± 0.10	0.05 ± 0.09	−0.04 ± 0.08	−0.05 ± 0.09
221420	–	0.37 ± 0.07	0.21 ± 0.08	0.33 ± 0.05	0.23 ± 0.09	0.22 ± 0.12	0.13 ± 0.04	0.33 ± 0.10
223171	0.19 ± 0.13	0.08 ± 0.07	−0.12 ± 0.10	0.09 ± 0.06	0.04 ± 0.12	0.11 ± 0.13	0.06 ± 0.05	−0.01 ± 0.14

Table 3 – *continued* Stellar Abundances for all target stars

HD	[C/H]	[Na/H]	[Al/H]	[Si/H]	[Ca/H]	[Ti I/H]	[Ti II/H]	[Ni/H]
Host Stars:								
142	0.11 ± 0.16	−0.01 ± 0.07	−0.20 ± 0.06	0.06 ± 0.07	0.08 ± 0.12	−0.12 ± 0.12	−0.09 ± 0.07	−0.01 ± 0.06
2039	0.22 ± 0.16	0.34 ± 0.07	−0.03 ± 0.05	0.28 ± 0.12	0.22 ± 0.12	0.15 ± 0.13	–	0.18 ± 0.06
17051	0.09 ± 0.11	0.06 ± 0.05	−0.17 ± 0.05	0.09 ± 0.07	0.07 ± 0.13	−0.02 ± 0.12	−0.03 ± 0.06	0.03 ± 0.04
23079	−0.07 ± 0.10	−0.15 ± 0.08	−0.33 ± 0.05	−0.08 ± 0.05	−0.12 ± 0.11	−0.13 ± 0.11	−0.27 ± 0.08	−0.24 ± 0.05
30177	0.27 ± 0.09	0.37 ± 0.09	0.26 ± 0.07	0.43 ± 0.08	0.14 ± 0.13	0.20 ± 0.13	0.13 ± 0.07	0.30 ± 0.11
39091	0.03 ± 0.06	0.09 ± 0.06	−0.15 ± 0.08	0.07 ± 0.03	0.07 ± 0.08	0.00 ± 0.02	0.00 ± 0.07	0.08 ± 0.05
70642	–	0.28 ± 0.12	–	0.19 ± 0.11	0.04 ± 0.06	0.11 ± 0.10	0.00 ± 0.08	0.17 ± 0.06
73526	0.22 ± 0.09	0.20 ± 0.06	0.15 ± 0.05	0.26 ± 0.08	0.13 ± 0.12	0.18 ± 0.11	0.12± 0.06	0.12 ± 0.11
75289	0.12 ± 0.18	0.08 ± 0.06	0.01 ± 0.05	0.23 ± 0.05	0.21 ± 0.10	0.17 ± 0.11	0.16 ± 0.05	0.19 ± 0.07
76700	0.16 ± 0.11	0.28 ± 0.08	0.24 ± 0.04	0.30 ± 0.09	0.17 ± 0.11	0.20 ± 0.10	−0.02 ± 0.05	0.11 ± 0.12
83443	0.30 ± 0.23	0.52 ± 0.09	0.33 ± 0.06	0.50 ± 0.02	0.16 ± 0.08	0.24 ± 0.17	0.17 ± 0.04	0.33 ± 0.10
102117	0.33 ± 0.13	0.24 ± 0.09	0.15 ± 0.12	0.29 ± 0.13	0.14 ± 0.08	0.24 ± 0.11	–	0.19 ± 0.09
117618	0.01 ± 0.15	0.03 ± 0.07	−0.14 ± 0.09	0.02 ± 0.06	0.01 ± 0.12	−0.06 ± 0.13	−0.04 ± 0.05	−0.08 ± 0.12
134987	0.29 ± 0.10	0.34 ± 0.07	0.15 ± 0.06	0.32 ± 0.05	0.16 ± 0.13	0.19 ± 0.11	0.11 ± 0.06	0.20 ± 0.11
160691	0.31 ± 0.12	0.42 ± 0.06	0.13 ± 0.05	0.31 ± 0.07	0.18 ± 0.11	0.18 ± 0.12	0.12 ± 0.05	0.18 ± 0.09
164427	0.14 ± 0.09	0.12 ± 0.08	−0.10 ± 0.06	0.11 ± 0.08	0.04 ± 0.12	0.04 ± 0.09	−0.11 ± 0.06	−0.01 ± 0.08
196050	0.20 ± 0.11	0.26 ± 0.07	–	0.26 ± 0.06	0.17 ± 0.11	0.03 ± 0.11	−0.07 ± 0.07	0.15 ± 0.09
213240	0.18 ± 0.08	0.10 ± 0.06	−0.08 ± 0.05	0.14 ± 0.06	0.08 ± 0.12	0.09 ± 0.11	0.00 ± 0.07	0.05 ± 0.10
216435	0.17 ± 0.09	0.20 ± 0.11	−0.01 ± 0.05	0.21 ± 0.07	0.14 ± 0.10	0.08 ± 0.04	0.08 ± 0.06	–
216437	0.23 ± 0.10	0.24 ± 0.07	0.10 ± 0.04	0.25 ± 0.08	0.18 ± 0.11	0.13 ± 0.10	0.16 ± 0.05	0.11 ± 0.10

Table 4. Comparison of metallicities for common stars

HD	This Paper	Santos et al. (2004)	Fishcer & Valenti (2005)
142	−0.02±0.07	0.14 ± 0.07	0.10
2039	0.16±0.07	0.32 ± 0.06	0.32
17051	0.01±0.07	0.26 ± 0.06	0.11
23079	−0.20±0.07	−0.11 ± 0.06	−0.11
30177	0.20±0.07	0.39	0.39
39091	0.03±0.08	0.10±0.04	0.05
70642	0.08±0.06	0.18±0.04	0.16
73526	0.11±0.07	0.27±0.06	0.25
75289	0.12±0.07	0.28±0.07	0.22
76700	0.10±0.08	0.41±0.05	0.35
83443	0.23±0.05	0.35±0.08	0.36
102117	0.18±0.07	–	0.30
117618	−0.04±0.08	–	0.00
134987	0.17±0.07	0.30±0.04	0.28
160691	0.18±0.06	0.32±0.04	0.29
196050	0.09±0.08	0.22±0.05	0.23
213240	0.09±0.09	0.17±0.05	0.14
216435	0.09±0.07	0.24±0.05	0.24
216437	0.13±0.07	0.25±0.04	0.22

NOTE - All Fischer and Valenti (2005) errors are approximately ±0.03.

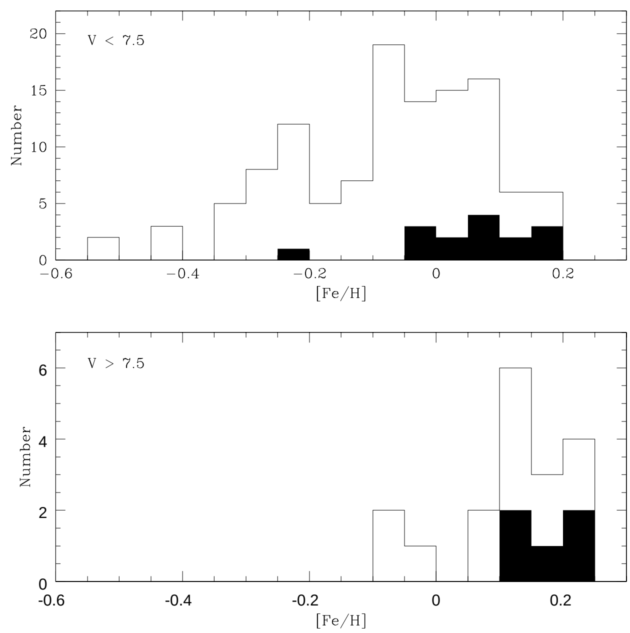

Figure 2. Histogram of metallicity for AAPS G-type stars. Known planetary host stars are shaded black. *Top:* Stars with V < 7.5. *Bottom:* Stars with V > 7.5.

to note that the differences between the two populations is close to that found by Fischer & Valenti (2005) who identified a 0.12 dex difference between host and non-host stars for their study.

A more powerful and non-parametric comparison between the two samples can be made with the Kolmogorov-Smirnov (K-S) test (Chakravart et al. 1967). This tests the hypothesis that the two observed empirical distributions are drawn from the same parent sample. A K-S test showed no significant difference between the two populations for the V > 7.5 sample. The V < 7.5 sample, however, shows a significant difference with 99.4% confidence (ie. probability of the two distributions being drawn from the same parent distribution = 6.1×10^{-3}). The nature of the K-S test is such that this does *not* indicate that planetary host stars are preferentially metal-rich, but rather just that the metallicity distrib-

Table 5. Metallicity Distributions.

Sample	Mean	Median	#
Host Stars:			
Spectroscopic Metallicities			
V < 7.5 :	+0.06±0.03	$0.09^{+0.04}_{-0.06}$	15
V > 7.5 :	+0.16±0.02	$0.16^{+0.04}_{-0.05}$	5
Photometric Metallicities			
V < 7.5 :	+0.06±0.03	$0.06^{+0.05}_{-0.04}$	15
V > 7.5 :	+0.16±0.02	$0.16^{+0.03}_{-0.05}$	4
Non-Host Stars:			
Spectroscopic Metallicities			
V < 7.5 :	−0.09±0.01	−0.07±0.02	103
V > 7.5 :	+0.10±0.03	$+0.15^{+0.02}_{-0.06}$	13
Photometric Metallicities			
V < 7.5 :	−0.08±0.02	$-0.05^{+0.02}_{-0.05}$	100
V > 7.5 :	+0.14±0.04	$+0.18^{+0.04}_{-0.06}$	11

Table 6. Statistical analysis of abundance distributions (V < 7.5).

Element		Planetary Hosts	Non-Planetary Hosts
Ni	Mean	+0.07± 0.03 (14)	−0.11 ± 0.02 (103)
	Median	+0.10± 0.06	$-0.10\ ^{+0.06}_{-0.07}$
Ca	Mean	+0.10± 0.02 (15)	−0.06 ± 0.01 (103)
	Median	$+0.08^{+0.08}_{-0.01}$	$-0.05\ ^{+0.02}_{-0.01}$
Ti I	Mean	+0.06± 0.03 (15)	−0.02 ± 0.01 (103)
	Median	$+0.08^{+0.03}_{-0.05}$	−0.01 ± 0.02
Ti II	Mean	+0.00± 0.03 (14)	−0.08 ± 0.01 (100)
	Median	$+0.00^{+0.11}_{-0.04}$	$-0.09^{+0.03}_{-0.01}$
C	Mean	+0.15± 0.03 (14)	−0.01 ± 0.02 (91)
	Median	$+0.16^{+0.02}_{-0.04}$	$+0.01\ ^{+0.02}_{-0.03}$
Si	Mean	+0.16± 0.03 (15)	+0.01 ± 0.02 (103)
	Median	$+0.19^{+0.04}_{-0.08}$	$+0.02\ ^{+0.02}_{-0.03}$
Na	Mean	+0.15± 0.04 (15)	−0.03 ± 0.02 (103)
	Median	$+0.12^{+0.12}_{-0.03}$	−0.04 ± 0.03
Al	Mean	−0.05± 0.04 (13)	−0.18 ± 0.02 (103)
	Median	$-0.08^{+0.04}_{-0.08}$	$-0.19\ ^{+0.02}_{-0.03}$

ution for these stars is different from the non-planetary host sample. Our data thus draws a strong conclusion that there are differences between the planet-host and non-planet-host metallicity distributions of the V<7.5 sample, and that this difference is in the sense that the planet-host stars have higher metallicities.

3.2 Other Elements

Abundances for seven other elements (in addition to Fe) were also estimated. In general, the bias of planetary host stars does not appear to be limited solely to Fe. Planetary host stars are weakly biased towards higher abundances in all of the elements studied here. The same analyses performed on Fe were performed for these other elements, and the results can be seen in Table 6 (for V < 7.5) and Table 7 (for V > 7.5).

The V<7.5 sample, reveals that planet-host stars hosts tend to have slightly higher abundances in all the elements measured. This is in contrast to previous studies which have found no such enrichment present (for example Gonzalez et al. 2001; Santos et al. 2000; Bodaghee et al. 2003; Fischer & Valenti 2005). The effect is most notable for Ni where the difference between the medians of the planetary hosts and the non-planetary hosts is 0.18 dex. This, combined with the relatively small uncertainties on the medians themselves, strongly suggests the observed effect is real. Si, Na, C and Ca display the effect less strongly, while Al, Ti I and Ti II showed the weakest trends with their medians only separated by 0.13, 0.08 and 0.08 dex respectively. The differences between planet hosts and non-planet hosts shown in Table 6 is similar to that listed in Bodaghee et al. (2003); Ecuvillon et al. (2004) and Berião et al. (2005). As with the [Fe/H] distribution, the V>7.5 sample reveals metal enrichment in both the planet-host and non-planet-host stars. Again, this is not surprising as this sample was selected based on its enrichment.

Table 7. Statistical analysis of abundance distributions (V > 7.5).

Element		Planetary Hosts	Non-Planetary Hosts
Ni	Mean	+0.21± 0.04 (5)	+0.16 ± 0.04 (13)
	Median	$+0.18^{+0.12}_{-0.06}$	$+0.11^{+0.12}_{-0.08}$
Ca	Mean	+0.16± 0.01 (5)	+0.11 ± 0.03 (13)
	Median	$+0.16^{+0.01}_{-0.02}$	$+0.12\ ^{+0.02}_{-0.11}$
Ti I	Mean	+0.19± 0.01 (5)	+0.15 ± 0.03 (13)
	Median	$+0.20^{+0.04}_{-0.02}$	$+0.17\ ^{+0.04}_{-0.08}$
Ti II	Mean	+0.10± 0.04 (4)	+0.04 ± 0.02 (13)
	Median	$+0.13^{+0.04}_{-0.01}$	$+0.05^{+0.02}_{-0.04}$
C	Mean	+0.23± 0.02 (5)	+0.21 ± 0.05 (10)
	Median	$+0.22^{+0.05}_{-0.06}$	$+0.25\ ^{+0.05}_{-0.10}$
Si	Mean	+0.35± 0.04 (5)	+0.27 ± 0.04 (13)
	Median	$+0.30^{+0.13}_{-0.02}$	$+0.32\ ^{+0.02}_{-0.04}$
Na	Mean	+0.34± 0.05 (5)	+0.30 ± 0.06 (13)
	Median	$+0.34^{+0.03}_{-0.06}$	$+0.36\ ^{+0.09}_{-0.14}$
Al	Mean	+0.19± 0.06 (5)	+0.11 ± 0.05 (13)
	Median	$+0.24^{+0.02}_{-0.09}$	$+0.12\ ^{+0.08}_{-0.03}$

3.3 [Fe/H] Correlation with Planetary Parameters

We examined our data to see if there are correlations present between the orbital elements of planets, and the metallicities of their host stars – see Figure 3 for plots of [Fe/H] against M$\sin i$, semi-major axis a, and eccentricity for all the G-dwarfs in our sample known to have planets. No clear correlations between these orbital parameters, and host star metallicity, are observed. This is consistent with the findings of other studies (for example Reid 2002; Santos et al. 2003; Fischer & Valenti 2005).

4 DISCUSSION

Our results have confirmed that the metallicity distributions of the planetary host stars and the non-planetary host stars are different at the 99.4% confidence level. Moreover, the data confirms previous suggestions that the planetary host stars are metal-rich. The trend is observed to be relatively

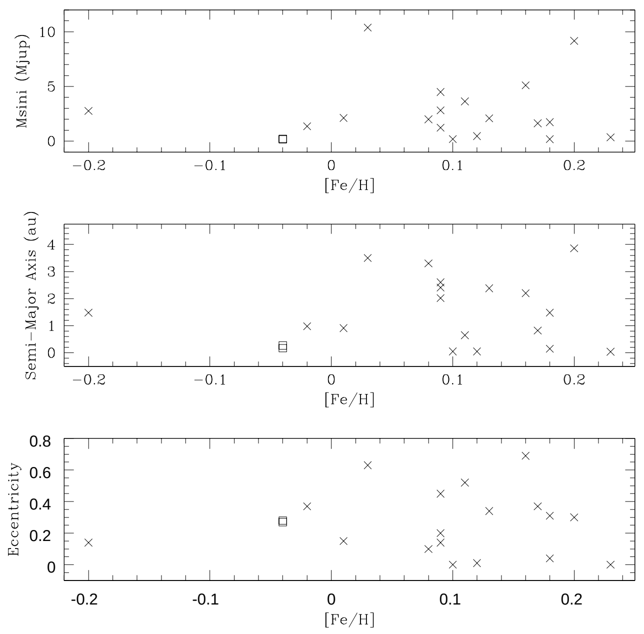

Figure 3. Distribution of the properties of extra-solar planetary systems as a function of metallicity. The brown dwarf candidate orbiting HD164427 has been omitted for clarity. The squares represent HD117618 whose companion properties have not yet been fully determined. *Top*: Plot of Msin*i* of the planetary companion vs. metallicity. *Middle*: Plot of the orbital semi-major axis of the planetary companion vs. metallicity. *Bottom*: Plot of the eccentricity of the orbit of the planetary companion vs. metallicity.

weak - it doesn't appear (based on currently known extra-solar planetary hosts) to be an "on-off" trend, such that planetary companions form above a critical metallicity of the host star. Determination of the cause of this trend is still the subject of much debate.

The two dominant models for the metallicity trend are: the "pollution" model, where metal rich material is added to the outer envelope of the star itself (Laughlin 2000; Gonzalez et al. 2001; Murray & Chaboyer 2002); and, the "primordial" model, where the gas cloud that the star originally formed from was already enriched (Santos et al. 2001). No clear consensus has emerged in favour of either model to date.

It has been suggested that an enrichment in lighter elements, and especially in ^{6}Li, would favour the pollution theory (Israelian et al. 2001). Thus it would appear that our findings of a trend for all elements we examined provides some support for this hypothesis, as was similarly reported in Santos et al. (2001, 2003, 2004, 2005) and Fischer & Valenti (2005). Simulations completed by other groups suggest that approximately 6 $M_\oplus$ of iron needs to be added to the host star's photosphere after the dissipation of the protoplanetary disk in order to produce the observed metallicity trend (Murray & Chaboyer 2002). However, no clear correlation between the metallicity of the host star and the orbital parameters of the remaining planetary companions is seen. It is hard to think of any mechanism by which the presence of the remaining planetary companion could have caused the accretion of another Jupiter-mass planet, independent of its final orbital parameters. There is, as yet, no widely accepted explanation for why *almost all* stars currently known to have planetary companions would have accreted this amount of iron while only $\sim$ 34% of non-host stars in this sample (V $<$ 7.5) show a similar level of enrichment.

These issues lead us to conclude that the enrichment seen in this study is most likely to be primordial – the gas cloud from which the star and subsequent planets formed was already enriched. This is in agreement with the conclusions of Santos et al. (2001, 2003, 2004, 2005) and Fischer & Valenti (2005). This is not to say that enrichment is essential for planetary formation (as indicated by the existence of a planetary host with [Fe/H] = −0.20). Rather, enrichment merely increases the efficiency of massive planet formation.

Boss (2000) concluded that if giant planets form via disc instabilities, as opposed to the core accretion method (Pollack et al. 1996), there would be no trend between the metallicity of the host star and the presence of a planetary companion. Indeed, there should be no direct link at all between them. We, however, clearly do observe a trend between the metallicty and the presence of a planetary companion. We thus draw the same conclusion as Santos et al. (2003, 2004, 2005) and Fischer & Valenti (2005) and support the core accretion scenario of giant planet formation. As with the Santos et al. (2003) data, the increase in planetary companions at higher metallicities suggests an increase in efficiency of planetary production with an increasing metallicity. However, this is by no means a firm conclusion as it is based solely on the predictive power of the Boss models.

4.1 Biassing planet searches for metallicity

The V $>$ 7.5 sample (selected because the stars were already known to be metal-rich) suggests that the biassing of target selection in a planet search towards higher metallicities may be somewhat more efficient in detecting planets. Of 19 stars studied, 5 have been found to have planetary companions (26±13% of the sample), compared to 15 hosts in the 117 stars studied with V $<$ 7.5 (13±5%). However, metallicity trend observed in this study is weak – the difference between the median of the planetary hosts and the non-planetary hosts is just 0.16 dex. We do not, therefore, see any evidence for any effect strong enough to lead to a "minimum metallicity" required for the planet formation. Moreover, several planetary hosts stars (both in this and other studies) have been found to have low metallicities (Santos et al. 2001; Reid 2002; Santos et al. 2003). These results would therefore caution against biasing the target stars of a planet search toward higher metallicities – while such a strategy may provide a gain in planet detection "hit rate" it would seriously compromise the ability of any resulting database to untangle the true cause of the metallicity trend.

5 SUMMARY

We have undertaken a detailed, uniform and internally consistent analysis of the abundances of 136 G-dwarfs, 20 of which are known to harbour an extra-solar planet. From this, we can confirm that the metallicity distributions of stars with planets and stars without known planets are significantly different, with evidence to indicate that planetary host stars do tend to be metal enriched. Our planetary host stars have a median [Fe/H] higher by 0.16 dex than non-planetary host stars. No apparent correlation was found between host star metallicity and the semi-major axis or the eccentricity of the planetary companions orbit, nor was there any statistical benefit found by biasing a sample of target stars towards higher metallicities.

Abundance analysis of other elements (C, Na, Al, Si, Ca, Ti and Ni) showed that the planetary host stars are biased towards higher abundances in all elements studied. As we have not observed any metallicity trends with the orbital parameters of the planetary companion(s), thought a key prediction of the Jupiter-mass accretion scenario, we conclude that the enrichment seen is most likely to be due to primordial enrichment of the gas cloud that produced the star and its planets.

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