Chemical Composition of Planet-harboring Stars

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Abstract. Based on the high-resolution, high signal-to-noise ratio spectra collected with the coudé echelle spectrograph attached to the 2.16m telescope at Beijing Astronomical Observatory, we determined the chemical abundance patterns for a sample of six planet-harboring stars. The result is used to investigate the connection between giant planet and high metallicity and to probe the influence of this process on other elements.

1.   Introduction

The discovery of the planet surrounding a main sequence star provides us an important clue to understand the theories of the planetary system and stars. The dependence of the planet formation on stellar metallicity is of great interest based on the facts that many such stars are really metal-rich. However, there exists a few stars which was found to hold planets but has quite low metallicity. This work presents the accurate metallicities for six planet-harboring stars. The main purposes are to investigate if all our sample stars follow the planet-high metallicity connection and to know how this process acts on different elements by studying the ratios between elements with the same nucleosynthesis history.

2.   Observations and Data Reductions

The observations were carried out with the coudé echelle spectrograph attached to the 2.16m telescope at the National Astronomical Observatories (Xinglong, China). The detector was a Tek CCD (1024×1024 pixels with 24×24 μm^2 each in size). The spectra have a resolution around $40\,000$, wavelength coverage from 5600Å to 8300Å, and S/N around 200 except for ρ Cnc which spectra has a lower quality.

The data reduction follows standard routines for order definition, background subtraction, wavelength calibration, radial velocity shift and continuum normalization. The equivalent widths were measured by a direct integration and Gaussian fitting depending on the line intensity.

Table 1.   Model parameters and element abundances

Star	47 UMa	51 Peg	55 Cnc	70 Vir	HD 29587	HD 98230
$T_{\rm eff}$ (K)	5756	5649	5046	5430	5550	5796
$\log g$	4.23	4.27	4.28	3.92	4.07	4.43
$[Fe/H]$	−0.08	0.26	0.19	−0.02	0.09	−0.35
$\xi_{\rm t}$ (kms^{-1})	1.05	0.45	1.45	0.75	0.90	0.85
$[Na/Fe]$	−0.01	−0.13	−	−0.09	−0.01	−0.04
$[Mg/Fe]$	−0.02	−0.15	−0.02	−0.08	−0.15	0.11
$[Al/Fe]$	0.19	−	−	0.07	−	−0.02
$[Si/Fe]$	0.05	0.05	0.09	0.07	0.17	0.00
$[Ca/Fe]$	0.11	0.01	−0.24	0.09	0.06	0.11
$[Sc/Fe]$	0.17	0.19	0.17	0.13	0.13	−0.04
$[Ti/Fe]$	−0.05	−0.03	−0.32	−0.03	−0.05	0.01
$[V/Fe]$	0.01	−0.05	−0.02	0.01	−0.07	−0.05
$[Cr/Fe]$	−0.09	0.14	−0.16	0.03	0.10	−0.00
$[Mn/Fe]$	−0.06	0.06	−0.11	−0.12	0.09	−0.28
$[Ni/Fe]$	0.03	0.20	0.04	0.02	0.15	−0.02
$[Y/Fe]$	−	−0.25	−0.35	−0.09	−0.37	−
$[Ba/Fe]$	0.01	0.11	−	0.18	0.02	0.31

3.   Line Analysis

The effective temperatures were derived from $(b − y)$ color indices using the calibration of Alonso et al. (1996). The surface gravities were accurately calculated from Hipparcos parallaxes except for HD 98230, which is estimated from photometric c_1 index because Hipparcos parallax is not available. The microturbulence velocity was determined from the abundance analysis by requiring a zero slope of [Fe/H] *vs.* EW.

The abundance analysis is based on a net of flux constant, homogeneous, LTE model atmospheres taken from Kurucz (1993). The abundances were derived by requiring that the calculated equivalent widths should match the observed ones. Solar abundances calculated from the moon spectrum, were used to derive stellar abundances relative to solar values. Such differential abundances are generally more reliable than absolute abundances because many systematic errors nearly cancel out.

4.   Result and Discussions

Fig. 1 shows the metallicities of our sample stars and the trends of individual elemental abundances with metallicities. As far as the planet-metallicity connection, we have following results: Firstly, we confirm the high metallicity for 51 Peg and ρ Cnc with [Fe/H] as high as 0.2 dex. Secondly, 70 Vir, 47 UMa and HD 29587, with metallicities from [Fe/H] = −0.08 to +0.09 are quite similar to the sun. These metallicities are still higher than most F and G-type main
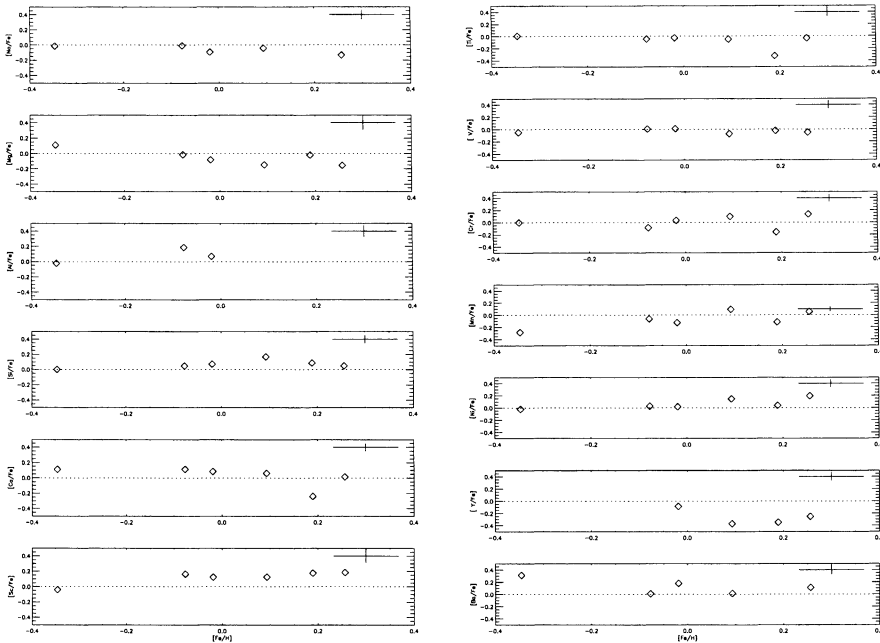
Figure 1.   The trend of [X/Fe] with [Fe/H] for Na, Mg, Al, Si, Ca, Sc, Ti, V, Cr, Mn, Ni, Y and Ba. The error bar is shown in the upper-right corner of each sub-figure.

sequence stars in the solar neighbourhood with a metallicity peak at [Fe/H] = −0.2 dex. All the above 5 stars seems to support the connection between the planet formation and stellar high metallicity. However, HD 98230 with [Fe/H] = −0.35 is contrary to this suggestion. Together with HD 114762, it seems that we need other explanation to understand their presence of giant planets. We found most elements are quite similar to the sun with [X/Fe] nearly close to zero, and there is no significant trend with metallicity. It seems that the high metallicity of planet host stars is primordial since there is no special signature in other elements based on this small sample of stars. Investigation on a large sample of planet host stars is necessary. In this respect, we have started a project on abundance determination of 70 planet host stars in order to detect abundance anomalies of elements other than iron statistically.

References

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