Chemical imprints in atmospheric abundance of stars with massive planets

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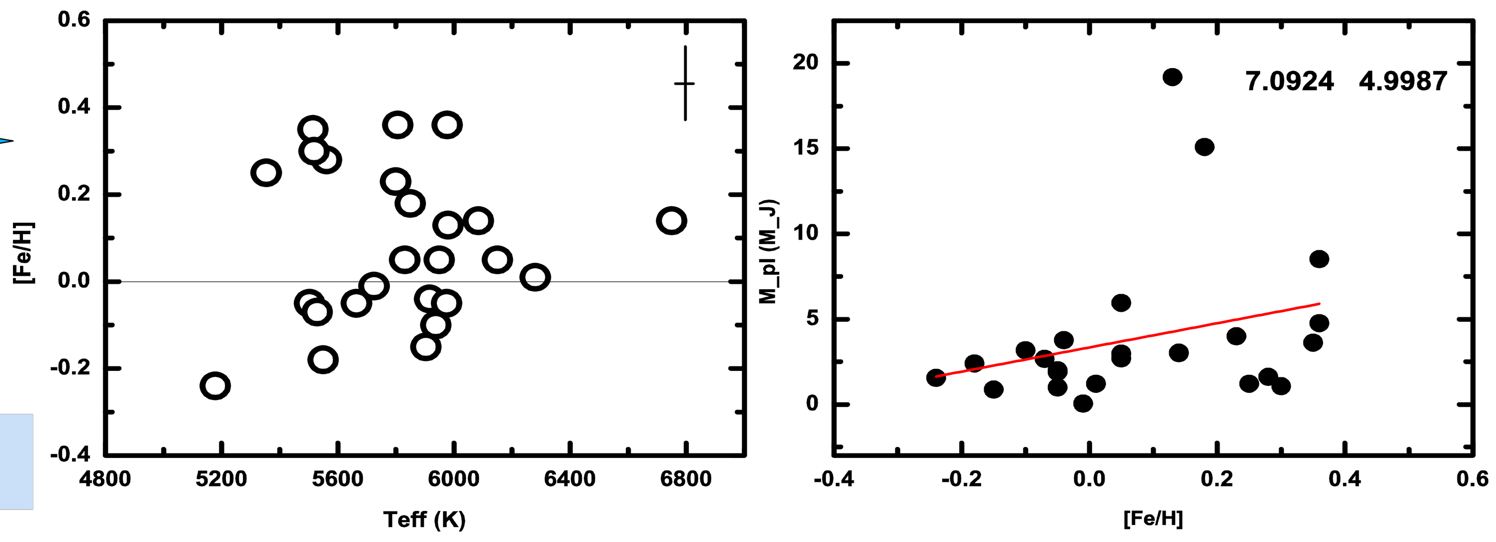
Abstract

Stellar parameters of 25 stars with detected massive planets and abundances of 25 elements from Li to Eu, were investigated based on homogeneous high resolution spectra. The iron abundance [Fe/H] and key elements (Li, C, O, Mg, Si) indicative of the planet formation, as well as the dependencies of [El/Fe] on the condensation temperature (Tcond), were analyzed. We found some interesting results: the mean values of C/O and [C/O] are <C/O> = 0.48 ±0.07 and <[C/O]> = -0.07 ±0.07, slightly lower than solar ones; the Mg/Si ratios range from 0.83 to 0.95 for four stars in our sample and from 1.0 to 1.86 for the remaining 21 stars; various slopes of [El/Fe] versus Tcond. The dependencies of the planetary mass on metallicity, the lithium abundance, the C/O and Mg/Si ratios, and also on the [El/Fe]--Tcond slopes were considered.

Observations and stellar parameters

The stars: selected from the SOPHIE Exoplanet Consortium programmes (Bouchy et al.2009).
The spectra: the archive of the SOPHIE echelle spectrograph (Perruchot et al. 2011) on the 1.93m telescope of OHP (France), a resolving power of R ~ 75 000 and the wavelengths range restricted to 4400—6800 ÅÅ (Moultaka et al. 2004).

The atmospheric parameters : Teff – independence of log A(FeI) on E_low, log g - iron ionisation balance, Vt – independence of log A(Fe) from EW_FeI for Fe I lines.
The abundances : determined under LTE approximations using the atmosphere models by Castelli & Kurucz (2004), new version LTE STARSP software package (Tsymbal, 1996) and the last version VALD atomic data (Kupka et al. 1999). For Sc, V, Mn, Ba and Eu the HFS was taken into account.



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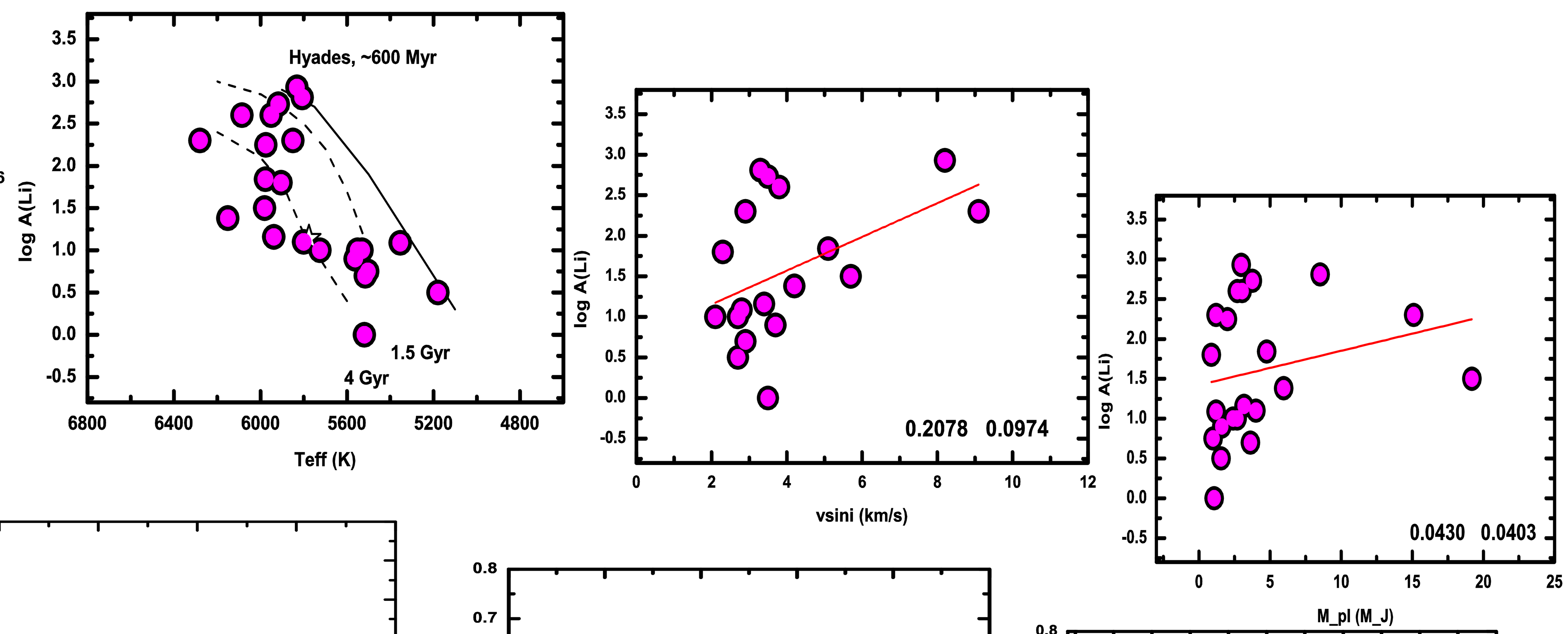
[Fe/H] vs. Teff and M_pl(M_J) vs. [Fe/H].

2



Introduction

The main features of the chemical composition of parent stars, which were considered as possible indicators of the presence of planets, are follows:

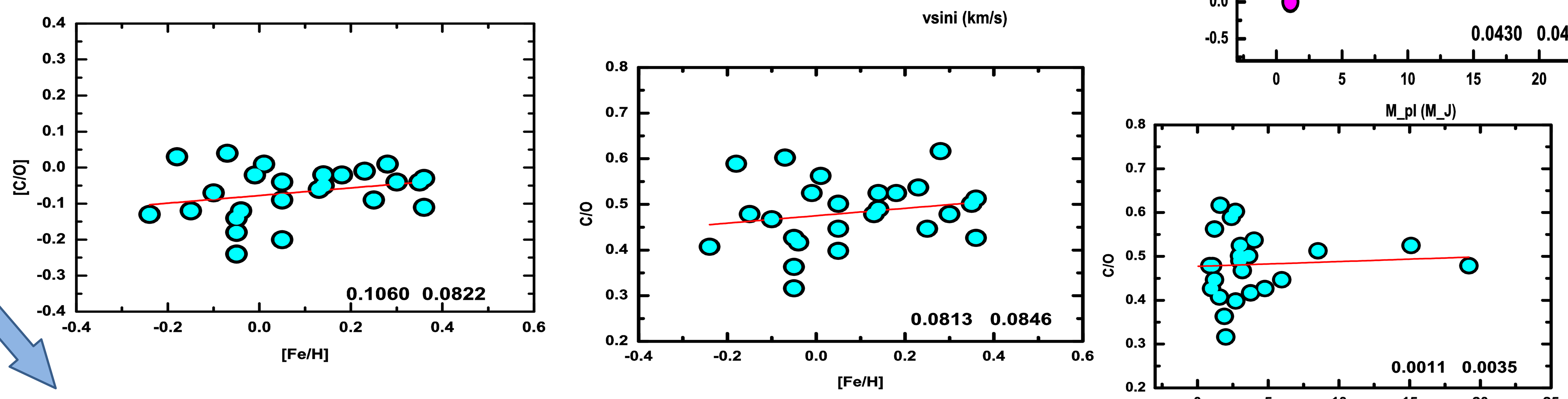
1 1) metallicity, [Fe/H]

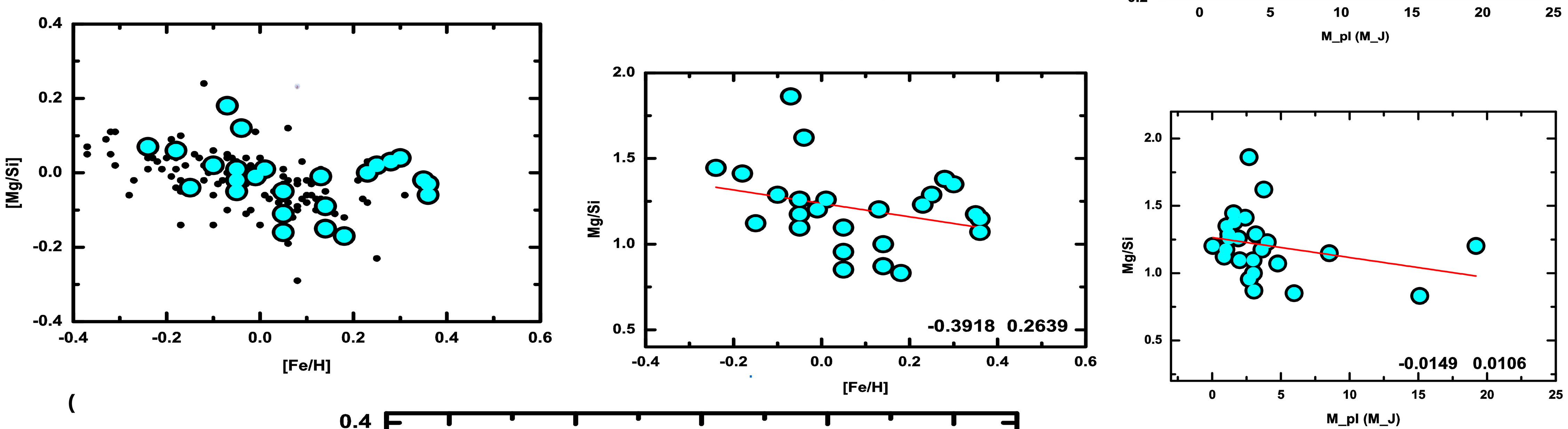
2 2) lithium content, logA(Li)

3 3) carbon and oxygen content, C/O, [C/O]

4 4) magnesium and silicon content, Mg/Si, [Mg/Si]

5 5) ratio of volatile to refractory elements and their dependence on the condensation temperature Tcond





Results

To highlight the possible connections between indicators and the presence of planets, we examined the relations of the chemical composition with different parameters, including the mass of the planet.

The following has been discovered for our target stars:
1) there are some stars with a lower [Fe/H] than solar one, and there is also a dependence of the planet's mass on metallicity that has the complex origin (see Adibekyan 2019),
2) the lithium content reflects the evolution of lithium with age, the dependence of lithium on the rotation velocity, and a weak dependence on the mass of the planet,
3) the average <[C/O]> ratio shows a small deficit (-0.07) and no dependence of C/O on the mass of the planet,
4) the trend of Mg/Si vs. [Fe/H] reflects the Galactic Chemical Evolution, while showing a slight negative trend with the mass of the planet,
5 5) the negative trend of the slopes, which correspond to dependence of the element abundance on condensation temperature for a given star, on the mass of the planet.

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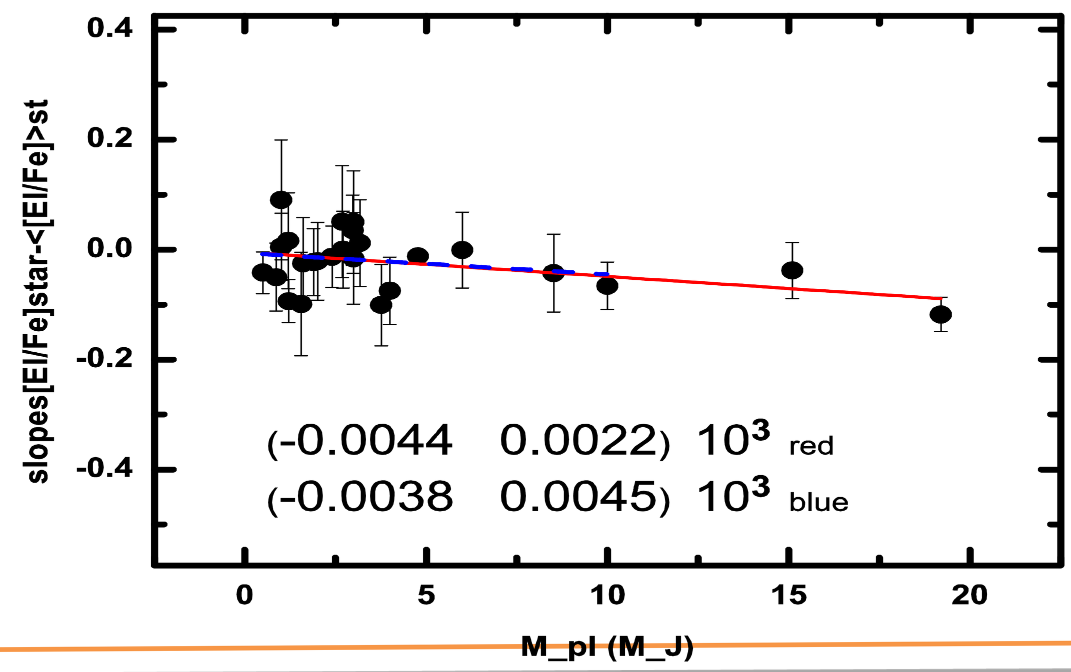

Conclusions

Our new and independent study of 25 stars with massive planets has yielded the following features of the chemical composition:
-- the stars of our sample do not have high carbon to oxygen ratios (C/O ratios do not exceed 0.8),
-- the Mg/Si ratio for most (80%) stars is in the range from 1.0 to 1.86,
-- for lithium, C/O, [C/O] ratios, no dependence on the planetary mass has been detected with a slope greater than the error value, while some dependence of the planetary mass on metallicity and the Mg/Si ratio is observed,
-- for most of the studied stars, the trends of refractory and volatile elements versus Tcond are not clearly and distinctly identified, and the slope absolute values are smaller than the error values.

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