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Chemical abundances of T Tauri stars in star forming regions

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Abstract. Accretion disks of T Tauri stars are commonly assumed to be the site where planets form. At the same time, surveys of old planet-host stars -the end product of planet formation- have shown that gas giant planets preferentially form around metal-rich stars. A critical question, with important implications for our understanding of planet formation, is therefore whether metal-rich T Tauri stars exist. In this context, we have started a project aimed at the determination of the metallicity of T Tauri stars in different star forming regions (SFRs): we present the results of a pilot study focusing on a few members of the Orion Nebula Cluster (ONC) and Sigma and Lambda Orionis clusters.

Key words. Stars: Chemical Abundances – Stars: Pre-main Sequence

1. Introduction

Soon after the discovery of the first extra-solar planet, it was noticed that planet-host stars were particularly metal-rich when compared with stars without planetary-mass companions (Santos et al. 2006; Fischer & Valenti 2005; Gonzalez 1997). More specifically the average metallicity of stars hosting a gas giant planet is [Fe/H] = +0.14 dex, to be compared with the value [Fe/H] ~ -0.1 dex for the solar neiborhood (Santos et al. 2001). Complementary studies suggested that the high metal content is primordial and not due to pollution by cannibalized planetary bodies (Santos et al. 2001). This result might have very important implications for our understanding of the formation of gas giant planets, providing support to a core accretion scenario theories rather than to disk instabilities (Santos et al. 2001; Santos et al. 2006). In this context an obvious question then is: what is the metallicity of stars that are likely to be forming planets now, i.e. *Classical T Tauri stars* (CTTs) in SFRs? If the high metal content of stars with planet is primordial, one would expect that metal-rich SFRs do exist or that populations of metal-rich T Tauri stars are present within them.

We also stress that in the last 10 years just a few studies on chemical composition of SFRs have been carried out; furthermore the available metallicities are affected by large errors and the samples in each SFR are too small.

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2. Observations & Data Reduction

Our sample includes members of three young clusters, namely Orion Nebula Cluster (ONC), σ Orionis and λ Orioni. We selected the stars to be analyzed from a larger sample of stars observed for different purposes (see Palla et al. 2005, 2007; Sacco et al. 2007, 2008). Our ONC sample consists of 9 late-K members whose spectra were acquired with FLAMES@VLT/UT2: seven stars were observed with the fiber-link to UVES and the CD#4 cross-disperser, providing a wavelength coverage between 6700 Å – 10000 Å and a resolution R∼40000. The other two stars were observed with Giraffe and HR15 setup. (R $\sim$ 19,000, 640 – 680 nm). For the σ Orionis cluster we analyzed FLAMES-UVES spectra for three stars observed with the CD#3 cross-disperser (4800 Å – 6800 Å); we enlarged our sample with the star HD294297 whose FLAMES-UVES spectrum (CD#4 cross-disperser) was retrieved from the ESO Archive (Progam 076.C-0145, PI Jeffries). Finally, we included in our λ Orionis sample one star observed with FLAMES-UVES (CD#3 cross-disperser) and one with Giraffe (HR15 setup). Data reduction was performed under ESO-MIDAS context & Giraffe BDLRS, following the standard procedure.

3. Method

3.1. Estimate of veiling

The spectra of young pre-main sequence (PMS) stars might be characterized by spectral veiling that affects measured equivalent widths (EWs), since photospheric absorption lines are filled in by disk emission. We estimated the spectral veiling by comparing the EWs of 7 strong lines in the spectra of our targets with those of a sample of 9 stars belonging to the older open cluster IC 2391 & IC 2602. Given $r = (EW_{IC}/\ EW_{SFR}) - 1$, we found that all our stars have veiling close to zero.

3.2. Stellar parameters and analysis

The stellar parameters were derived as follows: initial $T_{\rm eff}$ were retrieved from spectral types or photometry, while we obtained the final values by removing the trend between log n(Fe) and excitation potential. The surface gravities were obtained from $\log g = 4.44 + \log (M/M_\odot) - \log (L/L_\odot) + 4\times\log T_{\rm eff} - 15.0447$; microturbulence ($\xi$) by removing the trend of abundance values with EWs.

The analysis was performed by means of EWs and spectral synthesis methods using MOOG code (Sneden, 1973 -2006 version) and the Kurucz (1993) model atmospheres. In both cases, we build-up a spectral line list and we optimized it ($\log gf$ values) by an inverse solar abundance analysis. The uncertainities come primarily from two source of errors: i) standard deviation of abundances from different lines (EWs analysis) and the uncertainty in the best fit determination (spectral synthesis method); ii) the uncertainty on stellar parameters.

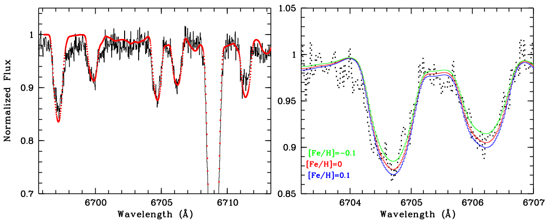

Fig. 1. Synthetic and observed spectra for the ONC star h673; in the left panel the observed spectrum and the best-fitting synthetic one with [Fe/H]=0 dex. In the right side we show three different synthetic profiles for [Fe/H]=−0.1, 0, 0.1 dex, respectively from top to bottom.

4. Results

We found for the three young clusters a very close-to solar metallicity (e.g. Fig 1). We derived an average metallicity of [Fe/H]=−0.03±0.05, [Fe/H]=−0.1±0.01 and [Fe/H]=0±0.07, respectively for the ONC,

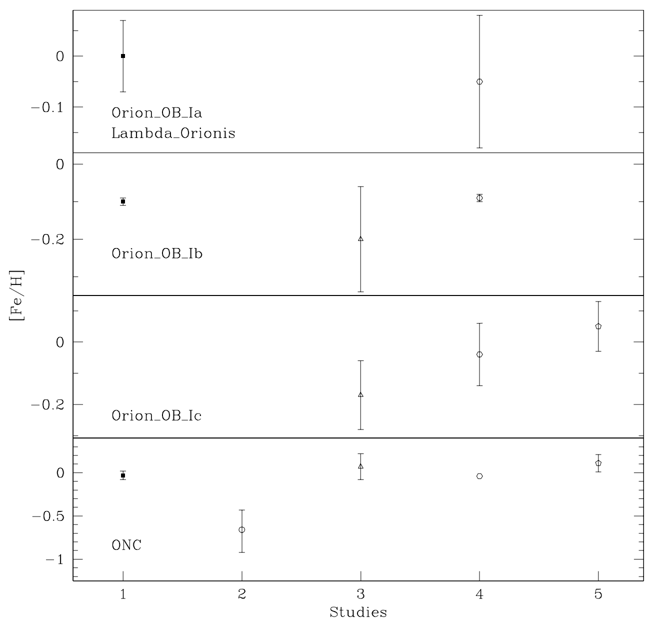

Fig. 2. Comparison with all previous works on Orion region: 1.this work, 2. Coronal abundances from Maggio et al. (2007), 3. Cunha et al. (1998 – F/G stars), 4. Cunha & Lambert (1994 – B stars), 5. Padgett (1996)

σ Orionis and λ Orionis: the iron abundance well agree with all previous chemical analysis in the Orion region (Fig. 2). Finally, we stress that none of the stars analyzed has an over-solar metallicity; nevertheless our work, as well as all the previous ones, included only Weak-lined T Tauri stars. In the next future we will also analyze CTTS (with accretion disks) in several near-by SFRs.

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