THE SARG SEARCH FOR PLANETS: FIRST RESULTS

Claudi R.U.[1], Barbieri M.[4], Bonanno G.[2], Carretta E.[1],Cosentino R.[2],[3], Desidera S.[1], Endl M.[7], Gratton R.[1], Lucatello S.[1],[5],Marzari F.[6], Scuderi S.[2]

[1]I.N.A.F. – Oss. Astronomico di Padova, Vicolo Osservatorio,5 35122 Padova, Italy
[2]I.N.A.F. – Oss. Astrofisico di Catania, Via S. Sofia, 78, Catania, Italy
[3]I.N.A.F. – Centro Galileo Galilei, Calle Alvarez de Abreu 70, 38700 Santa Cruz de La Palma (TF), Spain
[4]CISAS, c/o Dipartimento di Fisica, Universitá di Padova, via Marzolo 8, 35131 Padova, Italy
[5]Dipartimento di Astronomia, Universitá di Padova, Vicolo Osservatorio,5 35122 Padova, Italy
[6]Dipartimento di Fisica, Universitá di Padova, via Marzolo 8, 35131 Padova, Italy
[7]McDonald Observatory, The university of Texas at Austin, Austin, TX 78712, USA

Abstract

We present the results of 2 years of high precision radial velocity monitoring of a sample of visual binaries performed at Telescopio Nazionale Galileo (TNG) using the high resolution spectrograph SARG. In particular we describe the results obtained for the HD 219542 system. The A component of this binary system was found to have a 0.1 dex higher metallicity than B component (Gratton et al. 2001) but no velocity variations above the measurement errors (5 m/s) were detected. On the other hand the B component of HD 219542 shows a low amplitude variation with a period of 112 days suggesting a Saturn - mass planet. The results of stellar activity tests made are inconclusive and alternative interpretation can not be excluded.

Key words: Planets: exoplanets – Stars: binaries – Stars: activity

1. Introduction

Extrasolar planets exist and they have unexpected properties (see for example "The Exoplanets Enciclopedie" Schneider 2000). This is the result of about eight years of observations since the first planet discovere by Mayor & Queloz (1995) conducted mainly with the high precision radial velocity method (really planet long term search survey were conducted since 1980). Among more than 100 extrasolar planets discovered, two were observed transiting their host star: the best studied case is HD 209458 (Charbonneau et al. 2000, Henry et al. 2000). This allows the derivation of the planet mass, radius and density. Giant planets in close orbits (a$<$ 3.5 AU) are present in about 8% of the stars: however this frequency is a strong function of the star metallicity: more planets are present in more than 10% of the metal rich stars (while they are rare in stars with [Fe/H]< -0.1). There are already a lot of questions without an answer, in particular about planets formation and their interaction with the host star environment. Understanding these circumstances would allow to draw conclusions about planets formation and evolution and the frequency of habitable planets around stars. Binary systems are important laboratories to test these issues. In fact binary systems are a large fraction of the stars in the solar neighborhood and are a clear dynamical test – benches for dynamical perturbation on one planet orbits by stellar companion. Moreover it is possible to have insight on planet – metallicity connection: chemical composition differences among stars with and without planets are straightforwardly found. The most famous planet found in a wide binary system of equal mass stars was 16 Cyg B (Cochran et al. 1997) while really remarkable is the case of the planet in the γ Cep system which have a periastron of 12 AU (Hatzes et al. 2003). However, no systematic search for planets in binaries has been done insofar. The SARG exo-planet search (www.pd.astro.it/new_sites/ESP/) propose to fill this gap.

2. The SARG search Sample

The SARG search sample includes about 50 binary systems with a projected separation larger than 2 arcseconds. The visual magnitude of the objects ranges between 7.0 and 9.5. The sample was selected in order to obtain pairs of similar stars (ΔV $<$ 1) with spectral type ranges between F7 and K. The sample was selected from the Hipparcos Double and Multiple System Catalogue (Perryman et al., 1998) with a parallax larger than 10 mas. Finally we eliminated a few stars that from analysis of first epoch spectra revealed to be spectroscopic binaries, rapidly rotating or active stars. Analysis of available data showed that for the projected separation of our pairs ($\sim$ 200 – 300 AU), the critical semiaxis for dynamical stability of planets computed following Holman & Weigart (1999) is a few tens of AU.

3. SARG radial velocity measurements

We conduct the radial velocity survey with the SARG spectrograph (Gratton et al. 2001a), mounted at the Telescopio Nazionale Galileo (TNG). SARG is a High resolution (144,000) thermalized spectrograph equipped with an iodine absorption cell. This tecnique gives the best results (3 m/s, Butler et al. 1996). Spectra obtained with Iodine absorption cell are characterized by a superposition of the

Proc. 2nd *Eddington* workshop *"Stellar Structure and Habitable Planet Finding"*, Palermo, 9–11 April 2003 (ESA SP-485, July 2003, F. Favata, S. Aigrain eds.)

Figure 1. SARG spectrograph at TNG

stellar and iodine absorbing spectra. The latter, a forest of very narrow lines, is useful to determine the spectral shift due to Doppler effect caused by the orbit of the star around the planet – star system center of mass. This goal is achievable by a modellization of the instrumental profile together with the stellar spectrum. The modellization is mandatory to reach radial velocity precision below 10 m/s. We use AUSTRAL, a software developed by M. Endl et al. (2000) as Data analysis software (used in the discovery of several planets at ESO and McDonald : ι Hor, ϵ Eri, γ Cep).

4. SEARCH STATUS

The SARG exo–planet Search is a long time program (five years). It started in September 2000 and now, after about two years, we have completed just a third of the survey. We aquired a 50 % of the stellar template spectra and we have an average of 7.0 spectra for each star (the planned number is 20 spectra for star). The radial velocity precision of the SARG spectrograph was measured exploiting three standard stars: 51 Peg, ρ CrB, that are known to host a planet, and the constant radial velocity star τ Cet. In Figures 2 and 3 the radial velocity data for two of these stars are shown (51 Peg and τ Cet). The results indicate an accuracy of 2-3 m/s for radial velocity measurements with SARG, stable over a period larger than 2 years.

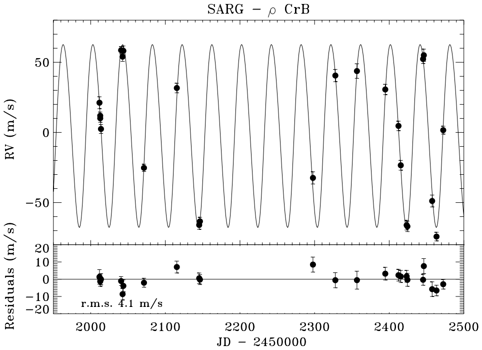

Figure 2. Radial velocity Data for ρ CrB. The radial velocity variations due to the planet discovered by Noyes et al. (1997) are clearly seen

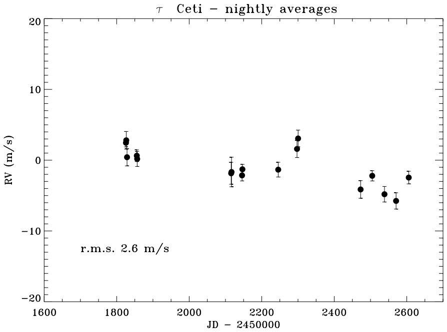

Figure 3. Radial velocity data for τ Ceti.

5. FIRST RESULTS: HD219542

In order to derive accurate chemical abundaces for the stars of the sample, the high S/N ratio template spectra, needed in the radial velocities measurements, were used. In this kind of analysis the derivation of accurate temperatures is the most critical fact. But, in the case of a binary system we can estimate with sufficent accuracy the magnitude difference between the two component and also the mass ratio. In this condition, Gratton et al. (2001b), showed that temperature differences with errors ≤ 15 K can be derived for the components of the binaries of our sample using the Fe ionization equilibrium, provided that a strictly differential line–by–line analysis is adopted.

In Figure 4 the run of differential abbundances (typical error: 0.016 dex) as function of the temperature differences

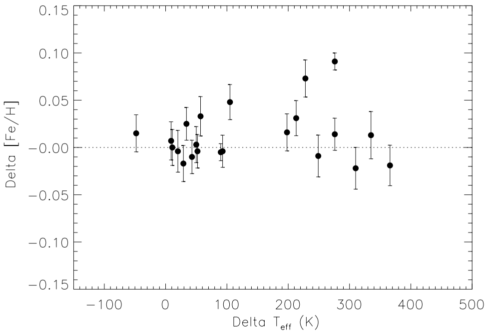

Figure 4. Run of the differential abundances as a function of the difference in temperature between the two components for 22 pairs in our sample

between the two components of 22 pairs of our sample, is shown. In three cases the difference between the two components is larger than the internal error, but only in one case (HD 219542) this difference is really significant (0.09 dex, about 9 times the internal error; the primary resulting more metal rich than the secondary). No spurious trend of the differences with excitation potential, line strength and wavelength were found. Both stars are still close to the ZAMS without indication of a high activity level and binary interaction, so that the abundances difference cannot be attributed to anomalies in the atmospheres. Finally there is some hint in the data that this difference is only limited to rocky elements, with no evidence for a variation in volatile ones. The interpretation of data as a results of an engulfing of planetary material is a reasonable consequence. The ingestion of 3 – 5 earth masses of rocky material (planets and/or planetesimals) by the primary of the system can explain the observed differences.

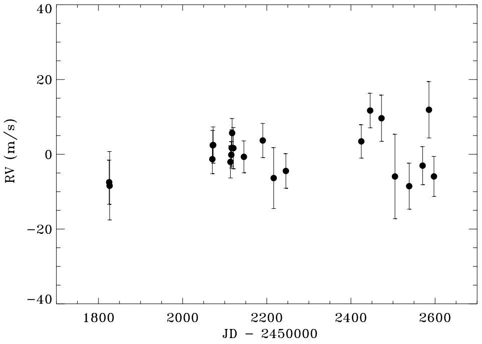

Figure 5. Radial velocity Data for HD219542A.

The radial velocity curves for the two components of the HD219542 system are shown in Figure 5 and 6 (Desidera et al. 2003). The primary does not host a massive close – in planet, while in the secondary low amplitude radial velocity variations are indeed detected. These may be interpreted as due to a slightly eccentric (e$\sim$ 0.3) keplerian motion with a period of 112 d, and velocity semi–amplitude of 13 m/s. The potential planet would have a minimum mass of 0.3 M_J with an orbital radius of 0.42 AU. The significance of the proposed orbit is about 97% which is a pretty large value but still lower than 99% as generally accepted lower limit.

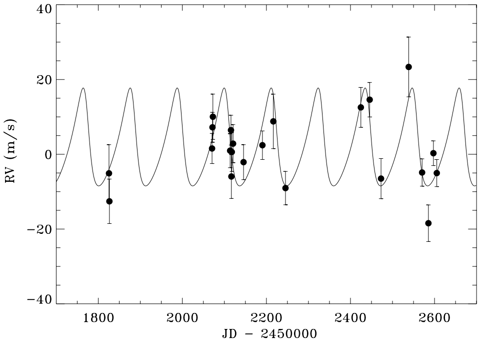

Figure 6. Radial velocity Data for HD219542B. Overplotted is the best orbital solution of the planet candidate

Stellar activity phenomena (spots, plages, flares) can induce spourious radial velocity variations. We acquired spectra of both components of HD 219542 (and of other 40 stars) using FEROS spectrograph at the ESO 1.5 m in La Silla. The spectra cover also the region of chromospheric diagnostic H and K Ca II lines. In Figure 8 the K line for HD 219542 A and B are compared to the solar spectrum and to the active star 36 Oph A. HD 219542 A and B are certainly not very active (low chromospheric emission, slow rotation, maybe some coronal X – ray emission) and the jitter induced by the HD 219542 A activity could be evaluated as a radial velocity variations of 4 m/s (using the relation by Saar et al. 1998). However the activity level required to explain the radial velocity scatter of HD 219542 B is low and can not be easily excluded from the data.

In order to evaluate the possibility that the small amplitude observed in the variation of radial velocity of HD 219542 B are not real, but rather due to the effects of lines asymmetries, we measured the line bisectors using CCF Tecniques (Queloz et al., 2001). Unfortunately this test revealed itself an inconclusive one.

6. Conclusion

After two years of search in visual binary system we have found a good planet candidate in the special system HD 219542. In order to confirm this claim we need at leastanother observative season.

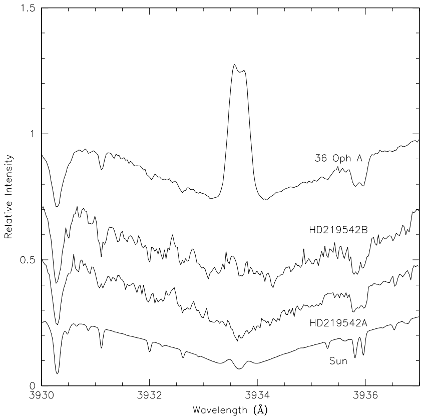

Figure 7. Comparison between the K line for active star 36 Oph A and the same for the two components of HD 219542 binary system. The K line for the Sun is also shown.

REFERENCES

Butler R.P., Marcy G.W., Williams E., McCharthy C., Vogt S.S., Dosanjh P., 1996, PASP, 108, 500

Charbonneau et al. 2000, ApJ, 568, 377

Cochran,W.D., Hatzes, A.P., Butler R.P., Marcy, G.W., 1997, ApJ, 483, 457

Desidera,S., Gratton R.G., Endl, M., Barbieri M., Claudi R.U., et al., 2003, A&A, In Press

Endl,M., Küster, M., &Els, S., 2000, A&A, 362, 585

Gratton, R.G., Bonanno, G., Claudi R.U., Cosentino R., Desidera S. et al., 2001, Exp. Astron., 12, 107

Gratton, R.G., Bonanno, G., Claudi R.U., Cosentino R., Desidera S. et al., 2001, A&A, 377, 123

Hatzes, A.P., Cochran W.D., Endl, M., McArthur, B., Paulson, D.B., et al., 2003, ApJ, in Prep.

Holman, P.A., Weigart, M.J., 1999, AJ, 117, 621

Mayor, M., Queloz, D., 1995, A&A,379, 279

Noyes, R.W., et al., 1997, ApJ, 483, L111

Perryman M.A.C. et al., 1998, A&A, 379, 279

Queloz, D., et al., 2001, A&A, 379, 279

Saar, S.H., Butler, R.P., Marcy G.W., 1998, ApJ, 498, L153