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Search of extra-solar planets with the spectrograph EMILIE and AAA system

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Abstract. The method of stellar velocity variations measurement has recently shown its capability by discovering tens of extra-solar planets. Accuracies achieved today are in the range of 3 to 10 m/s. The spectrograph EMILIE coupled to the Absolute Astronomical Accelerometer (AAA) system and established at the 1.52 m telescope of the Observatoire de Haute Provence is an instrument which aims at reaching an accuracy better than 1 m/s, long term. Results on some typical stars are presented.

1. Introduction

At this day, more than 40 extra-solar planets have been detected by the Doppler technique. All these planets induce a semi-amplitude of the reflex velocity greater than 10 m/s and have masses greater than 0.5 Saturn. Reach the velocity precision of 1 m/s over long time makes one hope detecting a new family of extra-solar planets. Essentially two methods have been developed for obtaining precise radial velocity (RV). Both involve to calibrate the wavelength instrumental drifts by imposing a set of stable reference lines. The first technique called Iodine cell method consists in placing in the stellar beam an iodine cell to superimpose stable absorption lines on the incoming starlight. Although reliable, this approach increases the photon noise RV errors, hence requires a larger telescope. The second technique, called double-fiber method, consist in making use of optical fiber feed for the starlight, plus a second fiber carrying light from a stable laboratory source. The critical point is that the stellar and reference beams do not exactly follow the same path through the spectrograph.
A somewhat different method consists to make use of a single fiber for both beams. An optical commutator alternately sends the two spectra to the CCD. No drift is permitted during the time interval necessary for a cycle of measure. This approach has been developed and tested with the spectrograph EMILIE. The second approach is to use a sliding reference spectrum constrained to track the stellar lines and to use the spectrograph as a null-checking device. This approach has been developed with the AAA system.

2. Principle of the spectrograph EMILIE with Absolute Astronomical Accelerometer system

EMILIE is an echelle spectrograph with cross dispersion (Bouchy et al. 1999a; Bouchy 1999b). This spectrograph is fed by a single fiber associated to an automatic guiding and focusing system using the fiber itself as position detector (Bouchy & Connes 1999c). An optical commutator allows sending alternately on the fiber the stellar beam and the reference beam, which is constituted here by the AAA system (Connes 1985; Schmitt 1997). This system is composed by a tunable Fabry-Perot (FP) illuminated by a white source and controlled by lasers. With this system and thanks to an optical system inside the spectrograph, the reference spectrum which is here the channeled sliding spectrum coming from the tunable FP and the stellar spectrum are locked on the same CCD pixels for all observational epochs. The goal of this system is at the same time to eliminate all calibration of the spectrograph and to eliminate the displacement of the spectra across the CCD pixels due to the earth motion and suspected to introduce an systematic error in the RV measurement.

3. Results

Some results obtained on Ups And and the Sun have been already discussed (Bouchy 1999b; Schmitt et al. 2000). We present here new results which specify the RV precision of the instrument over a term of few weeks.
Our campaign in March 2000 allowed us to test the precision over 11 nights. Figure 1-(a) and (b) show our measurements on Procyon and Beta Virgo. We made each night between 2 and 3 hours of measurements. Each point is dominated by photon noise and the dispersion over a night lies between 4 and 8 m/s. To reduce the photon noise to about 1 m/s, we compute the average of each night represented here by an open circle. The dispersion obtained over 11 nights is about 3 m/s. For these two stars, we can exclude the presence of an extra-solar planet of mass greater than 0.3 Saturn with an orbital period lower than 11 days.
Our campaigns in May and June 2000 allowed us to test the precision over 6 weeks on Beta Virgo. The dispersion on the average value of each night presented in Figure 1-(c) confirmed to be equal to about 3 m/s.

4. Conclusion

We estimate that the 3 m/s precision obtained is limited in part by the photon noise (estimated at about 1 m/s), in part by the "guiding noise" or geometrical fluctuations of the stellar beam because we do not yet use double fiber scrambler nor atmospheric dispersion corrector, and in part by the stellar activity itself. Our goal is to optimise the instrument in term of efficiency and to realise a programme of extra-solar planets search on about 50 chromospherically non-active stars.

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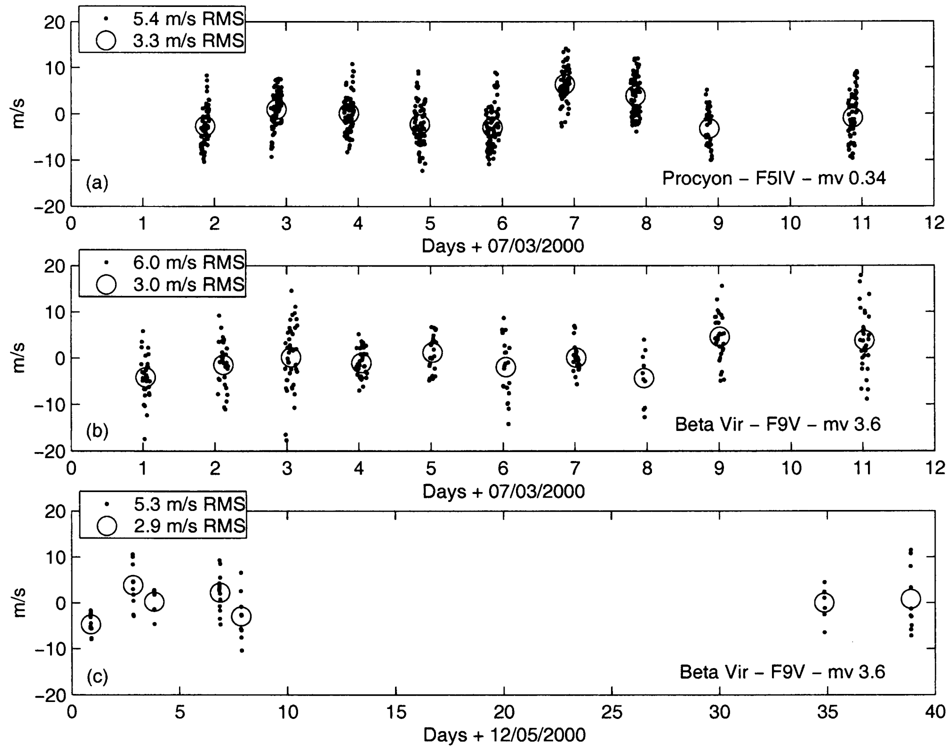

Figure 1. Radial velocity precision obtained on Procyon and Beta Virgo. Black points represent RV measurements carried out with 2 mn exposures on Procyon and 5 mn exposures on Beta Virgo. Open circles represent the average value of each night.

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