Radial velocity measurements of a sample of K-giants with the Hobby-Eberly telescope.

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Abstract. We present motivation and initial results of a large RV survey of K giants aimed at a detection of low-mass companions. The survey, performed with the Hobby-Eberly Telescope, utilizes high resolution (60,000) spectra for high precision radial velocity measurements. The primary goal of the survey is the selection of astrometrically stable reference stars for the Extra-solar Planet Interferometric Survey key project to be carried out with the Space Interferometry Mission.

INTRODUCTION

The main goal of this program is to select astrometric reference stars for a subset of 24 target stars to be searched for Earth-mass companions by the Space Interferometry Mission (SIM) key project *Extra-solar Planet Interferometric Survey* (EPIcS, [12]). (*http://planetquest.jpl.nasa.gov/SIM*). A $\sim$1 μas precision of the survey calls for reference stars that will keep the astrometric noise below that level. They also have to be prevalent enough to be easily found within 1° of a target for narrow-angle astrometry. These conditions appear to be best satisfied by clump giants [8] at distances $\sim$1 kpc away, because of the R $< 10^m$ SIM requirement. As this distance is insufficient to completely eliminate the possibility of an astrometric contamination by giant planets, each target requires two reference stars. About 10 reference star candidates per target (early K-giants) have been identified. These stars have to be radial velocity (RV) monitored to select the best two on the basis of the absence of a detectable binary motion signature.

Aside from the SIM/EPIcS reference star selection to be accomplished by this program, the precision RV measurements of a set of $\sim$300 distant K-giants accumulated in the selection process will provide a statistically significant and astrophysically very interesting material for more detailed investigations.

One of the most intriguing properties of red giants is their RV variation. [14] noted that all giants in their (small) sample display RV variations of 30-300 m/s. Long-term (>100 day) variations with RV amplitudes of several hundred m/s, reported by [5], may be induced by stellar rotation influencing active zones on stellar surface or by the existence of low-mass companions. Yet another type of RV variations, reported by [6],[7], the

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short-term RV changes of about 100 m/s within a $\sim$day are probably related to high order radial- or non-radial pulsations. [3] has reported the first results of a high precision RV survey of 182 K giants and presented evidence of a <50 m/s RV scatter in these stars that is most probably of an intrinsic origin.

It is interesting to note that, in spite of these uncertainties in RVs of K giants, several sub-stellar companions have already been found around these stars. First such companion was reported to orbit ιDra by [4]. More such detections have been reported by [13] (HD 47536), [11] (HD 59686, 91 Aqr, τ Gem, ν Oph). Finally, two sub-stellar companions to sub-giants have been reported by [1], [2].

The ongoing precision RV surveys usually involve main sequence stars (dwarfs) [10]. However, since the existence of planets orbiting evolved stars (giants) is extremely interesting from the point of view of the evolution of planetary systems, we have expanded the original goals of the SIM/EPIcS survey to include a detection of planets around the K-giant candidates for EPIcS reference stars.

OBSERVATIONS

Observations have been performed with the Hobby-Eberly Telescope (HET) located at the McDonald Observatory, Texas, using the High Resolution Spectrograph (HRS) at 60,000 resolution. The observing scheme follows standard practices implemented in high precision radial velocity measurements with the iodine (I2) cell [9].

Our program has been initiated in January 2004. In two trimesters of HET observations, between January and August 2004, we have collected 271 spectra for 120 objects. Observations for several stars were repeated at a several months interval to test the data reduction procedure and the performance of the RV measurement code. Altogether, we collected repeated observations for 26 stars. Ten of them were repeated in 2-6 months for tests, while the remaining 16 were repeated to improve the signal-to-noise of the spectra.

INITIAL RESULTS OF RADIAL VELOCITY MEASUREMENTS

Multiple observations of several K-giant EPIcS reference candidates were reduced with the standard IRAF [1] procedures. Radial velocities were calculated using the standard I2 RV technique [9]. The initial results are presented in Figure 1. A $\pm$50 m/s threshold has been tentatively adopted as a rejection criterion for candidate reference stars. The individual observations are plotted against epoch with error bars of $\pm 1\sigma$. The precision of our RV determinations varies in individual cases over a 19-32 m/s interval.

In Figure 1 (upper panel) an example of a binary system is presented. This bright giant of K0 spectral type was re-observed 12 and 143 days after the initial measurement. Our

[1] IRAF is distributed by the National Optical Astronomy Observatories, which are operated by the Association of Universities for Research in Astronomy, Inc., under cooperative agreement with the National Science Foundation

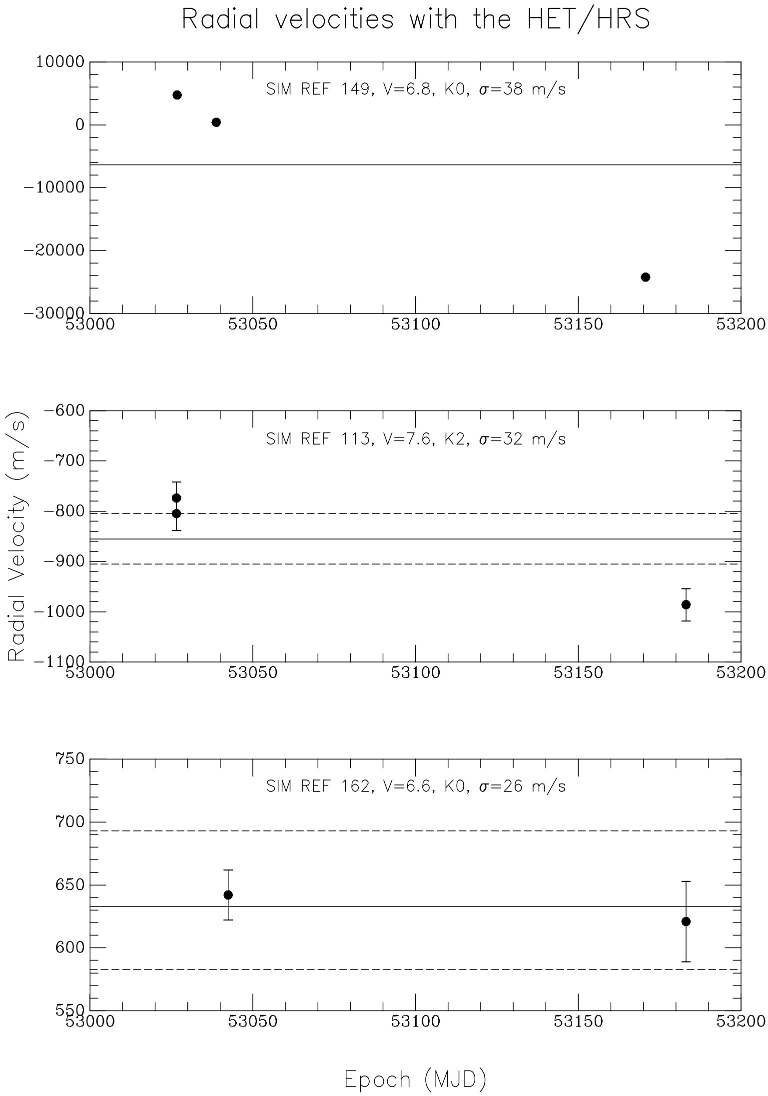

FIGURE 1. Relative radial velocities of three SIM/EPIcS candidate reference stars. The mean RV (relative to template) is plotted as solid line, dashed lines show the ±50 m/s threshold adopted for SIM/EPIcS reference stars pre-selection.

test calculations show that, in this case, RV variations in reach a 29 km/s level allowing us to reject the object from the SIM/EPIcS candidate list. In Figure 1 (middle panel) we show a system displaying much lower RV variations. Our observations of this bright K2 star repeated on the same night and after 157 days reveal RV variations at a 181 m/s level. This makes the star useless as a SIM/EPIcS reference object but it may be interesting as a possible host to a sub-stellar companion. Finally, in Figure 1 (bottom panel) we present an example of a promising SIM/EPIcS reference candidate. A bright star of K0 spectral type was re-observed after 141 days. Our calculations show that the RV changed by only 19 m/s, well within the uncertainty level accepted in the pre-selection process.

CONCLUSIONS

The queue-scheduled observing mode with the HET seems to be a very efficient way to implement a large, long-term project described above. The RV precision reached in our test measurements is already sufficient for SIM/EPIcS reference star pre-selection process. Our reduction procedure requires refinement to reach the RV precision adequate for finding Jovian-mass companions to our target stars.

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REFERENCES

1. Butler, R. P., Tinney, C. G., Marcy, G. W., Jones, H. R. A., Penny, A. J., Apps, K. 2001 ApJ 555, 410
2. Cochran, W.D., Hatzes, A. P., Endl, M., Paulson, D.B., Walker, G. A. H., Campbell, B., Yang, S. 2002 AAS 34.4202
3. Frink, S., Quirrenbach, A., Fischer, D., Röser, S., Schilbach, E. 2001 PASP 113, 173
4. Frink, S., Mitchell, D. S.,Quirrenbach, A., Fischer, D.A., Marcy, G.W., Butler, R.P. 2002 ApJ 576, 478
5. Hatzes, A.P., Cochran, W.D. 1993 ApJ 413, 339
6. Hatzes, A.P., Cochran, W.D. 1994a ApJ 422, 369
7. Hatzes, A.P., Cochran, W.D. 1994b ApJ 432, 763
8. Jimenez, R., Flynn, C., Kotoneva, E. 1998 MNRAS, 299, 515
9. Marcy, G. W. & Butler, R. P. 1992, PASP, 104, 270
10. Marcy, G. W., Butler, R. P., Fischer, D. A., & Vogt, S. S. 2003, ASP Conf. Ser. 294: Scientific Frontiers in Research on Extrasolar Planets, 1
11. Mitchell, D.S., Frink, S., Quirrenbach, A., Fischer, D.A., Marcy, G.W., Butler, R.P. 2003 AAS 33, 1440
12. Shao, M. et al. 2003 - unpublished
13. Setiawan, J., Hatzes, A. P., von der Lühe, O,Pasquini, L., Naef, D., da Silva, L., Udry, S., Queloz, D., Girardi, L. 2003 A&A 398, L19
14. Walker, G.A.H., Yang, S., Campbell, B., Irvin, A.W. 1989 ApJ, 343, L21