

**RADIAL VELOCITY SURVEY FOR PLANETS AND BROWN DWARF COMPANIONS TO VERY YOUNG BROWN DWARFS AND VERY LOW-MASS STARS IN CHA I WITH UVES AT THE VLT.** V. Joergens, *Leiden Observatory / Sterrewacht Leiden, P.O.Box 9513, 2300 RA Leiden, Netherlands (viki@strw.leidenuniv.nl).*

Multiplicity of brown dwarfs and the existence of planets around brown dwarfs are key parameters for planet and brown dwarf formation theories. However, at separations of 1–2 AU and smaller as well as at very young ages, the fraction of companions to brown dwarfs is poorly constrained.

This poster reports about results from an ongoing radial velocity (RV) survey for spectroscopic companions to very young brown dwarfs and (very) low-mass stars in the Cha I star forming cloud carried out with the high-resolution echelle spectrograph UVES at the 8 m VLT (Joergens 2005a). Time-resolved spectra have been taken between 2000 and 2004 of twelve brown dwarfs and (very) low-mass stars (M2.5–M8) so far. The achieved precision of the relative RVs range between 40 and 670 m/s and is sufficient to detect Jupiter-mass planets around the targets. This is the first RV survey of very young brown dwarfs and it probes the existences of companions in an as yet unexplored domain not only in terms of primary masses (substellar regime) and ages (a few Myr) but also in terms of companion masses (sensitive down to planetary masses) and separations ( $< 1$  AU).

The obtained RV data show that on time scales of 40 days and less the subsample of ten brown dwarfs and very low-mass stars ( $M \leq 0.12 M_{\odot}$ , spectral types M5–M8) has constant RVs. Estimates for upper limits for masses of hypothetical companions for them range between  $0.1 M_{\text{Jup}}$  and  $1.5 M_{\text{Jup}}$  for assumed orbital separations of 0.1 AU. This hints at a rather small multiplicity fraction for very young brown dwarfs and very low-mass stars for orbital separations of  $\leq 0.1$  AU and orbital periods of  $\leq 40$  days. Furthermore, the non-variable objects demonstrate the lack of any significant RV noise due to stellar activity down to the precision necessary to detect giant planets. Thus, very young brown dwarfs and very low-mass stars are suitable targets for searches for RV planets.

Three objects of the sample exhibit significant RV variations with peak-to-peak RV differences of  $2\text{--}3 \text{ km s}^{-1}$ . For the highest mass object observed with UVES (Sz 23,  $\sim 0.3 M_{\odot}$ ), the variations are on time scales of days and might be explained by rotational modulation. On the other hand, the brown dwarf candidate Cha H $\alpha$  8 (M6.5) and the low-mass star CHXR 74 (M4.5) display significant RV variations on time scales of at least several months, while they are both RV constant or show only much smaller amplitude variations on time scales of days to weeks, i.e. on time scales of the rotation periods. A suggested explanation for the detected RV variations of CHXR 74 and Cha H $\alpha$  8 are giant planets or very low-mass brown dwarfs of at least a few Jupiter masses orbiting with periods of several months or longer. Thus, the presented RV data indicate that orbital periods of companions to very young brown dwarfs and (very) low-mass stars are possibly several months or longer and orbital separations  $\geq 0.2$  AU. This parameter range has not been covered for all targets yet and will be probed by follow-up observations in 2006 for the remaining

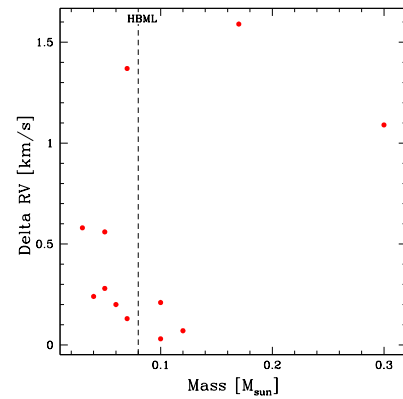


Figure 1: RV variations vs. object mass. Plotted are half peak-to-peak differences of the observed RVs. The upper three data points represent the RV variable objects with  $\Delta RV$  above  $1 \text{ km s}^{-1}$ . The remaining data points represent RV constant objects. The decrease of  $\Delta RV$  with increasing mass for the latter group indicates that they display no significant RV noise due to activity, which would cause the opposite effect, i.e. an increasing RV amplitude with mass. From Joergens (2005a).

targets. Furthermore, we show that the scaled down equivalent to the brown dwarf desert found around solar-like stars would be a 'giant planet desert' around brown dwarf and very low-mass star primaries if formed by the same mechanism. The present data test its existence for the targets in the limited separation range of the survey. So far, no hints for companions in a 'giant planet desert' have been found.

First results obtained within the framework of this survey based on UVES spectra taken in 2000 on mean RVs, rotational velocities  $v \sin i$ , Lithium absorption as well as on the kinematics of the brown dwarf population in Cha I have been published by Joergens & Guenther (2001). The data analysis was improved and revised RVs were measured by Joergens (2003). Follow-up UVES spectra were taken in 2002 and 2004. The results of the RV survey based on all data taken between 2000 and 2004 are published in Joergens (2005a) and an improved kinematic study in Joergens (2005b), resp.

## References

- [1] Joergens, V., Guenther, E. 2001, A&A, 379, L9
- [2] Joergens V. 2003, PhD thesis, Ludwigs-Maximilians Universität München
- [3] Joergens, V. 2005a, A&A subm.
- [4] Joergens, V. 2005b, A&A subm.

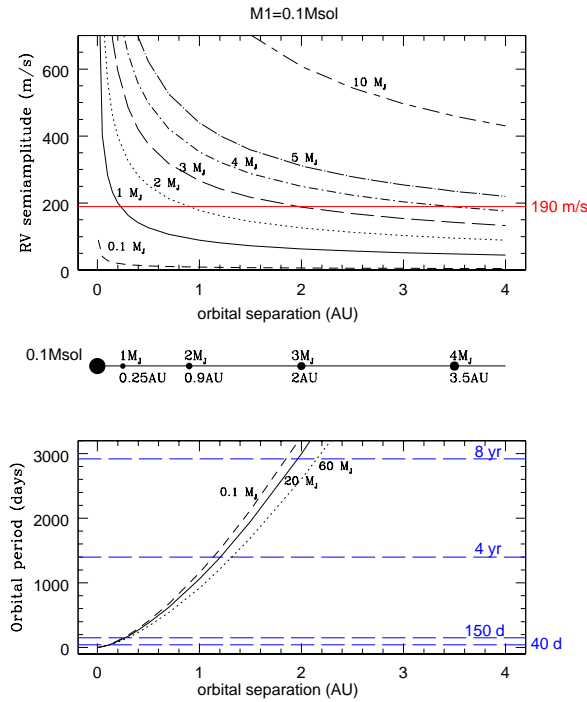


Figure 2: Covered orbital separation ranges as function of RV precision and time base of the obtained data for a  $0.1 M_{\odot}$  primary. *Top panel:* RV semi-amplitude vs orbital separation for different companion masses. With the average RV precision of  $190 \text{ m/s}$  for primaries of  $0.1 M_{\odot}$  achieved in this survey, a  $1 M_{\text{Jup}}$  companion can be detected out to  $0.25 \text{ AU}$ , a  $2 M_{\text{Jup}}$  companion out to  $0.9 \text{ AU}$ , a  $3 M_{\text{Jup}}$  companion out to  $2 \text{ AU}$ , a  $4 M_{\text{Jup}}$  companion out to  $3.5 \text{ AU}$  and companions of  $\geq 5 M_{\text{Jup}}$  at least out to  $4 \text{ AU}$ . However, due to limited time base not the whole possible separation ranges have been covered yet. This is displayed in the *bottom panel*, which shows the orbital period vs separation exemplarily for companion masses of  $0.1 M_{\text{Jup}}$ ,  $20 M_{\text{Jup}}$  and  $60 M_{\text{Jup}}$ . The orbital periods sampled in this survey so far vary among the different targets. For all targets a period of  $40 \text{ days}$  has been covered allowing the detection of substellar companions out to  $0.1 \text{ AU}$ . For some targets also periods of  $150 \text{ days}$ ,  $4 \text{ yr}$  and  $8 \text{ yr}$  have been probed and, thus, correspondingly larger separations as indicated in the plot. From Joergens (2005a).

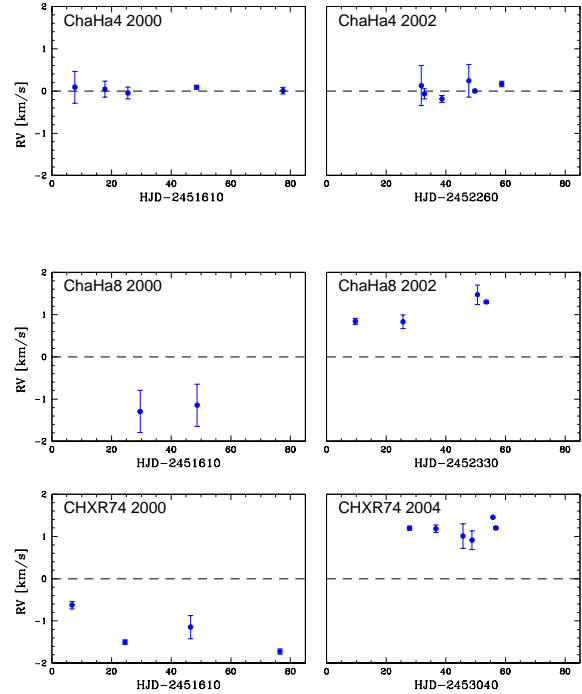


Figure 3: The relative RV vs. time in Julian days are shown as an example for three of the targets. The measured RVs for ChaHa4 ( $M_6$ ) are constant within the errors giving an upper limit for a companion at  $0.1 \text{ AU}$  of less than  $1 \text{ Jupiter}$  mass. The other two targets, ChaHa8 ( $M_{6.5}$ ) and CHXR74 ( $M_{4.5}$ ), reveal RV variations on time scales of at least several months, which cannot be caused by rotational modulation, hinting at companions of at least several Jupiter masses orbiting at orbital separations of larger than  $0.2\text{--}0.4 \text{ AU}$ . Based on UVES/VLT spectra. Error bars indicate  $1 \sigma$  errors. From Joergens (2005a).