K Giants as Astrometric Reference Stars for the Space Interferometry Mission

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Space Interferometry Mission

- Space Interferometry Mission (SIM, see e.g. NASA 1999) part of NASA's Origins Program
- 10 m baseline optical Michelson Interferometer
- scheduled for launch in 2006
- extremely precise astrometry: 4 μas in wide-angle mode, 1 μas in narrow-angle mode
- allows for astrometric detection of planets
- for global astrometry a minimum of 4 astrometric reference stars is needed in the grid per field of regard (15 or 20 degrees)

Requirements on the Grid

- $\approx$ 1500–3000 stars, distributed uniformly over the sky
- brighter than $\approx$ 12 mag
- astrometric jitter smaller than a few microarcseconds
  → no double stars, no variable or active stars
- placing grid stars in large distances reduces the astrometric jitter
  → intrinsically bright stars

→ K giants are the best type of stars for use with the SIM grid

Grid Star Selection and Proxy Sample Results

- we searched the Hipparcos, Tycho-1 (ESA 1997) and Tycho-2 Catalogues (Høg et al. 2000) for suitable K giants
- only stars with no signs for binarity and variability and with good astrometric and photometric quality were selected
- K giants have to be distant enough ($\gtrsim$ 1.5 kpc, i.e. $\lesssim$ 11.5 mag) so that the astrometric signature of possible planets around them is smaller than a few microarcseconds
  (a radial velocity survey of all grid candidates will make sure that there are no binaries in the sample)
  → not enough such stars in Hipparcos, but in Tycho-1 and Tycho-2
- however, best pre-selection possible for Hipparcos
  → defined a nearby proxy sample of Hipparcos K giants brighter than 6 mag and examined some properties of the sample
- observed the intrinsic radial velocity variations with a precision of typically 5–7 m/s (using the Hamilton Spectrograph with the 0.6 m CAT at Lick Observatory in conjunction with the iodine cell)

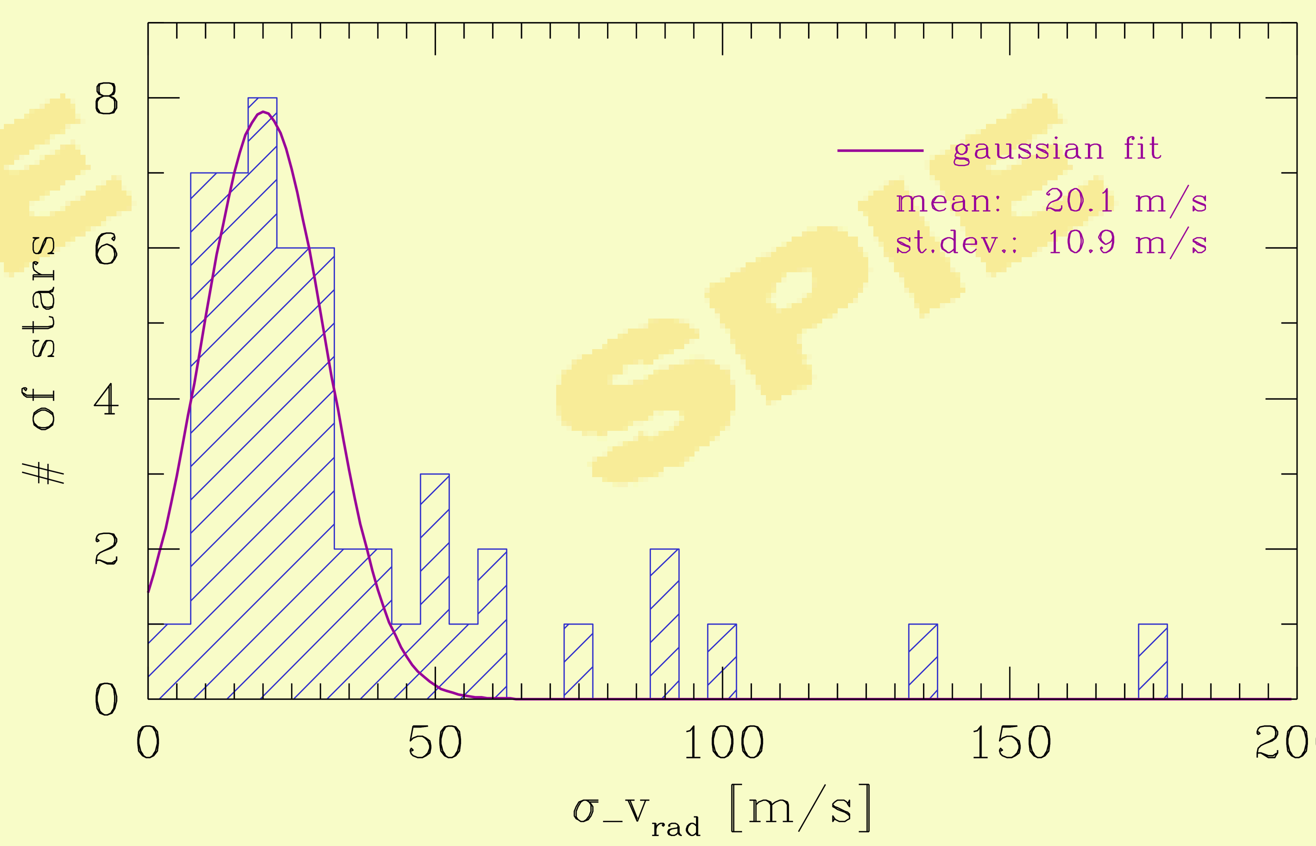

Figure 1:
Radial velocity dispersions measured for the stars in our proxy sample. Altogether we have at least 3 observations for 56 stars (4 of them are not shown in the diagram since they have dispersions larger than 200 m/s, some of them known spectroscopic binaries). A gaussian fit reveals a mean radial velocity dispersion in our sample around 20 m/s.
It is known that a few K giants display radial velocity variations of the order of a few hundred m/s (Hatzes & Cochran 1998). Our results show however that with a rigorous pre-selection it is possible to find K giants with considerably smaller variations, at least over the timescales of a few months that we have been able to probe so far.

Simulation

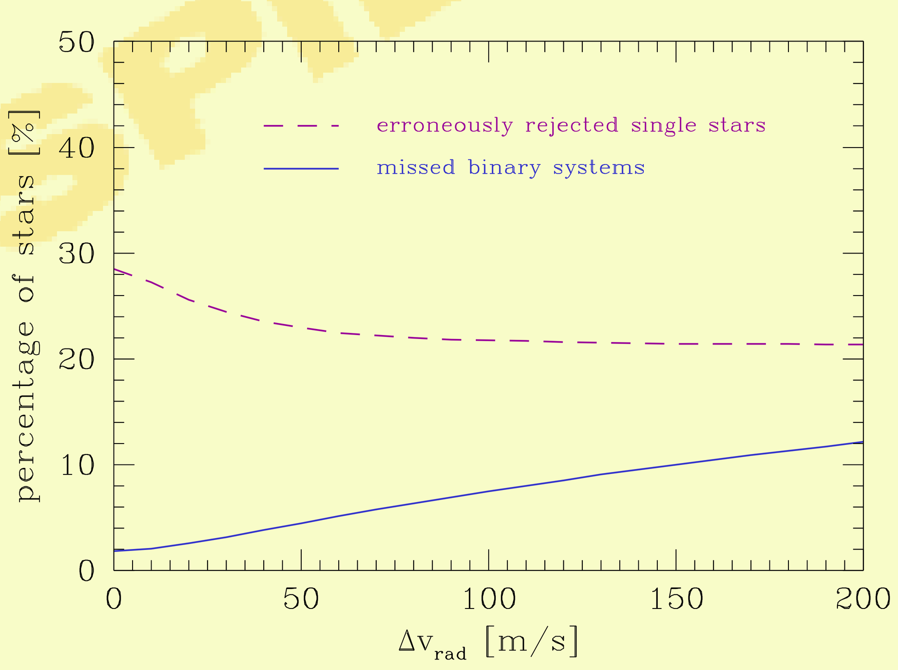

Figure 2:
Fractions of missed binary systems and erroneously rejected single stars as a function of measurement accuracy in a simulated radial velocity survey with 3 observations per star. The results of sets of 1000 simulations have been averaged to obtain these curves.
As expected, the fraction of missed binary systems increases with lesser accuracy.

- in order to come up with a final sample of truly single grid stars, the radial velocities of all candidates have to be measured repeatedly
- we simulated such a radial velocity survey with the aim to get estimates for the number of double stars that would typically be missed
- we assumed a binary contaminatin of our initial sample of 50% and distributions of orbital parameters as found in the literature
- on top of the binary orbits and the constant radial velocities for single stars we added the intrinsic radial velocity variability found in our proxy sample (see Fig. 1)
- we assumed 3 observations per star, distributed over a period of 5 years
- varying the measurement accuracy, we calculated the number of double stars that were typically missed as well as the number of single stars that were erroneously rejected

Conclusions

- it is possible to select suitable samples of candidate grid stars from astrometric catalogues
- radial velocities for these pre-selected grid stars have to be measured several times in order to sort out unwanted double stars
- we have shown that it is possible to find K giants with sufficiently small intrinsic radial velocity variations not to severely affect the identification of binaries, at least over timescales of a few month probed so far in our proxy sample
- we presented simulations of the number of stars that would typically be missed in such a radial velocity survey, as a a function of measurement accuracy
- it turns out that a degradation of the radial velocity accuracy from 20 m/s to 200 m/s increases the fraction of unidentified binary stars from 2.5% to 12.2%
- given the huge amount of observing time needed for a precise radial velocity survey (something of the order of hundred nights at a 10 m class telescope!) it is worth considering less time-consuming alternatives
- however, we strongly caution against concessions involving a larger contamination fraction of the final grid sample with binaries;
  it could easily lead to a much higher fraction of unusable SIM science observations, depending on the exact design of the grid

References

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