Preparing the PRIMA Astrometric Planet Search: Selecting Suitable Target and Reference Stars

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The Consortium

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consortium is building differential delay-lines at the VLTI that are necessary to operate PRIMA in precise astrometry mode (see also posters 47, 135, 136 and 139)
→ in exchange, consortium is provided with guaranteed time by ESO to conduct astrometric planet search with the AT's

Astrometry with PRIMA

- goal: astrometric accuracy of 10 μas, relative to a nearby ($<10''$) reference star
- target star brighter than K≈12 mag, reference star brighter than K≈16 mag
- astrometric signature $\theta_{\rm circ}$ of a companion in a circular orbit according to Kepler's Third Law:

$$\theta_{\rm circ} = 191\,\mu{\rm as} \cdot \frac{P\,[{\rm yr}]^{2/3} \cdot m_2\,[{\rm M}_J]}{d\,[10\,{\rm pc}] \cdot m_1\,[M_\odot]^{2/3}}$$

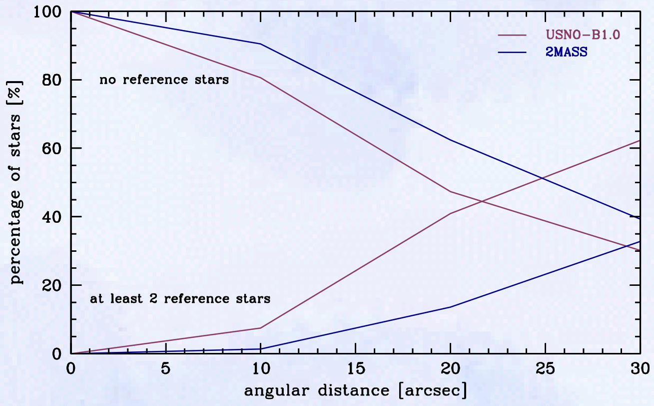
(P is the period in years, m_2 the companion mass in Jupiter masses, d the distance in parsec, and m_1 the mass of the primary in solar masses)

- most favorable target stars are closer than about 10 pc and less massive than about 0.5–1 $M_\odot$

Target Stars

The target stars for the Astrometric Planet Search with PRIMA will be selected to address a variety of scientific questions that cannot be tackled with the radial velocity (RV) observations:

1. **What are the masses of the detected RV planets? Are the orbits of the various planets in planetary systems coplanar?**
   - targets: already detected RV planets
   - number of suitable targets however very limited; some of the known RV planets do not have suitable reference stars, or the expected astrometric signature is too small
2. **How do the properties of planets orbiting early-type stars differ from those around later-type stars, and of planets orbiting young stars from those orbiting older stars?**
   - targets: early-type (A and F stars) as well as some of the youngest stars in nearby star-forming regions (both not observable with RV)
3. **What is the lowest mass planet that we can find? What is the frequency of planets around M stars as compared to e.g. K stars?**
   - in principle, best target stars for astrometry are low-mass stars that are really nearby
   - as a starting point, we have selected the 10 closest stars in each 0.1 $M_\odot$ mass bin between 0.08 and 1 $M_\odot$



Percentages of possible reference stars in the USNO-B1.0 (red) and 2MASS (blue) catalogs. The input sample of possible target stars consisted of all main-sequence stars from the CNS3 catalog. The upper curves show the percentages of target stars with no reference stars at all, whereas the lower curves show the percentages of target stars that have 2 or more possible reference stars in that catalog.

Reference Stars

- reference stars should be preferably located within 10″of the target (possible up to 30″ with degraded astrometric accuracy)
- reference stars should be as distant as possible, so that the astrometric signature of a possible companion (stellar or planetary) would be too small to be measurable with PRIMA
  → e.g., in order not to be sensitive to a Jupiter-mass planet in a several year orbit, low-mass stars would typically have to be located at distances larger than 1 kpc
- binary stars cannot be used at all, except for very long period systems where the astrometric signal is not detected over the relatively short PRIMA survey duration (3 years for the core program)
- suitable catalogs to search for PRIMA reference stars: 2MASS and USNO-B1.0 (UCAC2 catalog might in principle also work, but the current version is very deficient in faint stars close to bright ones)
  → preliminary search in the USNO-B1.0 yields possible reference stars within 10″ for about 20% of target stars (see figure)
- photometry and/or spectroscopy planned to verify the suitability of possible reference stars for PRIMA astrometry
- close double stars might also provide good target/reference stars for PRIMA, since both could be used at the same time as target and reference
- if an astrometric signal is detected, it is necessary to observe either the target or the reference star (preferably both) against another reference, in order to sort out to which component the signal belongs

Summary

- observable targets will be restricted to the closest stars in the solar neighborhood and to those stars that have suitable reference stars within at most 30″around them
  → e.g.: less than 10% of the stars in the CNS3 have 2 or more possible reference stars listed in the USNO-B1.0 within 10″, and about 40% of the possible target stars in the CNS3 do not have any possible reference star within 30″ in the USNO-B1.0