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Astrometric Survey for Extra-Solar Planets with PRIMA

Operation and Calibration Strategy

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1 Scope of this Document

The scope of this document is to establish procedures for the successful operation and calibration of PRIMA for microarcsecond astrometry. The hope is that if we identify potential problems early on, we might be able to work something out. Especially for calibration, it might be necessary to get additional observations for a number of stars in order to use them for accurate calibrations, so these have to be identified early on in the project. The goal is to have well-calibrated astrometric projected angular separation measurements in the end!

This document covers the strategies that we plan to employ for operation and calibration. Eventually these strategies will lead into the document on the *Operation and Calibration Plan*.

2 Overview: Calibration Requirements for Precise Astrometry with PRIMA

An overview of the most important calibration tasks, in particular as required for high precision astrometry. Possibly include an overview diagram.

3 Operation

3.1 Daytime Calibration of PRIMA Subsystems and PRIMA Alignment

Using an artificial source.

3.2 Nighttime Calibration of PRIMA Subsystems and PRIMA Alignment

3.2.1 Calibration of the FSU on a Real Star

3.2.2 Calibration of the PRIMA Transfer Function on Sky

3.2.3 Alignment of PRIMA on Sky

3.3 Pointing, Presetting and Pupil Optimization

3.4 Baseline Calibration

3.5 Fringe Integration Time

Choose the fringe integration time, based on the separation between target and reference star. Smaller separations yield smaller integration times.

4 Calibration

Consistency checks using various types of stars. At this stage, this is merely brainstorming; not everything might be really required.

4.1 Single Stars, non-resolved

Feed the same star into both instrument paths and look whether everything is what you expect.

4.2 Single Stars, resolved

For baseline calibration?

4.3 Visual Binary Stars with Known Orbits

Calibration Strategy:
Measure the separation of both components in the system and compare to the predicted value based on published elements. Is the current measurement consistent with the predicted value?

Very likely the published elements, even of the grade 1 orbits in the *Sixth Catalog of Orbits of Visual Binary Stars* by Hartkopf & Mason (2004), are not accurate enough to predict the separations of both components at microarcsecond level. However, it is useful to have an idea of the elements as a starting point; it should be possible to derive more accurate elements as PRIMA observations of these calibrator stars accumulate over time.

Need to look at availability of such systems in the WDS Catalog of Visual Binary Stars. Are the orbits accurate enough, and are there enough such systems available and distributed over the whole observable sky?

4.4 Calibration Procedures

Why, when, how often?

Probably need to measure the same star at various hour angles, and various stars at various hour angles (at the same time), and look for suspicious inconsistencies.

4.5 Need for Pre-Observations of Possible Calibrator Stars?

Need to evaluate that early on. Are there any special observations needed for calibrator stars before the start of the astrometric survey? Spectra, radial velocitties?

References

Delplancke, F., *Evaluation of a typical PRIMA observation duration*, 200?

Hartkopf, W.I., Mason, B.D., *Sixth Catalog of Orbits of Visual Binary Stars*, available at `http://ad.usno.navy.mil/wds/orb6.html`, 2004

A Lists of Possible Calibrator Stars

A.1 Visual Binaries with High Precision Orbits

The following list of 13 possible calibrator stars is taken from the high precision subset of the *Sixth Catalog of Orbits of Visual Binary Stars* by Hartkopf & Mason (2004) recommended for calibration purposes. Only systems with separations between 2″ and 10″, and with declinations between -70° and +20° were selected. The format of the table is the same as in the original catalog.

RA,Dec (2000).....	WDS.....	Name.....	ADS..	HD....	HIP...	V1...*	V2...*	....P.....	....a.....	...i....	Omega..*	....T.....	...e...	omega...	Referenc	G	N	P	E
013947.24-561147.2	01398-5612	DUN 5AB		10361J	7751	5.82	5.86	483.66	7.81689	142.824	13.116*	1813.494	0.5344	18.374	vAb1957	5		P	E
020202.80+024549.5	02020+0246	STF 202AB	1615	12446	9487	3.82	4.92	933.05	4.0	120.9	23.3	2098.643	0.696	225.4	Sca1983f	4	N	P	E
033647.31+003517.4	03368+0035	STF 422	2644	22468	16846	5.82	8.69	2101.	8.023	32.07	92.35	1900.0	0.18	151.97	Hop1964b	5	N	P	E
042316.83+112240.8	04233+1123	STF 535	3174	27762	20472	6.64	8.01	1128.00	2.040	145.5	114.0	2046.00	0.495	243.6	Hrt2000c	5	N	P	E
050029.67+050556.6	05005+0506	STT 93	3596	32022	23277	8.02	8.68	1467.52	2.530	99.7	241.3	1914.22	0.649	249.3	Sey1999a	5		P	E
081212.71+173853.3	08122+1739	STF1196AB-C	6650	68257	40167	5.05	6.20	1115.	7.70	146.	74.2	1970.	0.24	345.5	Hei1996b	4	N	P	E
084646.65+062508.1	08468+0625	STF1273AB-C	6993	74874	43109	3.38	6.48	990.	4.66	39.	49.3 *	1920.	0.30	200.	Hei1996b	4	N	P	E
121558.52+053825.2	12160+0538	STF1621	8486		59816	9.45	9.96	1100.	3.5	26.	2.	1973.67	0.89	275.	Sod1999	5	N	P	E
123033.75+094257.2	12306+0943	STF1647	8575	108875	61035	7.46	7.72	4273.	4.358	67.0	221.5	1864.3	0.6900	341.8	Hop1970	5	N	P	E
135458.30-080331.6	13550-0804	STF1788AB	9053	121325	67953	6.19	6.97	2613.	4.998	50.9	108.05	1823.8	0.35	293.5	Hop1970	5	N	P	E
161556.96+072129.6	16160+0721	STF2026	9982	146413	79702	8.70	9.08	473.5	2.457	133.1	12.3	1906.9	0.82	192.5	Hei1963a	4		P	E
180527.21+023008.8	18055+0230	STF2272AB	11046	165341	88601	4.03	5.87	88.38	4.554	121.16	302.12	1895.94	0.4992	14.0	Pbx2000b	1	N	P	E
204613.25+155425.8	20462+1554	STF2725	14270	197913	102490	7.09	7.90	2851.	7.364	66.0	20.9	1658.	0.18	276.3	Hop1973b	5		P	E

A.2 Visual Binaries with Known Orbits

A.3 Visual Binaries with no Detectable Orbital Motion

From the WDS (visual doubles without orbits) we selected those stars for which separation and orbital motion were determined at two separate epochs, and no orbital motion has been detected so far. There are only 8 of these systems in the right coordinate range for Paranal:

WDS Id	Disc	Comp	EPOCH Frst	Last	#	THETA FST	THETA LST	RHO First	RHO Last	Magnitudes Pri	Magnitudes Sec	Sp Ty	Prop. RA"	Mot DEC"	DM	Desig	Note	coord	Second. Prop.Mot
01541+0011	A 1918		1908	1991	12	322	322	1.2	1.2	11.09	11.32	G0	8	-14	-00	290	pD	8	-14
05381-0011	STF 758	AD	1842	2002	12	79	79	41.5	41.5	7.44	8.61		3	-1			pD	-4	1
07182-0020	SLE 303		1896	1998	6	81	81	22.3	22.3	11.87	12.24		-4	-1				-7	2
07279-0006	BAL1097		1897	1998	2	66	66	12.8	12.8	10.90	11.10		-8	-3				0	0
08166+0005	RST5288		1946	1969	2	322	322	1.5	1.5	10.40	11.40	G0	-79	20	+00	2242	pD	0	0
15204+0015	GIC 126		1958	1960	2	171	171	190.0	190.0	9.31	13.10	G5	125	-250	+00	3346	Np	0	0
19098-0017	A 863		1904	1991	11	123	123	0.4	0.4	9.82	10.07	F2	18	-1	-00	3660	pD	18	-1
21164-0003	LYS 42	AD	1984	1998	2	170	170	69.9	69.9	10.50	12.00		0	0			D	0	0

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