

Practice session: UV coverage and preparation of observations

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Abstract

This second practice session is about UV coverage and observations preparation. It will be done using the ASPRO software.

Key words: Optical long baseline interferometry, visibility, phase, UV coverage, VLTI, ASPRO

1 Observability and UV coverage

What you will need for this particular practice session:

You will need to use ASPRO and the catalogs named `sampleSources1.sou` and `sampleSources2.sou` provided with this practice session (you can copy this information into text files, see below). To set up ASPRO, please refer to the 1st part of this practice session about visibilities and model fitting.

```
!-----  
! sampleSources1.sou  
!-----  
ACHERNAR    EQ 2000.000    01:37:42.8466 -57:14:12.327  
NGC_1068    EQ 2000.000    02:42:40.8300 -00:00:48.400  
BETELGEUSE  EQ 2000.000    05:55:10.3053 +07:24:25.426  
HD_81720    EQ 2000.000    09:25:19.2802 -54:27:49.559  
HD_87643    EQ 2000.000    10:04:30.2893 -58:39:52.077
```

```

!-----
! sampleSources2.sou
!-----
STAR_40  EQ 2000.000    16:00:0.0    40:00:0.0
STAR_30  EQ 2000.000    16:00:0.0    30:00:0.0
STAR_20  EQ 2000.000    16:00:0.0    20:00:0.0
STAR_10  EQ 2000.000    16:00:0.0    10:00:0.0
STAR_0   EQ 2000.000    16:00:0.0     0:00:0.0
STAR_-20 EQ 2000.000    16:00:0.0   -20:00:0.0
STAR_-40 EQ 2000.000    16:00:0.0   -40:00:0.0
STAR_-60 EQ 2000.000    16:00:0.0   -60:00:0.0
STAR_-80 EQ 2000.000    16:00:0.0   -80:00:0.0

```

Exercise 1: Setting up an observation

Set the date: In *WHEN* → *Date & Time Setup*, put the date 28-AUG-2007 and time 14:00:00.

Set the place: In *WHERE* → *VLT, 2 Telescopes*.

Set the target: In *WHAT* → *Use Object catalog*, and select the file `sampleSources1.sou`. If you use the web version of ASPRO, you need to have an account on the JMMC server and to copy your files beforehand using the *File Management* panel.

Check the settings: Check with *WHAT* → *View Object catalog*, and look at the result in the xterm window. Note: you can do this step only with a local version of ASPRO as the web version has no access to a terminal.

Exercise 2: Observability of sources at different declinations and delay line constraints

First, we will check the observability of the sources with *OBSERVABILITY/COVERAGE* → *Observability of Source*. Set the minimum elevation to 30°, check the *Plot the twilight zones* box, and use UT1 and UT2. When everything is done, press the *GO* button.

Which stars are observable? Is the chosen date appropriate for observing all stars together? Change the date so that all targets are observable during the same night.

Delay lines limitation: Now, go to *OBSERVABILITY/COVERAGE* → *Observability limits due to delay lines*. How changing the target changes the observability? Compare the observability of all targets with UT1-UT4 and G1-J6. What do you conclude?

Sampling the UV plane with the VLTI

This goal of this section is to see how the *UV* coverage changes with baseline orientation and source declination.

You should first load the catalog named `sampleSources2.sou` in the *WHAT* → *Use Object catalog* menu. It contains 7 stars of R.A. 14:00:00 and of different declinations.

You should repeat all steps of exercise 1 until you continue. In this section, you will make intensive use of the *OBSERVABILITY/UV COVERAGE* menu of *ASPRO*.

Exercise 3: UV tracks for a North-South baseline

We will now study the *UV* coverage of the sources with *OBSERVABILITY/COVERAGE* → *UV coverage & PSF*.

- Select the star at declination -20 and set the wavelength to 2 microns. In the *Telescopes & Stations* panel, select any 2-telescope baseline oriented N-S (cf. Fig. 1, can be plotted using *OTHER* → *Plot interferometer sketch*) and have a look to the shape of *UV* coverage you get.
- Change stars, going from positive to negative declination and see what happens (you can over-plot the graphs by unchecking the *RESET FRAME* button in the *Telescopes & Stations*, and do not forget to adjust the *U-V range to plot*). Short baselines are not equivalent to long ones. Check this with different configurations, and explain.

Hint: Look at the orientation of the Earth in Fig.2.

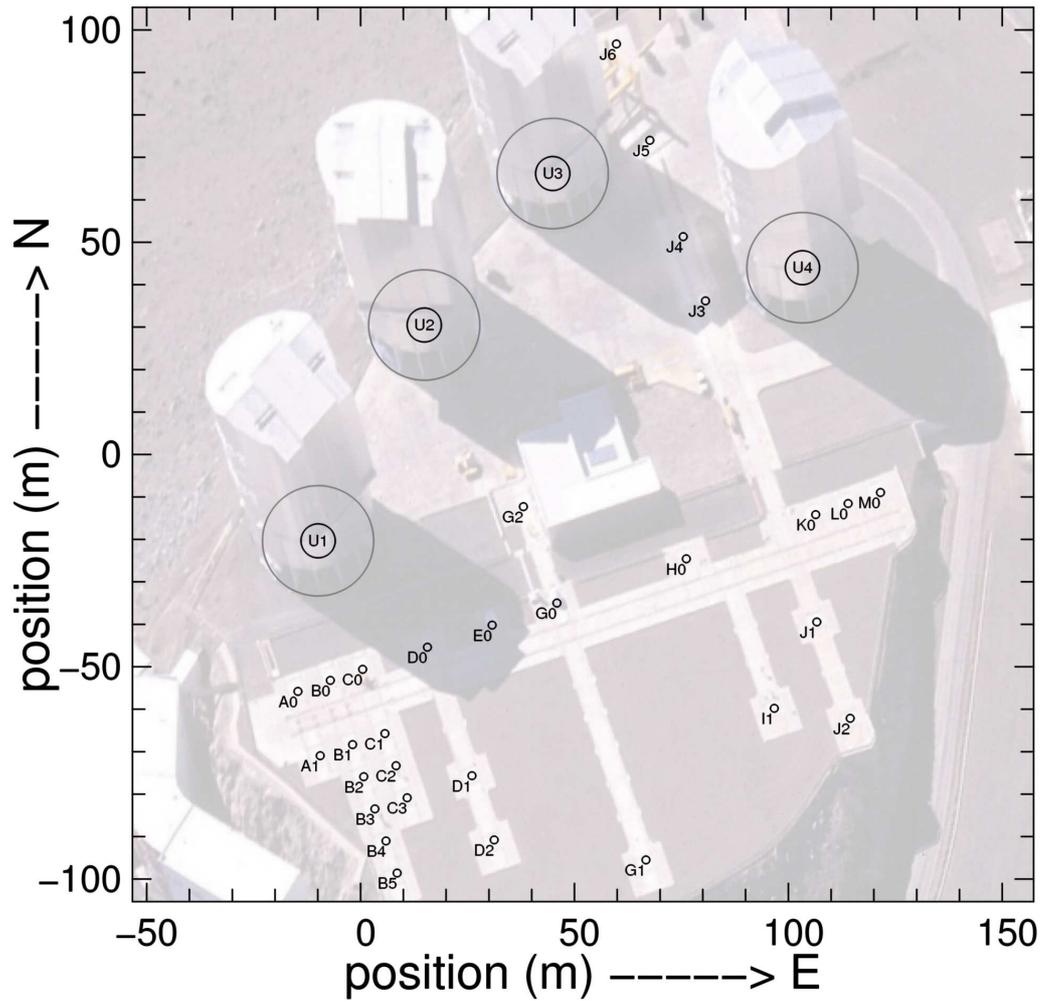


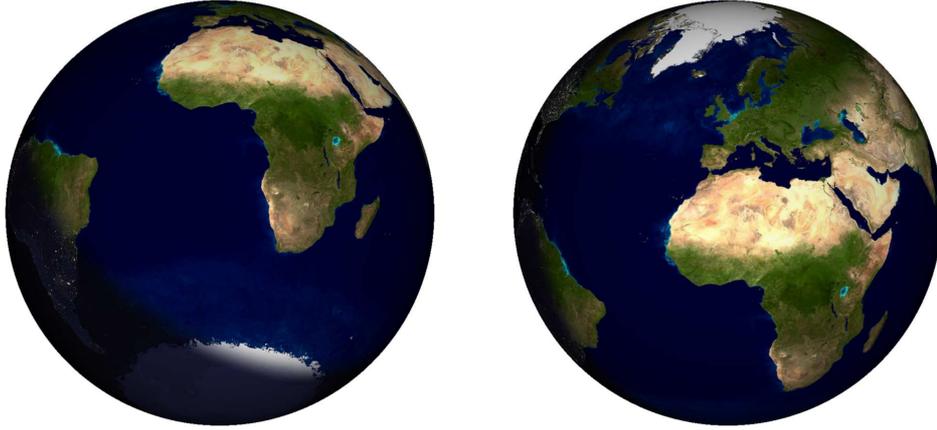
Fig. 1. The VLTI stations. Photo: Gerhard Hüdepohl

Exercise 4: UV tracks for an East-West baseline

Select a large 2-telescope baseline oriented E-W. Visualize the observability of the targets and check the delay line constraints. Plot the UV coverage for several stars.

UV tracks shape: Why are the UV -tracks elliptical (you can refer to the interferometry introduction articles)?

UV tracks and target declination: Have a look at the UV -tracks of a star above the equator and below the equator. What do you notice?



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Fig. 2. The Earth, as seen from a -25° declination (left) and a $+25^\circ$ declination (right). These images were generated using the free software xplanet, <http://xplanet.sourceforge.net>.

Hint : Look at the figure of the Earth in Fig.2 again.

Importance of the baseline orientation: Compare the N-S baseline and the E-W baseline in terms of *UV*-coverage and observability (how much *UV*-track do you cover with the same fixed delay?) Play with the star and the end of hour angle range.

Exercise 5: UV tracks for a 3-telescope-array

Observability:

- Select a large 3-telescope array configuration (in the *WHERE* menu).
- Visualize the observability of the targets (including constraints on delay lines). Look at the *OBSERVABILITY/COVERAGE* → *Observability limits due to delay lines* panel to see why the observability range is smaller with 3 telescopes than with 2 telescopes.

UV tracks for different configurations: In the *UV coverage* panel, try to add several 3-telescope configuration. For that you need to un-check the *reset frame* button. As an example, you can select 3 configurations i.e. A0-G1-J6, G2-J1-D2 and A1-B2-C1.

Beam shape: You can then display the “dirty beam” (the same as in radio-astronomy !) by using the *Display PSF* panel.

Exercise 6: Radius measurement of a star (uniform disk)

Here you will play with configurations and “real” observations. You will have a set of stars you want to observe. You must figure out if they are observable and choose the best observing setup to accurately measure the diameters.

In this part, you should load the catalog named `sampleSources1.sou`. Select an instrument and the K band ($2.1\mu\text{m}$). You should also select an observing period and an optimal array configuration to determine the radius of the targets with the highest accessible accuracy. In this section you will make intensive use of the *WHAT & Object Model* menu (or *UV Model/FIT, Source modeling* menu) and *OBSERVABILITY/COVERAGE* menu of **ASPRO**.

Table 1

Star main characteristics of catalog `sampleSources2.sou`

Object	Spectral Type from simbad	Ra	Dec	Diameter [mas]
HD 81720	K2III	09:25:19.28	-54:27:49.6	0.93
Achernar	B3Ve	01:37:42.85	-57:14:12.3	2.53
NGC 1068	AGN	02:42:40.83	-00:00:48.4	3
HD 87643	B[e]	10:04:30.29	-58:39:52.077	10
Betelgeuse	M2Iab	05:55:10.31	+07:24:25.4	44.20

Use the appropriate uniform disk model to either display the amplitude, the phase of the visibility, or the derivatives with respect to the diameter to visualize which part of the *UV* plane really constrains the model.

Optimizing the observability of a series of sources: Can you find a setup which fits well all the stars together? For that purpose, you should try to find a night and configuration which fits well all the stars characteristics for observability, visibility level, delay lines constraints, and *UV* tracks. Conclude on the feasibility of the observing program as it is.

More details about the object: Can one determine phenomena that occur at higher spatial frequencies, like limb darkening for all the stars?

Knowing the limitations: What accuracy do you need to fulfill your objectives?

1.1 Exercise 7: Binary parameter determination

In fact a “mistake” was introduced in the previous list: the stars HD 68273 (real name γ^2 Velorum) and HD 87643 are binary stars. First load/re-load the catalog named `sampleSources1.sou` and then select one of the stars HD 68273 or HD 87643 (repeat the exercise for both sources). Let us consider the binary systems with the properties summarized in Table 2.

Table 2

Binary system characteristics

Name	Ra	Dec	ρ [mas]	P.A. [°.]	Δ mag
HD 68273	08:09:31.9503	-47:20:11.716	3.65	75	0
HD 87643	10:04:30.2893	-58:39:52.077	34.5	-4	1

in *WHAT* \rightarrow *Object Model* you can define the binary star model, and in *OBSERVABILITY/COVERAGE* \rightarrow *UV Coverage & PSF* \rightarrow *Telescopes & Stations* you can plot the UV coverage together with the 2D image of the visibility of the source (check the box *Underplot a model image?*).

For that exercise you will select successively the stations I1-H0, I1-K0, and G1-H0 for North-South baselines, and E0-G0, E0-H0, and A0-K0 for East-West baselines. You will then repeat the following steps:

- Select the stations
- Visualize the *UV* coverage,
- Visualize the amplitude and phase
- Does the baseline constrain the parameters of the binary?
- Plot the visibility as a function of time.
- What do you notice about the baseline orientation / the binary system position angle?

1.2 Exercise 8: Prepare observations with ASPRO

Exit from ASPRO and call it again with `aspro @oipt`.

Do the equivalent of exercise 7 with the *Choose...* \rightarrow *AMBER, Periods 85, 86* or *Choose...* \rightarrow *MIDI, Periods 85, 86* for your favorite object.

References

- Berger, J. P. & Segransan, D. An introduction to visibility modeling, *New Astronomy Review*, 2007, 51, 576-582
- Millour, F., All you ever wanted to know about optical long baseline stellar interferometry, but were too shy to ask your adviser, *New Astronomy Review*, this issue.