Interferometry Practice Session 2
Observability and (u, v) coverage

F. Millour*

Max-Planck Institut fr Radioastronomie (MPIFR)

Auf dem Hügel 69, 53121 Bonn, Germany

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Abstract

This work session is divided into three main parts. The first one aims at showing the additional constraints in observability interferometers have. The second one intends to give you a clear idea about the (u, v) coverage you will get for baselines of different orientation and targets of different declination. In the third part, you will have to select different array configurations to efficiently measure the radius of 3 stars and the parameters (ρ, Θ, Δmag) of a binary system.

Practical considerations

You will need to use ASPRO and the catalogues named `TorunSources1.sou` and `TorunSources2.sou`. For setting up ASPRO, please refer to the 1st part of this practice session avout visibilities and model fitting.

1 Source observability

1.1 Setting up an observations

- In the *WHEN* menu, *Date & Time Setup* put the today's date `28-AUG-2007` and time `14:00:00`.

- In the *WHERE* menu, select *VLT, 2 Telescopes*

- In the *WHAT* menu, select *Use Object catalog* and select the file `TorunSources1.sou`.

- Check with the *WHAT* menu *View Object catalog* and look at the result in the xterm window.

1.2 Observability of sources at different declinations and delay lines constrains

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* button and the GO with UT1 and UT2.

- Which stars are observable?

- Go now to *OBSERVABILITY/COVERAGE, Obsevability limits due to delay lines*. How does it change the observabilty?

- Compare the observability with UT1-UT4 and G1-J6. What do you conclude ?

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*Based on the practice session of D. Ségransan at the Goutelas summer school

2 Sampling the (u, v) plane with the VLTI

This section aims at having some intuition about how (u,v) coverage change with baseline orientation and source declination.

    You should first load the catalogue named `TorunSources1.sou`. It contains 7 stars of R.A. 5:00:00 and of different declinations. In this section you will make an intensive use of the *OBSERVABILITY/UV COVERAGE* menu of **ASPRO**.

2.1 (u, v) tracks for a North-South baseline

We will study now the (u, v) 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 a 2 telescope baseline oriented N-S (cf. Fig. 1) and see what type of (u, v) coverage you get.

- Change stars, going from positive declination to negative ones and see what happens (you can overplot the graphs by unchecking the "RESET FRAME" button in the *Telescopes & Stations*).

Hint: have a look at the figure of the Earth in Fig.2

2.2 (u, v) tracks for a 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 (u, v) coverage for several stars.

- Why are the (u, v)-tracks elliptical ?

- Have a look at (u, v)-tracks of a star above the equator and below the equator. What do you notice?

Hint : have a look at the figure of the Earth in Fig.2

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

2.3 (u, v) tracks for a 3-telescope-array

- 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, Obsevability limits due to delay lines* panel to see why the observability range is smaller with 3 telescopes than wih 2 telescopes.

- In the (u, v) coverage panel, try to add several 3-telescope configuration checking off the *reset frame* button. As an example, you can select 4 configurations i.e. `A0-G1-J6`, `G2-J1-D2` and `A1-B2-C1`.

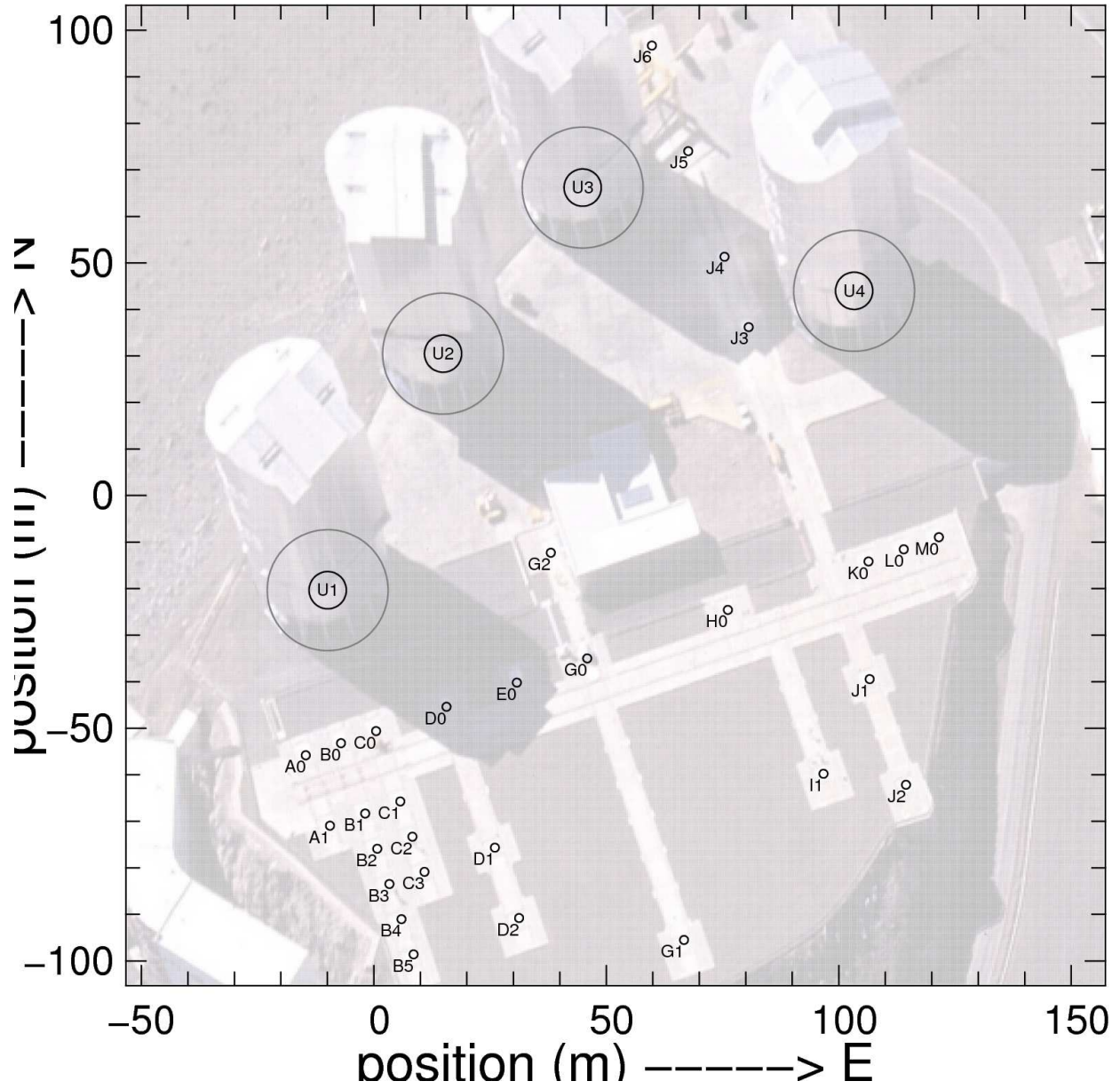- You can then display the dirty beam by using the *Display PSF* panel.

Figure 1: The VLTI stations. Photo: Gerhard Hüdeophl

Table 1: Star main characteristics of catalog `TorunSources2.sou`

Object	Spectral Type	Ra	Dec [mas]	Diameter
Betelgeuse	M2Iab	05:55:10.3053	+07:24:25.426	44.20
Achernar	B3Ve	01:37:42.8466	-57:14:12.327	2.53
HD 81720	K2III	09:25:19.2802	-54:27:49.559	0.93
HD 68273	K2III	08:09:31.9503	-47:20:11.716	0.5

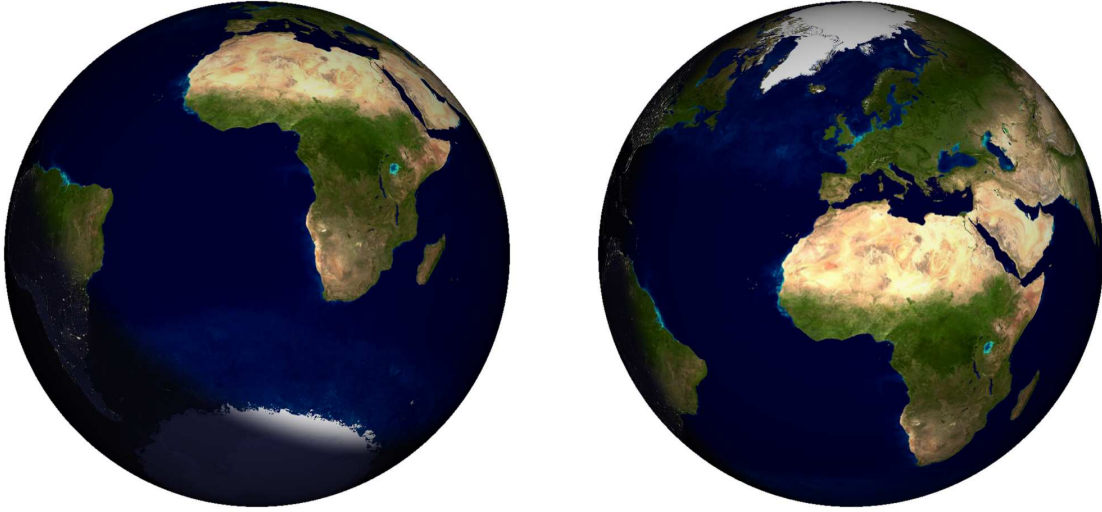Figure 2: The Earth, as seen from a -25°declination (upper) and a +25°declination (lower)

3 Radius measurements and binary parameter determination

3.1 Direct radius measurement

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

In this part you should load the catalogue named `TorunSources2.sou`. Select an instrument and the K band $(2.1\mu m)$. You should also select an observing period, an optimal array configuration to determine their radius with the best accuracy. In this section you will make an intensive use of the *WHAT & Object Model* menu (or *UV Model/FIT, Source modelling* menu) and *OBSERVABILITY/COVERAGE* menu of **ASPRO**.

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 (u, v) plane really contrain the model.

- Are we able to determine the radius of these stars ?

- Are we able to determine phenomena that occur at higher frequencies like limb darkening ?

- Can you find a setup which fits well for all the stars together ? For that, you must have both observability, delay lines and (u,v) tracks OK.

3.2 Binary parameter determination

In fact a mistake introduced in the previous list: the star HD 69273 is a binary star (real name γ^2 Velorum). First load/re-load the catalogue named `TorunSources2.sou` and then select star number 4. Let's consider it is a binary system with properties summarized in Table 2.

- Select the Baseline G2-G1

- Visualize the (u, v) coverage and the amplitude. Does this baseline constrain the parameters of the binary ? Plot the visibility as a function of time.

Table 2: Binary system characteristics

Ra	Dec	ρ [mas]	P.A. [°.]	Δmag
08:09:31.9503	-47:20:11.716	3.65	75	0

- Select the baselines A0-M0. Visualize the amplitude, the phase, and their derivatives.

- Does this 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 ?

If you arrive to this point, then you can play with the exercise 8 of yesterday.