Practice work

Introduction to closure phases

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Using ASPRO to visualize closure phases

The version of ASPRO you are using does has not have the capability to plot closure phases directly. Instead, you must follow this process for each of the exercises:

1. Use ASPRO to define UV coverage and a model for the source as in the first two practice sessions
2. Export the results work as an OIFITS file (OIFITS is the standard optical interferometry data exchange format), using OTHER|Export UT Table as OI_FITS
3. Use the OIFITS explorer tool (OTHER|OI_FITS File Explorer) in ASPRO to plot the closure phases that were written to the OIFITS file

NB: Since we are using the OFITS exporter tool you will need to select a WHEN, WHERE, and WHAT at the beginning of step 1. We suggest you use an observation in late December with AMBER and choose the object named HR_5999 using WHAT|Get CDS Object.

1 Closure phase dependence on resolution

Aims of this exercise:

- Practice visualising closure phases in ASPRO
- Illustrate how the amplitude of the closure phase signal varies with angular resolution

In this exercise you will generate a binary model with separation distance 0.5mas, position angle 10° and flux ratio 0.5.

1. Bring up the Telescopes & Stations window, then choose each of the following configurations of 3 telescopes in turn, clicking Go for each one For the second and third configurations, make sure that the RESET FRAME option in the Telescopes & Stations window is set to “No”. This will give a single UV Table containing all three configurations. What can you say about these configurations?
    a. G0-C0-D0
    b. G0-D0-K0
    c. E0-A0-M0
2. Generate the binary model described above, using the procedure you learned in the earlier practical sessions. Are you “resolving” the object with each of the above configurations? Export your observation as an OIFITS file (see above)

3. Using the OIFITS explorer tool, plot the closure phase as a function of time. How does the closure phase depend on angular resolution?
4. Increase the binary separation by a factor of 4. Do you observe the same closure phase dependence on resolution? What happens if you rotate the axis of the binary by 90°?

2 Closure phase of a binary system

Aims of this exercise:

- Illustrate how the amplitude of the closure phase signal depends on the fraction of asymmetric flux in the source

Use the model definition tool to generate a binary model consisting of two stars separated by 3 mas with position angle 0° and the following flux ratios: 1, 0.1, 1e-2, 1e-4, 1e-5.

Use the telescope configuration UT1, UT2 and UT4 and plot the visibility curve as a function of radius. Using your experience from the earlier practical sessions, you should be able to explain how the visibility amplitude depends on the flux ratio. For each of the models export a well identified OIFITS file.

2. Use the OIFITS explorer tool to open each of these files. What is the maximum closure phase amplitude variation for each flux ratio? What can you say about its dependence on flux ratio?

3 Closure phase of a disk+star+hot spot (or companion)

Aims of this exercise:

- Demonstrate that point-symmetric sources have closure phases of zero or 180°
- Demonstrate the corollary of the above; that measuring other closure phase values immediately tells you that your symmetric model is wrong!
- Practice finding triangles of baselines that are sensitive to particular features you want to detect

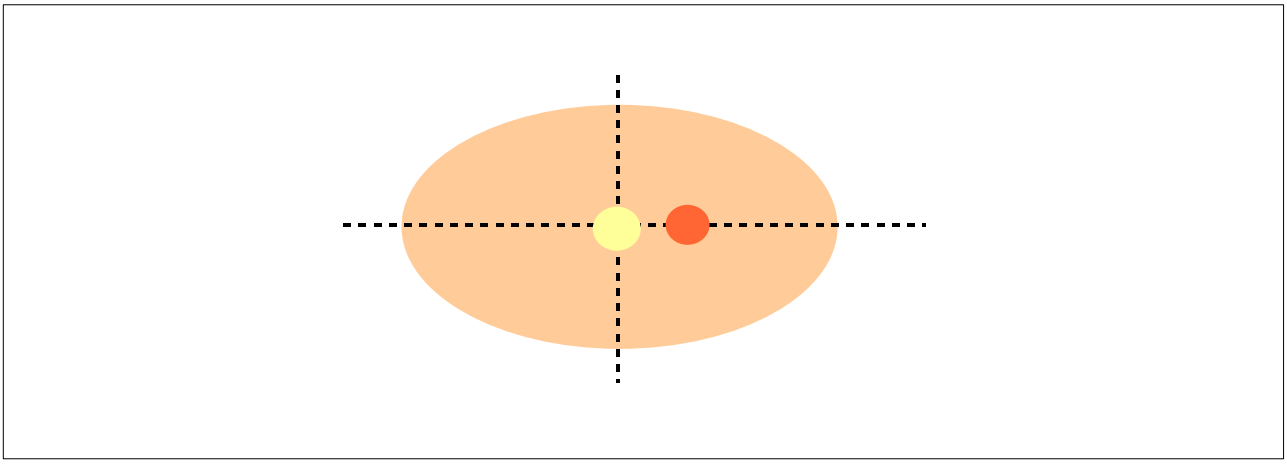

Figure 1: Cartoon of disk+star+hot spot model

Use the model definition tool to generate an elliptical elongated disk with 4 mas major axis and 2 mas minor axis oriented with a 0° orientation. Add a point source at the ellipse photo-center, to represent the star. The star/disk flux ratio should be 0.2.

1. Convince yourself that, whatever the telescope configuration you use you cannot observe a closure phase variation.
2. Now replace the point source by a binary oriented along the major axis, with 0.5 mas separation. The primary star should have a flux 10 times that of the companion. This simulates the presence of a hotspot or companion inside the disk (see Figure 1).
3. Find a triangle baseline configuration with two equal long baselines and one short baseline that maximizes the closure phase signal amplitude.
4. Now find a similar triangle configuration rotated by 90°. What level of closure phase signal variation do you detect ?

4 A real observation

Aims of this exercise:

- Illustrate the typical uncertainties on measured closure phases and differential phases
- Demonstrate the usefulness of spectrally-resolved data
- Practice astrophysical interpretation of real data

For this exercise, you will have to retrieve the following OIFITS file: `GAMMA_VEL_OIDATA_AVG.fits`.

Load it with the OIFITS explorer. This file contains actual observations of gamma Vel with AMBER using medium spectral resolution in the K band. There is one measurement with a 3 telescope configuration. The authors have interpreted these observations in the context of a binary consisting of an O star and Wolf-Rayet star. The WR star is supposed to have two luminous emission lines in the observed part of the spectrum.

1. Display the flux (note this is not normalised) as a function of wavelength: for this you will use the Time Sequence plot option that will display 3 curves, one corresponding to each baseline. You should identify one prominent emission line. The second one disappears because of absorption in the Earth's atmosphere.
2. Display the visibility as a function of wavelength. You should now see the second emission line. Why can this line be seen in the visibilities but not in the spectrum you plotted previously? What information can you extract from these curves in the context of the proposed model?
3. Display the (differential) phase as a function of wavelength. Explain the shape of the curves. What information can you extract in the context of the proposed model?
4. Same question as before but with the closure phase.