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# THE REQUIREMENT TO THE BASELINE KNOWING OF A SPACE VLBI

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ABSTRACT It is shown that the influence of a baseline knowing error on the fringe rate change during coherent averaging time interval is extremely increasing for space VLBI due to more angle velocity of a space baseline rotation comparatively with ground VLBI. It is shown on the example of Radioastron orbit that the requirement to its orbit for such a short wavelength as 1.35 cm is determined by unknowing of the fringe rate change during coherent averaging time interval rather than by delay ambiguity and this requirement is equal several meters.

The high parameters of the modern VLBI systems (the large bandwidth-$\Delta f$, the large time of coherent averaging-T etc) make the highest requirement to the accuracy of a baseline knowing, which as a rule impossible to satisfy a priori. The two dimensional search for the interferometric signal along delay with the step $1/2\Delta f$ and along fringe rate with the step $1/2T$ is usually fulfilled to facilitate this requirement. But it is naturally that delay and fringe rate change for the time average interval have to be known in advance without any searching with accuracy better than $1/2\Delta f$ and $1/2T$ respectively. Taking into account these consideration we can formulate the next requirements to accuracy of a baseline knowing:

$$\Delta D_\tau < \frac{\lambda_{\Delta f}}{2} N_\tau \qquad \Delta D_{\dot\tau} < \frac{\lambda_{\Delta f}}{2} \frac{1}{\Omega\, T}$$
$$\Delta D_f < \frac{\lambda}{2T} \frac{1}{\Omega} N_f \qquad \Delta D_{\dot f} < \frac{\lambda}{2T} \frac{1}{\Omega^2 T} \qquad (1)$$

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where $\lambda_{\Delta f} = C/\Delta f$, $N_\tau, N_f$ - number of steps in searching of delay and fringe rate, $\Delta D_\tau, \Delta D_f$ -the requirement to accuracy of a baseline knowing due to necessity of knowing of delay and fringe rate, $\Delta D_{\dot{\tau}}, \Delta D_{\dot{f}}$ -the requirement to accuracy of a baseline knowing due to necessity of knowing of delay and fringe rate changing during averaging time. It is naturally that the final expression for the accuracy of a baseline knowing looks like next one

$$\Delta D < \mathrm{Min}\ (\Delta D_\tau, \Delta D_f, \Delta D_{\dot{\tau}}, \Delta D_{\dot{f}}) \qquad (2)$$

The result of the calculation $\Delta D_\tau, \Delta D_f, \Delta D_{\dot{\tau}}, \Delta D_{\dot{f}}$ for three wavelengths $\lambda$ and bandwidth $\Delta f$ is shown at TABLE I. The calculation has been carried out for ground interferometers ( $\Omega < 7*10^{-5}$ rad/s ) for $T = 100$s, $N_\tau = N_f = 100$. It is seen from the TABLE I that delay and fringe rate changing during 100s (for example) are well known with enough accuracy for all ground interferometers. The angular rotating of space-ground baseline can be 20 times higher comparatively with ground baselines. It has happened at perigee of an orbit of the space radio telescope. It is seen from the expression (1) that the requirement to a base line accuracy due to necessity of knowing of fringe rate changing - $\Delta D_{\dot{f}}$ is especially increased when the angular speed of a baseline rotating is increased. The requirement to a baseline accuracy for a space-ground interferometer can become very high because $\Delta D_{\dot{f}}$ depends upon $\Omega$ by square law. To check this conclusion we have calculated dependence of the fringe rate changing for T=100s upon the error of a space-ground baseline. The calculation was carried out for the preliminary orbit of Radioastron space radio telescope (70000km - apogee, 7000km - perigee). We have chosen the most simple distinction from real orbit concluding at distinction of time of Radioastron passing through the same point of the orbit.Certainly the other baseline distinction can give less influence on the fringe rate changing but can give and more one.

TABLE I Requirement to The Baseline Knowing Ground Interferometers

| | $\lambda=10$cm<br>$\Delta f$=250KHz<br>$\lambda_{\Delta f}=1200$m | $\lambda=3$cm<br>$\Delta f$=2MHz<br>$\lambda_{\Delta f}=150$m | $\lambda=1$cm<br>$\Delta f$=100MHz<br>$\lambda_{\Delta f}=3$m |
|---|---|---|---|
| $\Delta D_{\tau}$,m | 60 000 | 7 500 | 150 |
| $\Delta D_{f}$,m | 700 | 210 | 70 |
| $\Delta D_{\dot{\tau}}$,m | 100 000 | 12 500 | 250 |
| $\Delta D_{\dot{f}}$,m | 1000 | 300 | 100 |

The distinction of acceleration in moving of the Radioastron connecting with a pointed out above his orbit distinction and also the meanings of dependence of fringe rate changing for T=100s upon baseline error - $\alpha$ in mHz/m are shown at TABLE II. If T is equal 100s then the permitting error in fringe rate changing for this time interval is equal $\delta f=5$mHz. The requirement to the base line knowing $\Delta D$ is determined by relation $\Delta D=\delta f/\alpha$. We can see from the TABLE II that for the wavelength $\lambda=1.35$cm it is required to know a baseline with accuracy 1.5, 2.5, and 50m for perigee, equator and apogee accordingly (last but one column of the table). Certainly it is possible to weaken the requirement to a base line knowing if we introduce the looking for the third parameter - the speed of changing of fringe rate. The requirement to the base line knowing for wavelength 1.35cm and for the number of steps of searching through this third parameter equal 100 is shown at last column of Table II. But in this case the signal to noise ratio is decreased due to increasing of the probability of false pulses.

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TABLE II Requirement to The Baseline Knowing a Space-Ground Interferometer on The Example of Radioastron

| | $a \cdot 10^7$, $m/s^2$ | $\alpha$, mHz/m $\lambda$=18cm | $\lambda$=6cm | $\lambda$=1.35cm | $\Delta l$,m $\lambda$=1.35 $N_f$=1 | $N_f$=100 |
|---|---|---|---|---|---|---|
| Per | 3 | 0.22 | 0.67 | 3 | 1.5 | 150 |
| Equ | 2 | 0.15 | 0.45 | 2 | 2.5 | 250 |
| Apo | 0.1 | 0.007 | 0.022 | 0.1 | 50 | 5000 |

## CONCLUSION

1. The requirement to the base line knowing $\Delta D$ is generally determined by requirement to know with enough accuracy delay, fringe rate and speed of their changing during time of coherent averaging.
2. For ground VlBI the changing of delay and fringe rate is known in advance practically for all frequencies and all baselines.
3. For space VLBI the requirement to a base line accuracy due to necessary of knowing of fringe rate changing - $\Delta D_f$. is becoming dominant especially for short wavelengths. For example for Radioastron it is necessary to know its space radio telescope orbit with accuracy several meters to observe at 1.35cm wavelength.

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