ON THE IMPACT OF THE GALACTIC ABERRATION ON VLBI-DERIVED PRECESSION MODEL

Z.M. MALKIN
Pulkovo Observatory
Pulkovskoe Ch. 65, St. Petersburg 196140, Russia
e-mail: malkin@gao.spb.ru

ABSTRACT. Corrections to adopted precession rate are usually computed from the linear trends in long-term time series of celestial pole offset (CPO), which are the differences between the measured and the theoretical coordinates of the celestial pole. However, there may be systematic effects in these series influencing obtained result. One of those effects is the Galactic aberration (GA). In this study, we have estimated the impact of GA on the trends in CPO series. A comparison of linear trends in two time series computed with and without modelling of GA has shown that the difference can reach 20 μas/cy, which is substantial for the modern precession model. It was also found that GA influences long-period nutation terms. Thus we can conclude that GA should be included in the VLBI reduction model to avoid these systematic errors.

1. INTRODUCTION

With improvement in the accuracy of astronomical position measurements, the requirements to the accuracy of models used during data processing are also increased. It becomes necessary to take into account finer effects influencing the positions and motions of celestial objects. One of these effects is the Galactic aberration (GA), which is the prevailing part of the acceleration of the Solar system barycenter (SSB) due to its non-linear motion. This effect causes supplement systematic source motions that can influence secular terms in the celestial pole offset (CPO) series, and thus also the precession rate derived from analysis of trends in these series, or from a global VLBI solution.

The impact of GA on VLBI observations (also space astrometric observations) was foreseen many years ago, see e.g., a historical overview in Malkin (2011). However, until recently, the motions of radio sources due to GA were much smaller than the observational accuracy, and the length of highly accurate VLBI observation time series was relatively short to accumulate a significant error from ignoring GA. Thus the inclusion of the GA term in observational models was postponed. In this paper, we show that modeling of GA during the processing of long series of VLBI observations became already substantial. In particular, ignoring corrections of radio source motions for GA directly influences the determination of the precession rate.

2. THE IMPACT OF GA ON SOURCE PROPER MOTIONS

The basic formula for source proper motion caused by GA is given by Kovalevsky (2003)

$$\begin{aligned} \mu_l \cos b &= -A \sin l \,, \\ \mu_b &= -A \cos l \sin b \,, \\ A &= \frac{R_0 \Omega_0^2}{c} \,, \end{aligned} \tag{1}$$

where l and b are the source Galactic coordinates, R_0 is the Galactocentric distance of the SSB, V_0 and Ω_0 are Galactic rotation parameters, c is the speed of light. With the latest estimates of the Galactic rotation parameters, the Galactic aberration constant A = 5.0 μas with an error of several percent, which is sufficient as a good first approximation in order to model the GA effect.

Since GA has not been taken into account so far, its effect is present in all VLBI-derived catalogues of radio source positions, which are thus apparent coordinates. To derive the true coordinates w.r.t. GA influence, the corrections (4) must be subtracted from the catalog positions.

	Series	w/o GA	with GA
		Linear trend, μas/yr	
Variant 1	dX	9.6 ± 0.5	9.7 ± 0.5
	dY	-18.8 ± 0.6	-18.6 ± 0.6
		Linear trend, μas/yr	
	dX	3.6 ± 0.8	3.6 ± 0.8
	dY	-14.0 ± 0.8	-14.0 ± 0.8
Variant 2		Amplitude of 18.6-yr term, μas	
	dX	60.9 ± 5.7	62.6 ± 5.7
	dY	55.5 ± 5.5	54.7 ± 5.5

Table 1: Linear trend and the amplitude of the 18.6-year nutation term in the CPO series

3. THE IMPACT OF GA ON THE PRECESSION RATE

Corrections to the adopted precession rate can be derived directly from analysis of the linear trend in CPO time series dX and dY obtained from individual 24-hour observing sessions. To estimate the impact of GA, we processed 3136 24-hour session observed in 1984–2010, 5.6 million observations in total; 19 of 3136 CPO estimates were excluded from further analysis due to abnormal values or formal errors. After correcting for the Free Core Nutation (FCN), the CPO measurements are interpreted as errors in the adopted precession-nutation model.

Data were processed in two variants: with and without GA modelling. For each variant, dX and dY series were computed. At the next step, the parameters of linear trend in these CPO series were estimated both with and without simultaneous estimation of the parameters of the 18.6-year nutation term. Results of this computation are presented in Table 1.

4. CONCLUSIONS

We have estimated the impact of GA on parameters of precession-nutation model derived from VLBI observations. We found that influence on the linear trends in CPO series, i.e. precession rate, reaches about 0.2 μas/yr. The GA also influences the amplitudes of long-term nutation terms at a μas level, which, in turn causes a change in the linear trend. Notice that modern requirements to the accuracy of the precession model are 1 μas/cy (Capitaine et al. 2003).

Thus, our results indicate that the influence of GA on estimates of precession and nutation parameters is small but not negligible. Therefore, in spite of the fact that the computed effect is smaller than its formal uncertainty, it seems to be already necessary to include the GA correction in standard algorithms for the reduction of the VLBI and observations, as was foreseen may years ago.

More details on this study are given in Malkin (2011).

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5. REFERENCES

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