ANALYSIS AND SYNTHESIS OF CATALOGUES OF EXTRAGALACTIC RADIO SOURCES

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ABSTRACT. Recent observation catalogues of extragalactic radio sources obtained by Very Long Baseline Interferometry agree in the mean to a few milliarcseconds (mas). Within this range the position differences show constant, linear and periodic offsets. To cast light on these offsets the differences between some of the representative observation catalogues are plotted. Especially, the periodic variations of declination differences of observation catalogues having significantly different epochs are tentatively explained by an uncertainty of the general precession in declination. In terms of the luni-solar precession this uncertainty is estimated to be of the order of -1 to -2 mas per year.

1. Introduction

Observation catalogues of extragalactic radio sources set up by VLBI reflect the properties of the respective instrumental systems leading to catalogue differences of 1 to 2 milliarcseconds (mas). The more recent VLBI observation catalogues are assessed in pairs by simply plotting right ascension (RA) and declination (Dec) differences vs RA and Dec, respectively.

The difference patterns evidence an uncertainty of the luni-solar precession and, for some catalogues, a treatment of nutation not strictly complying with the IAU recommendations.

An independent approach to catalogue comparison aims at a compilation catalogue derived from the individual observations by weighted least squares adjustment of right ascensions, declinations, systematic catalogue differences and, optionally, precession terms. Results are presented below.

2. Analysis

Table 1 lists the observation catalogues taken into consideration. Each catalogue pair gives rise to four plots. Only a few plots of $\Delta\delta$ vs RA are displayed here for discussing some marked features.

https://doi.org/10.1017/S025292110006423X Published online by Cambridge University Press

TABLE 1. Selection of radio interferometric catalogues

Designation	Reference	Number of objects *)	Mean standard deviation (mas)		Mean epoch (1900+)	
			RA	Dec	RA	Dec
Short baseline interferometry:						
Q07	Wade and Johnston, 1977	30	32.3	30.3	75.4	75.4
Q15	Kaplan et al., 1982	14	16.7	13.9	79.9	79.9
Very long baseline interferometry:						
Q17	Fanselow et al., 1984	98	3.6	3.8	79.2	79.1
Q19B	Ma et al., 1986	75	1.2	2.8	81.9	81.9
Q22A	Sovers et al., 1988	106	1.3	1.6	83.4	83.3
Q23	Ma, 1988	164	0.8	0.9	85.2	85.4
Q27	Sovers, 1989	150	1.5	2.0	84.7	84.5
Q28	Ma et al., 1990	182	0.6	0.6	85.4	85.5

*) outliers omitted

2.1 CATALOGUES Q17 AND Q27

Apart from an offset of -2 mas in Fig. 1 there is evidence of a periodic variation given by

$$\Delta\delta = \delta(Q17) - \delta(Q27) = A \cos \alpha$$

which may be attributed to the variation of Dec as a function of the general precession in declination (n). Bearing in mind the different epochs t_1 and t_2 of Q17 and Q27, the amplitude A seems to be caused by the uncertainty Δn of the general precession in declination.

Enforcing agreement of the declinations by disposing of Δn yields

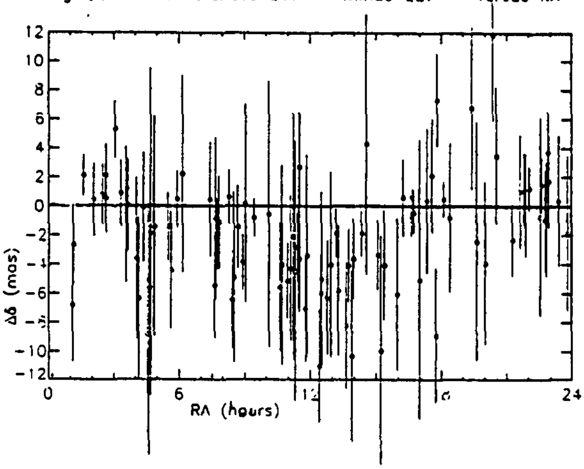
$$A \cos \alpha + (t_2 - t_1) \Delta n \cos\alpha = 0.$$

Taking $t_2 - t_1 = 5.4$ years and $A \simeq 4$ mas from Fig. 1, one gets by this geometrical interpretation the rough estimate of

$$\Delta n = - 0.74 \text{ mas/yr}$$

which is equivalent to the correction $\Delta\psi = - 1.9$ mas/yr of the luni-solar precession ψ.

Fig. 1. Dec differences Q17 minus Q27 versus RA



For comparison, a weighted least squares fit of precession in declination to the coordinate differences Q17 minus Q27 resulted in corrections of the luni-solar precession of

$$\Delta\psi_{\alpha} = -0.98 \pm 0.44 \text{ mas/yr} \quad \text{and} \quad \Delta\psi_{\delta} = -1.17 \pm 0.20 \text{ mas/yr}$$

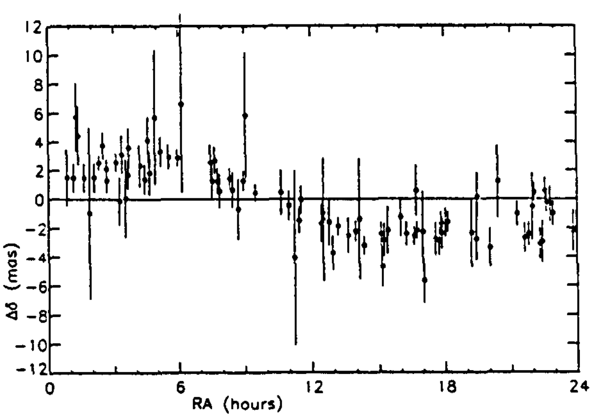
for RA and Dec, respectively.

2.2. CATALOGUES Q27 AND Q28

Only a small epoch difference exists between catalogues Q27 and Q28. In these circumstances the sinusoidal variation in declination of Fig. 2 could be associated with a modification of the nutation in obliquity ($\Delta\varepsilon$) in the course of data reduction for the one or the other of the two catalogues. To first order, the declination difference can be associated with

$$\Delta\delta = \Delta(\Delta\varepsilon) \sin \alpha.$$

Fig. 2. Dec differences QUA27 minus QUA28 versus RA



The relative change of $\Delta\varepsilon$ in the models of nutation would amount to 3-4 mas indicating a rotation of that order about the x-axis of the conventional coordinate system.

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3. Synthesis

A compilation catalogue has been derived from catalogues of Table 1 by simultaneously solving for source positions and systematic catalogue differences in a least squares adjustment process.

By having recourse to the compilation catalogue an uncertainty of the luni-solar precession could be determined by solving for a precession correction in a post-fit analysis (Walter, 1990). Moreover, a global solution of the compilation catalogue with the precession as additional unknown could be accomplished. Table 2 presents some typical results of these two approaches. For testing the effect of lengthening the time baseline, two catalogues built from measurements of connected interferometry, Q07 and Q15, have been included.

TABLE 2. Corrections $\Delta\psi_\alpha$ and $\Delta\psi_\delta$ to the luni-solar precession derived independently from RA and Dec measurements

Observation catalogues	Number of objects	$\Delta\psi_\alpha$ (mas/yr)	$\Delta\psi_\delta$ (mas/yr)	Number of obs. in RA and Dec
Post-fit analysis				
Q17	40	-1.69 ± 0.46	-1.60 ± 0.28	40
Q17, Q22A	40	-1.60 ± 0.52	-1.20 ± 0.35	80
Q17, Q22A, Q27	40	-1.28 ± 0.46	-0.89 ± 0.35	120
Q17, Q19B, Q22A, Q23, Q27, Q28	40	-0.71 ± 0.21	-0.74 ± 0.21	240
Simultaneous solution				
Q17, Q22A, Q27	40	-0.86 ± 0.36	-0.82 ± 0.22	120
Q17, Q19B, Q22A, Q23, Q27, Q28	40	-0.96 ± 0.18	-0.55 ± 0.15	240
Q07, Q15, Q17, Q19, Q22A, Q23, Q27, Q28	8	-3.13 ± 0.27	-2.42 ± 0.15	64

4. Conclusions

Observation catalogues have reached a level of internal accuracy allowing the identification of uncertainties in the physical model of precession provided that the catalogue epochs cover a baseline of at least 5 years. This uncertainty has been confirmed by three different methods: (1), direct comparison of observation catalogues, (2), post-fit analysis of the luni-solar precession by referring to a compilation catalogue, and, (3), global solution for source position, systematic differences and precession.

The results have in common the negative sign for the correction of the luni-solar precession while its magnitude ranges from -1 to -3 mas/yr depending on the data selected for the various case studies.

From comparing catalogues of nearly equal epochs periodic variations of milliarcsecond amplitude are detected. They may be ascribed to specific nutation models applied to the reduction of the original measurements, confirming the occurence of relative rotations between coordinate systems (Ma et al., 1990).

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https://doi.org/10.1017/S025292110006423X Published online by Cambridge University Press