

## RECENT OBSERVATIONS RELEVANT TO THE IMPROVEMENT OF FK4

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Since the closing date for material included in the FK4 many new positions of fundamental stars have been published, most of them observed differentially. I think in these few minutes it is neither desirable nor necessary to present a list of all these catalogues. We are mainly interested in recent observations which allow us to improve the fundamental system of positions and even more the system of proper motions.

The average values of the mean errors of the individual centennial proper motions in the FK4 are about  $\pm 0''.15$  in the northern hemisphere, rising to  $\pm 0''.4$  in the south. The errors of the system seem to be of almost the same order but they are different in both components, namely in the  $\mu_\alpha$  system from only  $\pm 0''.05$  in the north to  $\pm 0''.13$  in the south, but from  $\pm 0''.09$  to  $\pm 0''.36$  in the  $\mu_\delta$  system. Such data look fairly favourable but I remember the differences between the proper motion systems of FK4 and its predecessors FK3 and N30, which rise to  $0''.9$  in  $\mu_\alpha$  and  $0''.6$  or  $0''.7$  in  $\mu_\delta$ . These numbers leave some doubt as to the real accuracy of our fundamental proper motions.

The system is the basis for the derivation of precessional corrections and the parameters of galactic rotation, their terms being smaller than  $0''.5$  per century. A detailed study by Fricke (1967) has shown that the solutions for P and especially for Q from both components  $\mu_\alpha$  and  $\mu_\delta$  are discordant. These quantities and also the precessional correction  $\Delta k_\delta$  cannot be well-determined from  $\mu_\alpha$ . But it is very interesting to see that the discordance appears in FK4, N30, and FK3 in a similar manner. We must conclude that the discordance is due to the basic material, namely the absolutely observed catalogue systems.

Today various programmes for improvement of the fundamental system are in progress. Scott will present here the status of the SRS programme. Very often we learn about the errors in the FK4 which were exposed by an observed catalogue but as the dispersion between catalogue systems observed at nearly the same epoch is similar or even much larger than the presented deviations from FK4, it seems somewhat risky to identify all differences with errors of the fundamental system.

Already at the IAU Assembly in Prague. Fricke and Gliese (1968) presented a paper "Desiderata for FK5" which included a preliminary comparison between recent observations and the FK4 system. The weighted mean of these new data - observations with classical meridian instruments, with astrolabes, and with photoelectric transit instruments of the Time Service in the USSR - indicated errors in the FK4 system which reach a maximum of  $0.008 \text{ sec } \delta$  in the northern hemisphere and a remarkable correction

$\Delta\alpha_{\delta}$  of about  $-0.02 \text{ sec } \delta$  between  $-70^\circ$  and  $-80^\circ$ . Some of the catalogues also showed deviations from the FK4 in declination or a magnitude equation in right ascension which were not confirmed by other catalogues.

In March 1970 the systems of 14 absolute catalogues observed later than 1950 and not used for FK4 and additional astrolabe observations from 11 different observatories were available. We remember that the fundamental right ascension system was compiled from only 34 catalogues which were observed between 1915 and 1960.

This sample of recent catalogues confirms once more that the dispersion among the systems observed at nearly the same epoch has not decreased remarkably since the last century. The deviations among them are normally below  $0.15$  but in a few regions differences up to  $0.4$  have been observed. Even between the fairly reliable systems of both six-inch catalogues of the US Naval Observatory, the 3rd and the 4th Washington Catalogue for 1950, there are differences of up to  $0.25$  in the declinations.

But the mean of these recent catalogues does not generally deviate from FK4 by more than  $0.05$ , especially in  $\Delta\delta_{\delta}$ .

Figure 1 shows the  $\Delta\delta_{\delta}$  (recent mean - FK4) in five declination zones from  $+75^\circ$  to  $-20^\circ$ , mean epoch 1957. We realize once more that the terms periodic in RA vary with declination. South of  $-30^\circ$  the new material is so poor that it is not yet possible to examine the fundamental declination system in the south.

The  $\Delta\alpha_{\delta}$  - curves in Figure 2 confirm the 1967 result: The FK4 probably needs a positive correction north of  $+40^\circ$  between  $14^{\text{h}}$  and  $21^{\text{h}}$  with a maximum of  $+0.007 \text{ sec } \delta$  at  $+60^\circ$ ,  $17^{\text{h}}$ . A smaller negative correction seems to be necessary in the zones north of  $+20^\circ$  between  $23^{\text{h}}$  and  $7^{\text{h}}$ , which reaches  $-0.004 \text{ sec } \delta$  at  $40^\circ$ ,  $2^{\text{h}}$ .

South of  $-30^\circ$  we know only preliminary results from the meridian circle at Cerro Calan, which point to fairly small  $\alpha$ -dependent deviations not exceeding  $0.005 \text{ sec } \delta$ .

The  $\alpha_{\delta}$  - system in the northern and equatorial region (Figure 3) seems to need small negative corrections between  $+50^\circ$  and  $+5^\circ$  with a maximum of  $-0.005 \text{ sec } \delta$  at  $+25^\circ$  declination and a positive correction  $\Delta\alpha_{\delta} = +0.005$  at  $-10^\circ$  (solid line). It is interesting to see that in the equatorial zone the new observations obviously agree better with N 30 (dashed line) than with FK4.

The most problematic situation is in the southern  $\alpha_{\delta}$  - system. Scott probably will point to the difficulties experienced in deriving right ascensions in the south. In these zones the modern fundamental systems are based mainly on the enormous observational work with the Cape Reversible Transit Circle.

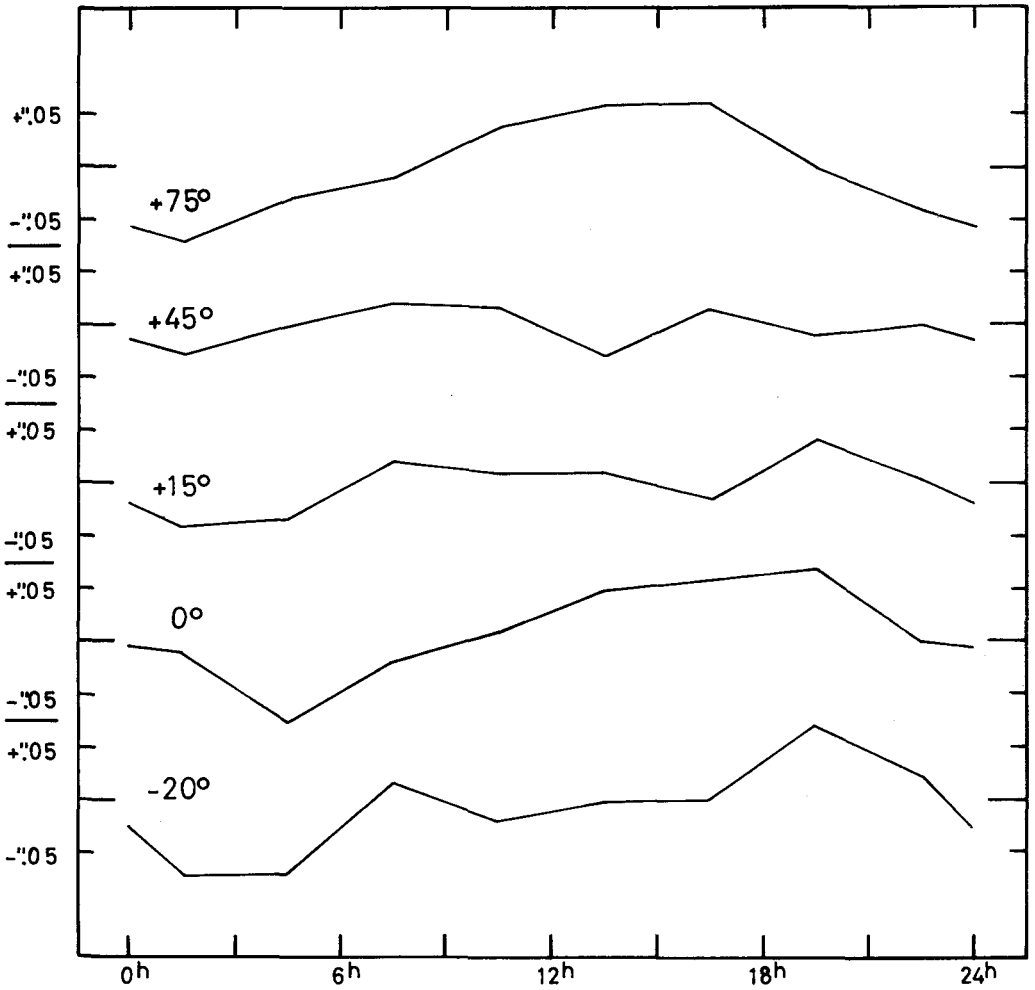


FIG.1.  $\Delta \delta_{\alpha}$

FIG. 1.  $\Delta \delta_{\alpha}$  (Mean of recent observations - FK4) in 5 declination zones. Mean declinations:  $+75^{\circ}$ ,  $+45^{\circ}$ ,  $+15^{\circ}$ ,  $0^{\circ}$ ,  $-20^{\circ}$ . Mean epoch about 1957.

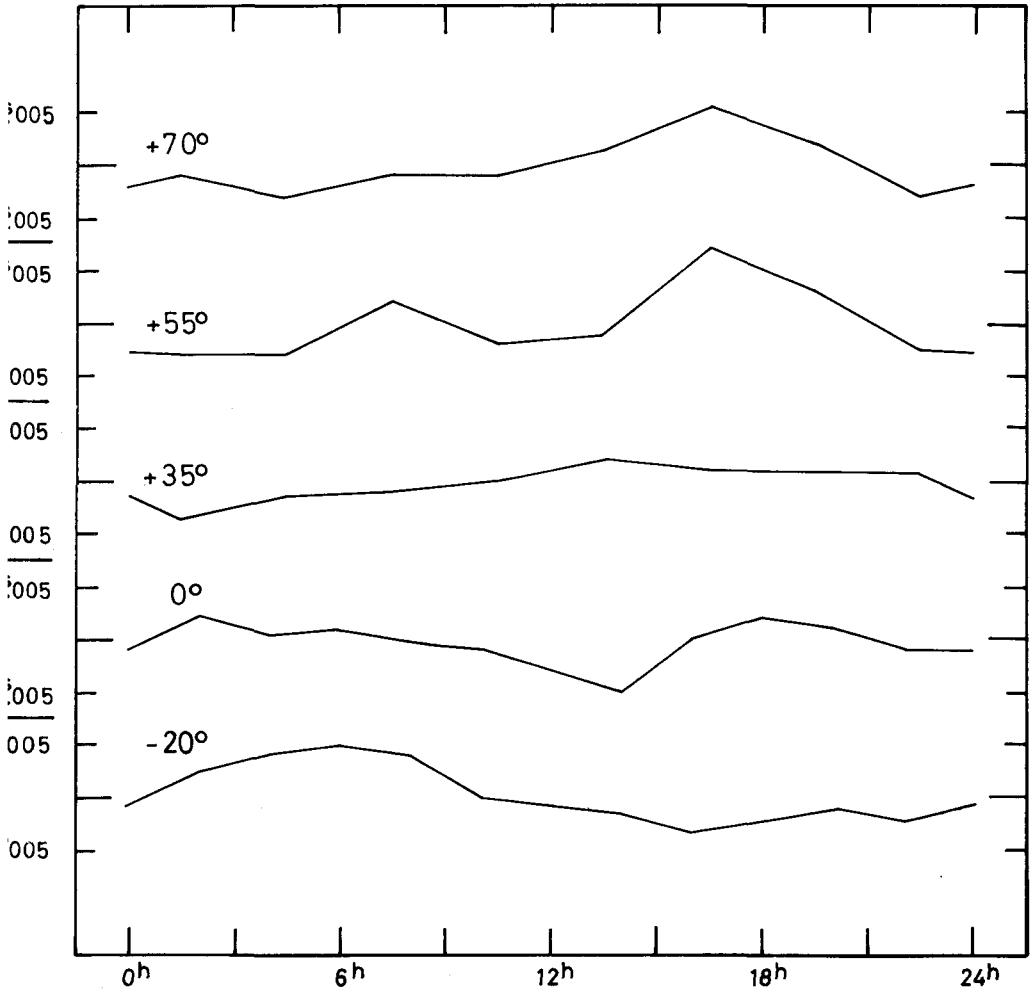


FIG. 2.  $\Delta\alpha \cos \delta$

FIG. 2.  $\Delta\alpha \cos \delta$  (Mean of recent observations - FK4) in 5 declination zones. Mean declinations:  $+70^\circ$ ,  $+55^\circ$ ,  $+35^\circ$ ,  $0^\circ$ ,  $-20^\circ$ . Mean epoch: 1957 (north) - 1960 (south).

Unfortunately the right ascension system of this very instrument was subject to fairly large long-range fluctuations (Gliese, 1965). In Figure 4 we see that the recent observations at Cerro Calan require a remarkable negative correction of the FK4 right ascensions from  $-50^\circ$  to  $-85^\circ$ . The astrolabe results from the Cape and from Santiago seem to confirm such corrections. Even the last catalogue observed with the Cape R. T. C., already included in FK4, points in this direction whereas the system of the last catalogue included in N30, namely the 1st Cape Catalogue for 1950, deviates from its successor by more than  $+0''.3$ . This Cape Catalogue from 1940 seems mainly responsible for the errors in N30 and - with smaller effect - still in FK4.

From this figure in particular we see the unreliability of a fundamental system based on only a few catalogues. We realize that it will be possible to replace the FK4 in this region by an FK5 with a remarkably improved right ascension system. But the time does not seem ripe for this until the SRS programme, the compilation of the astrolabe systems at Paris, the common treatment of PZT observations and time service measurements have been finished.

In these few minutes I have said nothing about a magnitude equation in the fundamental system or about recent observations for an equinox or an equator correction.

But let us look once more at the right ascensions at  $-60^\circ$  or  $-70^\circ$ . Corrections of the order of  $-0''.4$  at 1965 probably will produce corrections in the proper motion system of some tenths of a second of arc per century. In the formulae for  $\mu_\alpha$  the terms  $Q$  of the galactic rotation and the precessional corrections are given as

$$\mu'' = 0.87 Q \cos \alpha \sin \delta + (0.19 Q + \Delta n) \sin \alpha \sin \delta + (0.46 Q + \Delta k) \cos \delta \quad [+ \text{term (P)} + \text{solar motion terms}] .$$

The large negative ( $\Delta \mu_\alpha$ ) which will be produced by the recent observations will probably diminish the term  $(0.46 Q + \Delta k)$ .  $Q$  itself depends mainly on the ( $\Delta \mu_\alpha$ ) and on the ( $\Delta \mu_\delta$ ) but we may hope to get a negative correction of  $\Delta k$  - just as we need it.

So I close this paper in the expectation that the recent observations will effectively improve not only the fundamental system of positions but also the system of proper motions.

#### References

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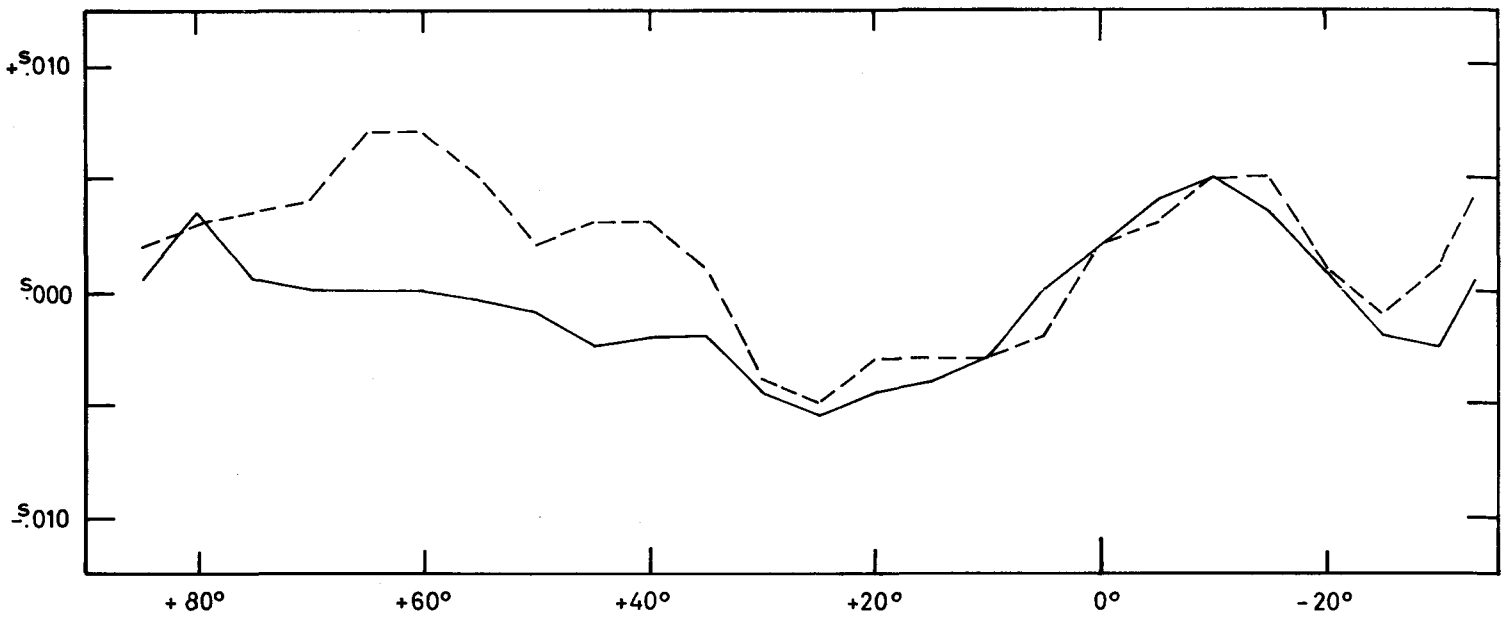


FIG. 3.  $\Delta\alpha_\delta \cos \delta$

FIG. 3.  $\Delta\alpha_\delta \cos \delta$  (Mean of recent observations - FK4)<sub>1957-1960</sub>: solid line, and  $(\Delta\alpha_\delta - 0.010) \cos \delta$  (N30 - FK4)<sub>1960</sub>: dashed line, from +90° to -30°.

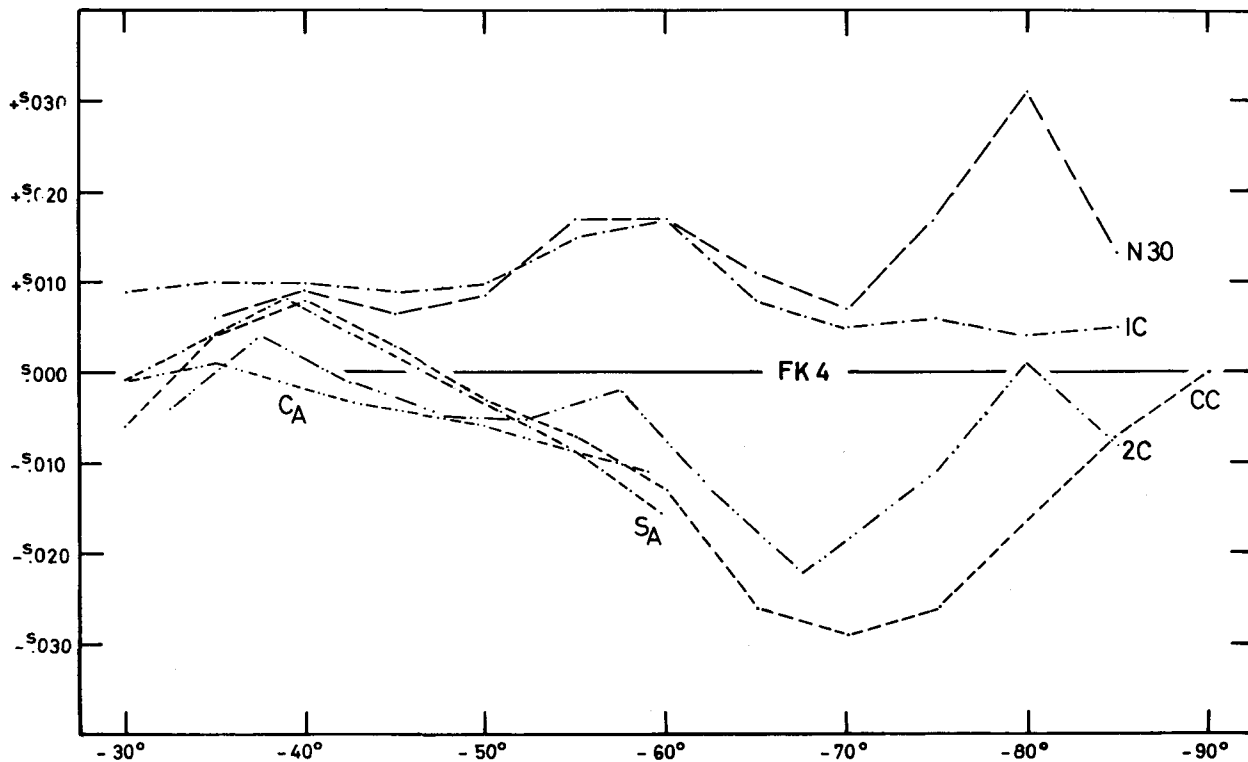


FIG. 4.  $\Delta\alpha_\delta \cos \delta$

FIG. 4.  $\Delta\alpha_\delta \cos \delta$  (Catalogue system - FK4) from  $-30^\circ$  to  $-90^\circ$ .  
 Catalogues and observations: N30 (1960): — — — ; meridian circle  
 at Cerro Calan (1965): CC - - - - -; 1. Cape Cat. for 1950 (1940):  
 1C — · — · — ; 2. Cape Cat. for 1950 (1956): 2C — · — · — ; astrolabe  
 at Santiago (1967): S<sub>A</sub> - - - - -; astrolabe at Cape (1966):