

Part II: Current Research

CONSTRUCTION OF THE SYSTEM OF POSITIONS AND PROPER MOTIONS IN THE FK5

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ABSTRACT. The various steps for the derivation of a fundamental catalogue are described and a report on the present status of the work on the FK5 is given. The observational material for the determination of the FK5 system is described and the systematic corrections to the FK4 are discussed.

1. INTRODUCTION

Work on the compilation of a fundamental catalogue can be subdivided in various tasks which are, more or less, independent from each other. In the case of the construction of the Fifth Fundamental Catalogue (FK5), which is being compiled at the Astronomisches Rechen-Institut in accordance with a resolution adopted by the XV General Assembly of the IAU held in Sydney (1973), these tasks consist essentially in:

- (1) Improvement of the individual accuracy of the fundamental stars,
- (2) Derivation of the system of the FK5,
- (3) Determination of corrections to the FK4 equinox and equator,
- (4) A rediscussion of the values for general precession,
- (5) Inclusion of new (faint and bright) fundamental stars in the FK5.

Not all of these steps have necessarily to be performed in the construction of a new fundamental catalogue. In the case of the FK4 (Fricke, Kopff, 1963), for instance, no change in the precessional constant was made, and no stars were added to the FK3 stars (on the contrary, more than 50 stars were cancelled because of their double star character); the equinox and equator corrections were discussed in the compilation of the FK4, but no correction to the FK3 equinox was applied. The changes involved in the transition from the FK4 to the FK5 are therefore large compared with the transition from the FK3 to the FK4.

In the recent years reports on the work related with the construction of the FK5 have been given continuously in various papers by Fricke (1974, 1975, 1978, 1979, 1980a, 1980b, 1981, 1982a, 1982b, 1985), Schwan (1977, 1983, 1986a, 1986b), and Bien et al. (1978).

2. PRESENT STATUS OF THE WORK ON THE FK5

The FK5 will consist of two parts which are substantially different from each other with respect to the accuracy of the mean positions and proper motions.

The first part will contain the classical 1535 fundamental stars which are already given in the FK4. The mean positions and proper motions for these stars have been derived by determining individual and systematic corrections to the FK4; in addition systematic corrections to the FK4 equinox and its fictitious motion are applied, and the FK5 proper motions are based on the new precessional values. Work on this basic part of the FK5 is finished and its publication is in preparation. Reports on the determination of the equinox and on the derivation of the new constant of luni-solar precession were given by Fricke (1977, 1982a). In the present paper information on the construction of the FK5 system will be given. Detailed discussions on the determination of the system of the FK5 and on the derivation of the individual corrections to the FK4 stars will be given in separate publications by the Astronomisches Rechen-Institut after the publication of the FK5.

The second part of the work on the FK5 consists in the derivation of mean positions and proper motions for approximately 3000 new fundamental stars in the magnitude range from about magnitude 5 to magnitude 9.5. This part of the work is being made in collaboration with the U.S. Naval Observatory, in particular with T. Corbin. The new fundamental stars will be selected from the FK4 Supplement (Fricke, 1963) and from the IRS list. We expect that about 1000 FK4 Sup stars with magnitudes 5 to 7 and about 2000 IRS stars with magnitudes 6.5 to 9.5 will become new fundamental stars. The new fundamental stars will be selected mainly on the basis of their history of observation under the additional condition that a homogeneous distribution over the sky and according to the apparent magnitude should be achieved. All reductions are made in the system of the FK4.

We will present the new fundamental stars in a separate publication since the average individual accuracy of these new fundamental stars is expected to be inferior to the accuracy of the classical fundamental stars by a factor of at least two.

3. OBSERVATIONAL MATERIAL FOR DERIVING THE FK5 SYSTEM

The system of the FK5 is based on absolute and quasi-absolute catalogues with mean epochs later than 1900, altogether about 85 catalogues giving observations from 1900 to about 1980. The observations presented in these catalogues were made with meridian circles, vertical circles and astrolabes. Part of the catalogues give right ascensions or declinations only so that nearly 70 catalogues were definitely available for the derivation of the system of mean positions and proper motions in right ascension and about 50 catalogues in declination. It is well known that the region south of -30° has the poorest history of observations. At $\delta = -50^\circ$, for example, only 15 catalogues have contributed to the system in right ascension (and 12 in declination), in comparison with 57 (50)

catalogues at $\delta = 0^\circ$, and 45 (40) catalogues at $\delta = +50^\circ$. Since the completion of the FK4 about 25 absolute or quasi-absolute catalogues have become available providing observations of right ascensions, and about 15 catalogues with observations of declinations. The systematic differences Cat-FK4 as a function of the declination were given for these catalogues by Fricke (1985).

4. THE SYSTEMATIC CORRECTIONS FK5-FK4

The system of the FK5 has been derived by determining systematic corrections to the FK4 which was adopted as a preliminary system. For all of the relevant absolute and quasi-absolute catalogues systematic differences Cat-FK4 were determined with the aid of the analytical method as described by Bien et al. (1978). Since the determination of corrections to the equinox and equator of the FK4 was performed as a separate task, these relations Cat-FK4 were reduced to the FK4 zero points in α and δ , roughly speaking by subtracting the mean equatorial differences $\langle \text{Cat-FK4} \rangle$ from the systematic differences. On the basis of the reduced relations, corrections to the systems of mean FK4 positions and proper motions were derived using the analytical method developed by Schwan (1983). Weights were assigned to the catalogues on the basis of the deviation of a catalogue from the mean of all catalogues. The mean epochs of the FK5 system in right ascension (declination) vary from 1931-1951 (1935-1949) depending on the zone of declination. This dispersion of mean epochs is large compared with the negligible small dispersion of mean epochs of the FK4 system. The reason for this difference is that all absolute and quasi-absolute catalogues have been used for the derivation of the system of mean FK5 positions whereas in the FK4 only the modern catalogues were used.

The corrections to the mean FK4 positions are small and shall not be discussed here. There is only one exception, namely the region near $\delta = -70^\circ$ where the corrections $\Delta\alpha \cos \delta$ (FK5-FK4) are about -0^s007 at the mean epoch 1935 of the FK4 system in right ascension. In this part of the sky the system in right ascension is based on only 15 catalogues, and 9 of these catalogues have become available after the completion of the FK4.

Large systematic errors in the FK4 right ascensions near $\delta = -70^\circ$ have been detected from quasi-absolute observations soon after the publication of the FK4 (Anguita, 1974). In that region of the sky the systematic corrections to the FK4 proper motions in right ascension amount to $\Delta\mu \cos \delta = -0^s053 = -0^!80$ per century. North of -50° the proper motion corrections $\Delta\mu \cos \delta$ do not exceed $+ 0^s02/\text{cy}$. The mean error of the FK4 proper motion system in right ascension is about $+ 0^s004/\text{cy}$ north of -30° , and it increases to about $\pm 0^s012/\text{cy}$ in the polar region south of -75° .

The corrections to the system of FK4 proper motions in declination do in general not exceed $\pm 0^!2/\text{cy}$; the largest corrections occur in the southern polar region. The mean error of the proper motion system in declination is about $+ 0^!04/\text{cy}$ north of -30° and increases to $\pm 0^!1/\text{cy}$ in the region south of -75° .

One remark may be added concerning the catalogue Cape 2/50 (Stoy, 1968). This catalogue has a mean epoch of 1955.6 and is already included in the FK4. The systematic differences Cape 2/50-FK4 are, in right ascension and declination, very similar to the systematic corrections FK5-FK4 for this epoch. In other words, the catalogue Cape 2/50, which is the latest catalogue still included in the FK4, already clearly indicates the systematic errors of the FK4 in the southern sky.

5. CONCLUSIONS

The transition from FK4 to FK5 will imply considerable systematic corrections to the FK4 proper motions. These corrections are the result of introducing new precessional quantities, of eliminating the fictitious motion of the FK4 equinox, and of eliminating the regional systematic errors in the FK4 proper motions. All of these changes are of importance for results which have been obtained in the past from studies of stellar proper motions. A rediscussion of such results should therefore be performed in the future.

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Discussion:

ROESER In deriving the individual corrections to positions and proper motions of FK4 Stars, we have processed the new observational catalogues not yet contained in FK4. The range of epochs available is therefore about 20-30 years. This may give an indication for some stars to be double, but is not good enough to determine orbits. This can only be done, when the old catalogues already contained in the FK4 are reprocessed.

KOVALEVSKY 1) When will the catalogue of extension stars be published?

2) Will you present systematic differences FK5-FK4 in two dimensional α, δ space?

SCHWAN 1) We are still waiting for data which will have to be included in the extension to new fundamental stars; e.g. at present, the final version of the SRS is not yet available.

2) We will present the systematic differences in 3-dimensional α, δ, η space in the form of coefficients of functions which depend on α, δ and the apparent magnitude m . In addition, we will provide tables of the systematic differences as a function of α, δ and δ .

WORLEY Am I right in assuming that only the eight double stars of the FK4 given orbital corrections were so treated in FK5? Many more of the FK3-5 stars are binary and show orbital motion, and new ones have been discovered recently. As you strive for ever greater accuracy, it seems important to investigate each individual object to see if orbital corrections will improve things. Not many astronomers know that the southern visual surveys, through oversight, were not performed in the zones -70° to -75° . It is therefore possible that some of the large discrepancy found in this area in the FK5 might be due to undetected binaries. At least, this problem needs consideration.

SCHWAN We are aware of the problems coming up with double stars in a fundamental catalogue. For this reason already with the transition from FK3 to FK4 more than 50 stars were cancelled because of their double star character. In our work on the determination of individual corrections to the FK4, a few stars have shown up whose motion may be influenced by orbital motion. We have treated these stars in the same way as all other stars since the indication for orbital motion was not significant enough in comparison with the accuracy of our data.

GLIESE We have seen the large deviation of observations at about mean epoch 1970 from the southern FK4 RA system. For them the large correction at $-70^\circ \Delta\mu \cos \delta$ (FK5-FK4) which is based also on catalogues close to 1900 where systems are not very well defined so I expect a final

decision on other p.m. system in RA by the HIPPARCOS results when we have an epoch difference of 20 years between two sets of reliable observations of RA systems.

HUGHES How many orbital stars are included in FK5?

SCHWAN The same number as in the FK4.

EICHHORN Is the "mean" epoch you are publishing for each star the "central epoch" in the sense that this is the epoch of no correlation between proper motion and position? And do you give the standard errors of the individual positions at central epoch?

SCHWAN Yes, the mean epochs and the individual mean errors are given exactly in the sense which you have described.

CORBIN Did you find it necessary to use a zenith distance cut-off for the catalogues?

SCHWAN Yes, we used the fluctuations of each catalogue relative to the others to determine a cut-off.