

THE AGK3, SRS AND RELATED PROJECTS

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1. Introduction

This report consists of a brief summary of the status of a number of programs of an international nature which are now in progress at various observatories of the world. These programs have received strong endorsements from Commission 8 of this Union, as well as from a number of international organizations interested in accurate positions and motions of the stars to the 9th magnitude of brightness. Among the organizations and conferences which have explicitly endorsed the programs are:

- (1) The Symposium on Coordination of Galactic Research, Groningen, 1953.
- (2) Conference on the Problems of Astrometry, Evanston, 1953.
- (3) Astrometric Conference, Pulkovo, 1954.
- (4) Conference on Astrometry, Brussels, 1955.
- (5) International Union of Geodesy and Geophysics, 1954 and 1963.
- (6) International Astronomical Union, 1955.
- (7) Second Astrometric Conference, Cincinnati, 1959.
- (8) First Inter-American Conference on Astronomy, La Plata and Cordoba, 1959.
- (9) Meeting on Problems of Astrometry and Celestial Mechanics, La Plata, 1960.
- (10) Committee on Space Research, COSPAR, 1966.

The principal purpose of the astrometric programs now in progress in both hemispheres of the sky is the determination of accurate positions and proper motions on a fundamental system for all stars to the 9th magnitude of brightness. The survey of each hemisphere of the sky comprises a number of interrelated programs designed to accomplish the following objectives:

- (1) The improvement of the positions and motions of the fundamental stars.
- (2) The relation of the positions of 20000 reference stars in each hemisphere of the sky to the fundamental system by means of differential observations with meridian circles.
- (3) The determination of photographic positions of modern epoch on a fundamental system for all stars to the 9th magnitude through the use of the reference stars in the reduction of the plates.
- (4) The derivation of fundamental proper motions for all stars to the 9th magnitude through a comparison of the new photographic positions with similar positions obtained in previous photographic surveys.

The task of improving the positions of the fundamental stars and relating the

reference stars to the fundamental system is being carried out in two major programs, the AGK3R for the Northern sky and the Southern Reference Star Program (SRS) for the Southern sky.

2. Northern Reference Star Program, the AGK3R

The AGK3R program resulted directly from resolutions adopted at the Conference on Problems in Astrometry held at Evanston, Ill., September 3–5, 1953. Decisions of an organizational nature, the adoption of the star list, and the division of the star list among the observers were accomplished at a Conference on Astrometry held at Brussels, March 28–30, 1955.

The coordination of the AGK3R Work was carried out by a Committee appointed by Commission 8 during the Dublin Meeting of the IAU in 1955.

Both the Evanston and Brussels Conferences, as well as the Meetings of Commission 8 at Dublin, strongly recommended the revision of the FK3 so as to bring the fundamental coordinate system up to date for the purpose of the AGK3R program. This task was accomplished in 1963 with the publication of the FK4. All work on the revision of the fundamental catalog was done at the 'Astronomisches Rechen-Institut' of Heidelberg under the supervision of the late Dr. Kopff and the present Director, Dr. Fricke.

All results of the AGK3R program were reduced to the FK4 either by the observers themselves or at the U.S. Naval Observatory during the course of compiling the final catalogue.

Observations of the AGK3R stars began in 1956 and were essentially completed by 1963. By the end of 1964 all results had been received at the U.S. Naval Observatory for use in the compilation of a final catalogue of positions of the northern reference stars.

The observations of the AGK3R stars were carried out with meridian circles at Bergedorf, Bordeaux, Heidelberg, Herstmonceux, Nicolaiev, Ottawa, Paris, Pulkovo, Strasbourg and two instruments at the U.S. Naval Observatory. During the course of the program well over 300000 apparent places were computed at the U.S. Naval Observatory for the various observatories taking part in the program.

The final catalog has just been completed at the U.S. Naval Observatory. It contains the positions of 21 499 reference stars between -5° and $+90^\circ$ declination. Since this work was completed so shortly before the beginning of the present meeting of the IAU, there has been no opportunity to compare it with other catalogs or to make other investigations of the characteristics of the final results. It has been possible, however, to develop the mean errors in both right ascension and declination, which are shown in Tables 1 and 2.

To understand these tables it should be recalled that the star list adopted at Brussels consisted of a combination of two star lists; one was the KSZ list selected at the

Table 1
AGK3R: mean errors in right ascension
 Unit: m.e. $\cos \delta = 0^{\circ}0001$

Declination	(C + S) All Stars				Z Stars, $M \leq 8.8$				Z Stars, $M \geq 8.9$			
	No. Stars	Avg.	50%	95%	No. Stars	Avg.	50%	95%	No. Stars	Avg.	50%	95%
- 5° to + 5°	2154	54	52	93	734	61	56	124	475	71	62	144
+ 5° + 15°	2168	50	48	88	703	56	51	110	501	63	58	128
+ 15° + 20°	1089	49	46	90	349	47	44	88	210	58	54	119
+ 20° + 25°	1010	48	46	89	342	51	49	95	258	56	50	113
+ 25° + 40°	2763	44	42	80	1187	47	44	91	507	48	45	99
+ 40° + 50°	1573	49	46	87	629	53	50	105	235	54	51	103
+ 50° + 70°	2252	45	43	78	852	47	44	94	317	43	41	87
+ 70° + 90°	802	49	47	85	261	51	48	99	132	48	43	96

All Stars: Avg. = 50; 50% = 47; 95% = 95.

Table 2
AGK3R: mean errors in declination
 Unit: m.e. = 0''001

Declination	(C + S) All Stars				Z Stars, $M \leq 8.8$				Z Stars, $M \geq 8.9$			
	No. Stars	Avg.	50%	95%	No. Stars	Avg.	50%	95%	No. Stars	Avg.	50%	95%
- 5° to + 5°	2154	115	112	194	734	121	108	252	475	139	126	290
+ 5° + 15°	2168	108	103	186	703	108	102	204	501	127	116	264
+ 15° + 20°	1089	112	109	194	349	113	107	217	210	137	126	264
+ 20° + 25°	1010	113	107	204	342	102	094	201	258	125	117	250
+ 25° + 40°	2763	117	111	210	1187	103	095	196	507	121	114	237
+ 40° + 50°	1573	121	116	204	629	118	108	240	235	142	130	282
+ 50° + 70°	2252	116	111	201	852	105	096	204	317	116	105	240
+ 70° + 90°	802	134	129	225	261	124	112	259	132	133	124	272

All Stars: Avg. = 116; 50% = 109; 95% = 214.

Pulkovo and Sternberg Observatories for use in the U.S.S.R. program for relating the proper motions of the stars to the background galaxies, and the other was a list selected at the U.S. Naval Observatory for use in the reduction of photographic plates exposed with an objective grating which would produce a 3.5 magnitude difference between the central image of a star and its first order spectrum. The C stars indicated in the tables are those that were common to both lists. The Z stars are those that remained in the KSZ list after the removal of the C stars, and the S stars are those that remained in the U.S. Naval Observatory list after the removal of the C stars.

The C and S stars were observed 10 times each during the program, whereas, in general, the Z stars were observed only 8 times each, except for the bright Z stars in the zone $+5^\circ$ to $+40^\circ$.

The divisions of the tables of mean errors according to declination were made at points where changes took place in the combination of observatories committed to the program.

3. Southern Reference Star Program, SRS

The Southern Reference Star Program was organized by a Committee appointed at the Moscow 1958 Meeting of the IAU. This Committee held or participated in three Conferences to explore the possibility of organizing a program in the Southern Hemisphere similar to the AGK3R. These Conferences were held at Cincinnati, May 17–21, 1959, La Plata and Cordoba, October 30 – November 3, 1959, and at La Plata, November 7–11, 1960. In addition to the Conferences, considerable correspondence with many observatories was conducted in an effort to solicit commitments to the program.

The SRS program is not as elegantly organized as the AGK3R, nor are all the observations being made simultaneously at all observatories as they were during the AGK3R. It is hoped, however, that these shortcomings will not be detrimental to the results.

It is very fortunate that a number of Northern observatories, working from their home stations and at very inconvenient zenith distances, have agreed to observe as

Table 3
Status of the SRS Program, June 1, 1967

Observatory	Zone	Commitment		Date		Observations Completed
		Stars	observations	Started	mo. yr.	
Abbadia	+ 5° to -15°	1560	4	4	62	90%
Bordeaux	+ 5 to -15	1560	4	6	62	72
Bucharest	+ 5 to -10	1176	4	7	62	100
Nicolaiev	0 to -20	5984	2	3	64	100
San Fernando	-10 to -30	3709	4	3	63	45
Tokyo	-10 to -30	3560	4	3	63	95
6-in. N.O.	+ 5 to -20	{ 6450 1233 }	{ 2/ 4 }	9	66	15
Cape	{ -30 to -40 -40 to -52 -52 to -90 }	10082	4	4	61	{ 45 100 0 }
Santiago-Pulkovo	{ -25 to -47 -47 to -90 }	11496	4	1	63	{ 82 100 }
Bergedorf-Perth	0 to -90	To start late 1967				
7-in. N.O.		To start mid 1967				
El Leoncito	+ 5 to -90					

far South as -20° and in two cases to -30° declination. It is also very fortunate that the Pulkovo, Bergedorf, and U.S. Naval Observatories found it possible to undertake expensive expeditions to the Southern hemisphere. We should also be very thankful that the Cape Observatory threw its full weight into the program. Without its help it would have been difficult to have had a program at all.

The status of the Southern Reference Star observations as of June 1, 1967, is shown in Table 3.

4. Reference Star Lists

As mentioned earlier the Northern Reference Star List consisted of a combination of a star list selected at the U.S. Naval Observatory and the KSZ list.

The list between 0° and -30° was compiled at the U.S. Naval Observatory by adding stars in accordance with the AGK3R criteria to the KSZ list, which extended to -30° declination, to bring it up to the density of the AGK3R. The star list South

Table 4
Distribution of the reference stars by magnitude and declination

Magnitude	AGK3R list		SRS list	
	+ 90° to + 30°	+ 30° to 0°	0° to - 30°	- 30° to - 90°
$m \leq 6.9$	8.1%	6.5%	3.8%	0.4%
$7.0 \leq m \leq 7.4$	13.0	10.3	8.6	3.9
$7.5 \leq m \leq 7.9$	19.3	17.2	15.0	13.5
$8.0 \leq m \leq 8.4$	25.0	26.7	30.6	23.6
$8.5 \leq m \leq 8.8$	22.7	23.2	34.3	27.3
$m = 8.9$	4.5	5.7	3.8	6.4
$m = 9.0$	4.2	5.1	3.1	9.6
$m = 9.1$	2.0	3.5	0.4	5.6
$m \geq 9.2$	1.2	1.8	0.2	9.8
No. stars	9891	9963	8586	10210

Table 5
Distribution of reference stars by spectral type and declination

Spectral type	AGK3R list		SRS list	
	+ 90° to + 30°	+ 30° to 0°	0° to - 30°	- 30° to - 90°
B	3.4%	3.2%	3.4%	0.2%
A	16.1	16.2	14.6	3.1
F	15.0	17.0	15.5	8.2
G	15.8	16.4	15.7	19.9
K	42.7	40.0	48.3	64.0
M	3.3	2.6	2.3	4.3
Other	3.7	4.6	0.2	0.3
No. stars	9891	9963	8586	10210

of -30° was selected at the Cape Observatory by use of the KSZ criteria and then adding brighter stars until the density of the AGK3R was reached.

The distributions of the resulting star lists in each quarter of the sky, according to magnitude and spectral type, are shown in Tables 4 and 5.

5. Fundamental Star Catalog

It was mentioned earlier that the FK4 had been adopted as a reference coordinate system for the AGK3R program.

There is some doubt as to whether or not it will serve as an adequate system for the Southern Reference Stars.

In relating reference stars to a fundamental system one is interested in:

(1) The precision of the fundamental stars when updated to the epoch of observation of the reference stars.

(2) The possible systematic errors of the updated fundamental stars.

During the past few days Commission 8 has heard several reports that modern observations of the Southern fundamental stars do, indeed, indicate rather large systematic errors in the FK4. It may, therefore, be necessary to consider a revision of the positions of the Southern FK4 stars before compiling the catalog of final positions of the Southern Reference Stars. Material for such revision may be on hand at the completion of the SRS observing program. All SRS observers are, of course, generating relative corrections to the positions of the fundamental stars observed each night in conjunction with the reference stars. In addition, the Cape Observatory is continuing its traditional fundamental work and the Russian and Chilean observers at Santiago are carrying out fundamental series of observations of the southern FK4 stars by use of methods developed at Pulkovo. It is also planned that the Bergedorf and U.S. Naval Observatory expeditions to the Southern hemisphere will do limited programs of a fundamental nature. This material, along with accumulated astrolabe results, may be sufficient to effect the required improvement of the positions of the Southern Fundamental Stars.

6. Photographic Programs

AGK3: The principal purpose in observing the Northern Reference Stars was, of course, to provide reference stars for the reduction of the AGK3 photographic plates. These plates were taken at the Hamburg-Bergedorf Observatory during the years the reference stars were being observed. In all 1939, $5^\circ \times 5^\circ$ plates were taken to cover the sky from the North pole to -5° declination, the last set of plates having been centered at $-2^\circ 5'$ declination.

All AGK2 stars appearing on these plates have been measured. The new AGK3 positions of mean epoch 1958 are being compared with the earlier AGK2 positions

of mean epoch 1930 for the derivation of proper motions. For this purpose, the original AGK2 positions have been re-reduced to the system of the FK4. The final solutions may now be started through the use of the AGK3R catalog just completed. It is expected that the resulting positions will have mean errors of approximately $\pm 0''.14$ or $\pm 0''.15$. The mean errors of the proper motions derived from a comparison of the AGK2 and AGK3 positions are expected to be about $\pm 0''.8/\text{century}$. This work has advanced to the point where Professor Dieckvoss feels that the first volume of the results, covering the sky from $+90^\circ$ to $+55^\circ$, may be ready for the printer by the end of the year.

Southern sky: The photography of the Southern sky is being done by the Cape and Sydney Observatories. The Cape Observatory has completed the photographs of the zone -40° to -52° with a mean epoch of 1962. The measurement and a preliminary solution of these plates are in progress. The photography of the zone -30° to -40° commenced in March 1966 and is still in progress. The next zone to be undertaken at the Cape will be in the region 0° to -30° .

The Sydney Observatory is now engaged in the photography of the zone -51° to -65° . Earlier, it exposed a set of plates extending from -48° to -54° . The latter plates are now being measured at the University of South Florida.

In addition to the current work in the Southern hemisphere, the Cape and Yale Observatories are now finishing the measurement and discussion of earlier series of photographs. The Cape Observatory has but one more volume to publish of its first series of photographs of the Southern sky which started about 35 years ago. The remaining volume is for the South polar cap and includes the stars South of -80° declination.

During 1941, while its instrument was in South Africa, the Yale Observatory photographed the zones -40° to -50° and -60° to -70° . Later, about 1953, after its instrument had been moved to Australia, a set of plates was taken for the zones -30° to -40° and -70° to -90° . These plates are now being reduced. The results for the region -30° to -35° are in press and those for -35° to -40° will be ready for the printer sometime next year. The remaining zones may require 2 or 3 more years before their reductions are completed.

DISCUSSION

W. Dieckvoss: The revision of the AGK2, which has been carried out at Bergedorf, included the application of systematic corrections to the original coordinates measured at Bonn and Bergedorf before making new plate solutions. The AGK2-revised is on the FK4 system and when published will render the present printed volumes of the AGK2 obsolete.