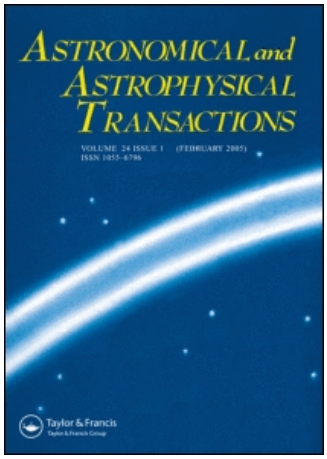

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THE FIELDS OF REFERENCE STARS FOR OPTICAL POSITIONAL OBSERVATIONS OF ASTROMETRIC EXTRAGALACTIC RADIO SOURCES

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The Pulkovo programme (Pul ERS) and the techniques used to create a catalogue of coordinates and magnitudes for more than 7000 faint stars in 73 small fields around extragalactic radiosources (ERS) are described. Accurate positions of stars in the fields around ERS 2200+420 and ERS 2021+614 are given. The catalogue containing 223 stars is presented. The errors of coordinate reductions in the system of reference stars from the CMC catalogue are found to be 1.5–2.0 times smaller than for those in the system of the PPM catalogue. This programme (Pul ERS) is required for quick identification of the extragalactic radio sources and for obtaining their characteristics from observations with large telescopes and CCD detectors.

KEY WORDS Extragalactic radiosources, fundamental system, intermediate star catalogues

The future of astrometry is connected with the creation of a new fundamental reference system based on extragalactic radio sources (ERSs). The positions of these ERSs are determined by VLBI methods with high accuracy $(0.1\text{–}3) \times 10^{-3''}$ [1]. The basic list of ERSs was published in 1984, and at present it contains 422 compact objects distributed on the sky and identified with optical objects with positional variances to $+0.03''$ [2, 3]. The IAU approved a rezolution about the creation of the fundamental inertial frame based on accurate positions of ERSs [4]. But in order to use this frame for optical astronomy, which provides the majority positional observations, it is necessary to connect the optical and coordinates of ERSs.

More than 50% of ERSs are fainter than 18 mag in the optical region. This fact demands much observing time and large telescopes for their identification [5]. Also it is necessary to create an intermediate system of reference stars for reductions of their coordinates.

In mid-80's, the creation of the systems connecting the positions of ERSs and the fundamental reference frame started. The first way consists in the search for and

observations of radio stars, which may be a foundation for the system intermediate between optical and radio one. The second way is to observe the objects from the new list of faint stars near ERSs in the optical region by photographic methods to use their positions for identifications of ERSs.

Meridian methods can provide 10–15 stars to 10th–13th magnitude within 2–3° around ERSs. This is not sufficient for large telescopes because they deal with small sky fields and there remains a great difference in magnitudes between the ERSs and the stars of the reference system.

Using sensitive techniques of CCD imaging give a leads to great progress in this direction of investigations. CCD observations with large telescopes ensure registration of objects fainter than 20^m in several seconds (for example, NTT [6]). But the size of existing CCD detectors is rather small yet (in most cases, under 1024 × 1024 pixels, with the size of a pixel from 30 to 7.5 μm). The largest chip actually available is the 2048 × 2048 CCD chip with 27 μm pixels manufactured by Tektronix [7].

The progress in technology is very rapid, but it is improbable that within 5–10 years CCD detectors covering the whole focal plane of Schmidt telescopes (240 × 240 or 480 × 480 mm) will be manufactured. Presently more than 12 telescopes with mirror diameters exceeding 3 m exist. A lot of new telescopes with mirror 7 m are currently being constructed or projected. Moreover, all these telescopes (both existing and being have very small working fields, from 8′ to 60′, and there is a great probability that no reference star from known catalogues will be near the observed ERS. Used CCD detectors (for example, 1024 × 1024 × 18 μm) makes these fields still narrower, from 47″ to 6′ for Ritchey–Chretien and 16–20′ for Schmidt telescopes.

For such small fields it is necessary to have an intermediate reference star system obtained by means of photographic method and containing 30–40 stars of magnitude 14–17 within 4–10′ around the ERS. Such programmes for telescopes with CCD detectors are under way at several observatories [8].

The creation of the first epoch of the catalogue of positions for faint stars around 73 ERSs from the IERS list [2] situated to the north of declination +26° is started. It is planned to take 3–4 plates with exposure time 20–30 minute for each field. One plate must be obtained for photometry. It is a plate with two exposures, a short and a long one (30s and 20m), or with an objective grating creating difractional satellites of stars fainter than central images by 4.2m. This technique provides prolongation of the characteristic curve by 4m to fainter stars.

It is suggested to measure in a 2 × 2° field:

- 20–30 reference stars from the PPM catalogue or from meridian catalogues (AGK3R or CMC-5),
- all stars from the programme of meridian observations of RRS2 (Radio Reference Stars [9]),
- 30–60 stars(14-16 mag) in the field ~ 6′ around the ERS,
- 40–60 stars in the ring from 6′ to 16′ around the ERS.

Table 1. The list of extragalactic radio sources (Pul ERS) for observation with the Pulkovo Normal Astrograph

ERS Name	*m*	*ERS Name*	*m*	*ERS Name*	*m*	*ERS Name*	*m*
0016+731	18.0	0711+356	19.0	1216+487	18.5	1803+784	16.4
0026+346	20.2	0716+714	13.2	1308+326	19.0	1807+698	14.2
0116+319	15.7	0738+313	17.5	1311+678		1928+738	15.5
0133+476	18.0	0804+499	18.4	1323+321	19.0	2007+776	16.5
0153+744	16.0	0814+425	18.5	1328+307	17.0	2021+614	19.0
0202+319	18.0	0828+493	17.5	1342+663	19.0	2030+547	18.7
0212+735	19.0	0831+557	18.5	1418+546	14.5	2037+511	21.0
0224+671	19.5	0833+585	18.0	1435+638	15.0	2113+293	19.5
0300+470	18.0	0836+710	16.5	1547+507	18.5	2200+420	14.0
0316+413	15.1	0859+470	18.7	1611+343	17.5	2201+315	14.5
0333+321	17.0	0917+624	19.5	1633+382	18.0	2234+282	19.0
0355+508		0923+392	17.8	1637+574	17.0	2253+417	18.8
0420+417	19.0	0954+658	18.0	1638+398	18.5	2319+272	20.0
0454+844	16.5	1030+415	18.2	1641+399	16.3	2337+264	20.0
0552+398	18.0	1031+567	20.3	1652+398	14.0	2351+456	19.0
0609+607	20.0	1039+811	16.5	1732+389	19.5	2352+495	19.0
0615+820	17.5	1128+385	19.0	1738+476	17.5		
0642+449	19.0	1150+812	18.6	1739+522	18.5	73 ERSs	
0710+439	19.8	1213+350	20.0	1749+701	16.5		

Table 2. Standard errors of reductions and average deviations for star positions obtained relative to the catalogue CMC and PPM

ERS plate No.	*refer. stars*	*reduction Sx*	*errors Sy*	*stars measured*	$(O-C)a$	$\pm$ *err*	$(O-C)d$	$\pm$ *err*
ERS 2200+420		reference stars: CMC-5						
16557	28	±0.″210	±0.″203	20	0.ˢ002	±0.ˢ007	0.″03	±0.″10
16574	27	0.202	0.226	20	0.001	.008	0.11	.09
16599	28	0.192	0.231	20	0.010	.008	0.09	.08
16624	28	0.223	0.250	20	−0.000	.007	0.06	.09
ERS 2021+614								
16577	31	±0.190	±0.251	18	0.014	±0.006	0.27	±0.10
16593	30	0.211	0.210	18	0.008	.007	0.19	.09
16605	31	0.190	0.260	18	0.012	.006	0.26	.10
16607	31	0.140	0.272	18	0.010	.006	0.31	.10
ERS 2200+420		reference stars: PPM						
16557	32	±0.341	±0.343	21	−0.000	±0.004	−0.01	±0.06
16574	32	0.381	0.336	21	0.001	.003	−0.08	.06
16599	32	0.342	0.325	21	−0.004	.004	−0.08	.07
16624	32	0.354	0.317	21	−0.005	.007	−0.18	.06
ERS 2021+614								
16577	27	±0.312	±0.336	23	−0.011	±0.002	−0.11	±0.04
16593	26	0.270	0.306	23	−0.013	.002	−0.13	.04
16605	26	0.353	0.373	23	−0.012	.002	−0.29	.05
16607	26	0.355	0.401	23	−0.010	.002	−0.31	.04

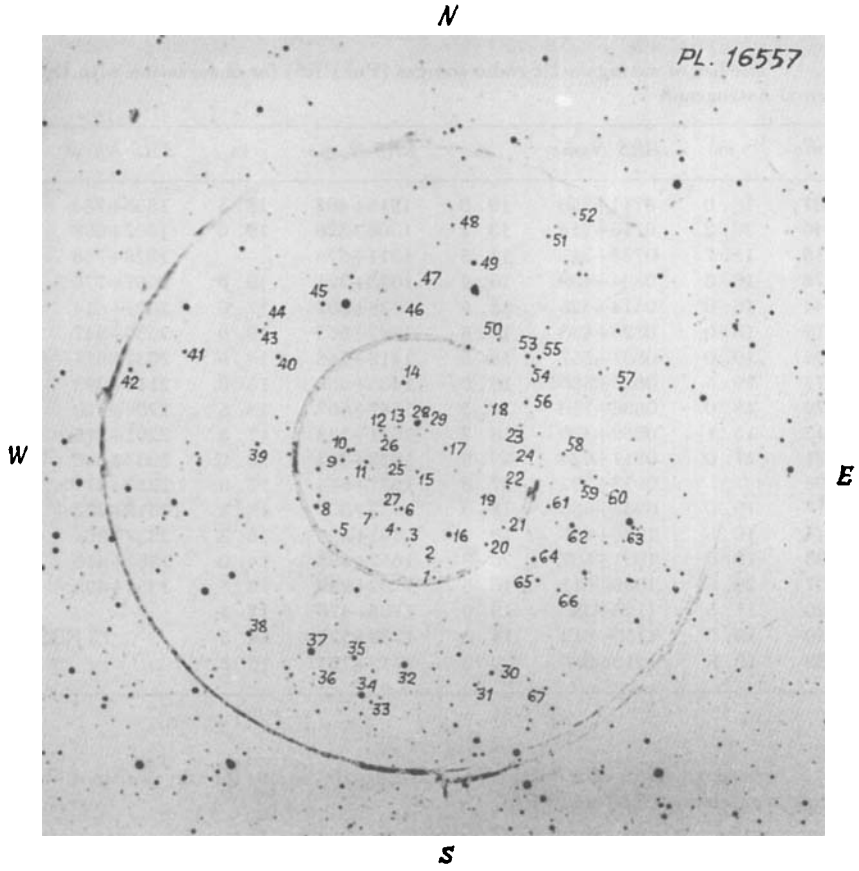

Figure 1 The finding chart for stars around ERS 2200+420 (Table 3, star numbers from 1 to 67). The inner circle has 6′ radius and the outer circle has 16′ radius.

It is proposed to calculate coordinates and photographic magnitudes of 7000–8000 stars in the instrumental photometric system of the normal astrograph, similar to B filter of the international system UBV. 18 ERSs are brighter than 16.5m (11 of them are brighter than 16.0m), and they might be found in our plates. Their identification and calculation of coordinates could be made directly using the plates of the normal astrograph. Till May 1993 about 70% of all plates for this programme had been obtained.

Two fields were used for study the technique:

1. ERS 2200+420, $M_v = 14.0$, $\alpha = 22^h02^m43^s.2912$, $\delta = 42°16'39''.982$,
2. ERS 2021+614, $M_v = 19.0$, $\alpha = 20^h22^m06^s.6814$, $\delta = 61°36'58''.815$.

Four plates for every field were obtained with the normal astrograph at Pulkovo in 1991. The epoch of calculated coordinates is 1991.689 for first field and 1991.696 for the second one. We used two systems of reference stars for reductions: that of

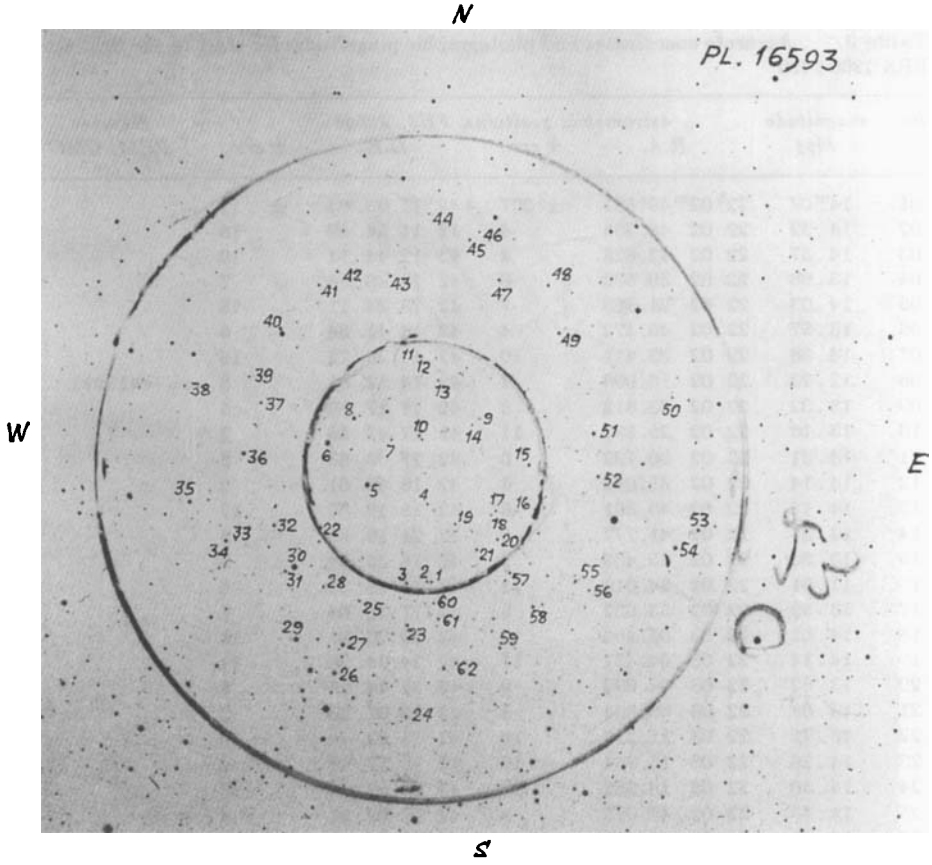

Figure 2 The finding chart for stars around ERS 2021+614 (Table 4, star numbers from 1 to 62). The inner circle has 6′ radius and the outer circle has 16′ radius.

the photographic catalogue PPM and that of meridian catalogue CMC (La Palma, Carlsberg Meridian Catalogue – 5). The number of reference stars used for plates of the normal astrograph:

1st field: PPM – 32 stars, CMC – 28 stars,

2nd field: PPM – 27 stars, CMC – 31 stars.

Reductions of coordinates of stars were made using method of eight plate constants for connection between tangential and measured coordinates. Our calculations showed that errors of reductions with CMC-5 reference stars are twice better than those with PPM stars practically for all plates (Table 2).

We obtained a catalogue of 223 stars of magnitude 11–15, 113 of them in the first field (Figure 1, Table 3), and 110 of them in the second one (Figure 2, Table 4), in the region $1.5 \times 1.5°$. All results are given in the reference frame of CMC-5 stars. These stars showed the reduction errors from 0.140″ to 0.270″, on the average the error amounts to +0.210″ (external error).

Table 3. Accurate coordinates and photographic magnitudes for stars in the field around ERS 2200+420

No.	*magnitude Mpg*	*astrometric positions, FK5, J2000 R.A.*	*± err*	*D.E.*	*± err*	*Number PPM, CMC*
01	$14^m.07$	$22^h 02^m 49^s.531$	$\pm^s.007$	$+42° 11' 03''.64$	$\pm''.11$	
02	14.32	22 02 48.285	4	42 11 54.49	18	
03	14.57	22 02 42.626	4	42 12 44.11	10	
04	13.66	22 02 39.632	6	42 13 38.68	7	
05	14.03	22 02 21.368	7	42 13 34.11	15	
06	13.57	22 02 40.472	4	42 14 41.84	6	
07	14.38	22 02 33.411	10	42 14 25.72	16	
08	12.23	22 02 16.096	2	42 14 52.86	8	c415022
09	13.32	22 02 23.812	8	42 17 17.10	5	
10	13.16	22 02 25.581	11	42 17 47.36	2	
11	13.31	22 02 30.792	6	42 17 09.83	8	
12	14.14	22 02 35.062	8	42 18 48.61	6	
13	14.15	22 02 40.361	6	42 18 59.39	17	
14	12.85	22 02 41.777	5	42 21 19.63	3	
15	13.90	22 02 45.437	2	42 16 35.54	9	
16	11.91	22 02 54.014	12	42 13 18.35	4	
17	13.59	22 02 53.632	6	42 17 48.06	7	
18	14.05	22 03 05.499	9	42 20 00.91	11	
19	14.14	22 03 04.471	11	42 14 24.28	14	
20	13.62	22 03 04.692	9	42 12 44.26	5	
21	14.08	22 03 09.864	8	42 13 37.23	3	
22	13.76	22 03 11.275	10	42 15 42.74	10	
23	14.26	22 03 15.364	10	42 18 57.98	8	
24	14.50	22 03 18.252	22	42 16 52.98	13	
25	14.13	22 02 40.075	5	42 17 09.91	4	
26	14.10	22 02 36.257	12	42 18 31.55	3	
27	14.03	22 02 38.896	11	42 14 39.15	4	
28	11.28	22 02 45.556	6	42 19 10.32	3	
29	13.33	22 02 46.146	11	42 19 14.78	7	
30	12.93	22 03 05.518	10	42 06 01.66	9	
31	13.85	22 03 00.686	7	42 05 25.13	9	
32	11.22	22 02 40.528	7	42 06 32.92	3	
33	13.72	22 02 30.772	11	42 04 36.26	12	
34	11.13	22 02 28.045	9	42 04 59.14	6	c317492
35	12.56	22 02 26.131	15	42 06 57.52	6	
36	10.61	22 02 13.855	6	42 07 19.90	13	
37	13.64	22 02 06.706	10	42 06 28.52	7	
38	12.43	22 01 55.938	12	42 08 17.85	5	
39	13.08	22 01 59.462	9	42 18 12.03	7	
40	12.65	22 02 05.836	10	42 22 46.77	6	
41	13.37	22 01 39.221	8	42 23 05.40	11	
42	13.19	22 01 23.605	7	42 22 09.91	4	
43	13.38	22 02 00.619	10	42 24 08.98	7	
44	13.98	22 02 02.459	11	42 24 30.14	4	
45	12.78	22 02 18.892	8	42 25 31.85	7	
46	13.56	22 02 40.758	12	42 25 14.06	13	
47	13.74	22 02 45.652	13	42 26 29.61	8	
48	13.52	22 02 56.583	11	42 29 33.23	12	
49	12.42	22 03 02.501	7	42 27 32.86	10	
50	13.96	22 03 09.352	14	42 23 28.39	16	

Table 3. Continued

No.	*magnitude* *Mpg*	*astrometric positions, FK5, J2000* *R.A.*	± *err*	*D.E.*	± *err*	*Number* *PPM, CMC*
51	13ᵐ.48	22ʰ 03ᵐ 24ˢ.117	±ˢ.007	+42° 28′ 53″.08	±″. 9	
52	13.82	22 03 31.630	9	42 30 01. 72	7	
53	12.93	22 03 17.568	4	42 22 36. 29	8	
54	13.73	22 03 19.166	6	42 22 04. 81	11	
55	13.11	22 03 20.877	6	42 22 32. 84	8	
56	13.16	22 03 16.893	7	42 20 11. 10	5	
57	12.78	22 03 44.361	7	42 20 47. 93	8	
58	13.70	22 03 27.525	4	42 17 25. 82	13	
59	13.18	22 03 32.709	9	42 15 55. 20	8	
60	13.93	22 03 36.569	2	42 16 10. 80	9	
61	13.60	22 03 22.792	4	42 14 40. 48	11	
62	11.99	22 03 29.401	6	42 13 40. 48	5	c317512
63	10.20	22 03 46.022	4	42 13 47. 68	8	
64	12.69	22 03 18.246	10	42 11 55. 11	7	
65	13.39	22 03 19.317	17	42 10 48. 54	3	
66	13.89	22 03 25.356	12	42 10 16. 14	10	
67	13.55	22 03 22.831	7	42 04 05. 38	4	
68	9.34	21 59 53.094	11	41 56 21. 40	6	p62321
69	7.20	21 58 55.771	10	41 41 46. 20	7	p62295
70	8.30	21 59 13.871	9	41 57 32. 96	5	p62303
71	9.10	21 59 42.267	9	41 34 24. 57	11	p62317
72*	10.70	22 03 41.251	2	41 54 10. 84	9	p62425
73	11.00	22 02 01.724	8	41 42 40. 07	11	p62386
74	9.70	21 59 26.717	14	42 36 51. 96	8	p62311
75	9.31	21 59 42.712	7	42 34 15. 88	10	p62318
76	9.60	21 59 26.744	15	42 28 29. 68	6	p62312
77	10.60	21 59 30.432	5	42 50 58. 68	2	p62314
78	8.80	21 59 51.478	7	42 46 49. 61	12	p62320
79	9.60	22 02 21.087	17	42 51 16. 55	15	p62395
80	7.00	22 02 44.313	4	42 48 52. 43	17	p62406
81	10.70	22 03 13.993	10	42 54 08. 11	13	p62419
82*	9.18	22 01 24.382	0	42 01 30. 48	3	c209528
83*	9.38	22 00 42.498	4	42 17 44. 67	14	c209523
84*	9.11	22 03 52.831	2	42 00 34. 82	6	p62432
85*	9.30	22 01 37.477	7	42 40 54. 42	5	p62370
86*	9.61	22 01 50.439	9	42 01 25. 47	12	c317487
87*	8.49	22 02 25.402	4	42 25 31. 70	9	c317491
88*	7.30	22 00 11.012	7	42 35 01. 16	5	p62330
89	10.50	22 00 13.607	7	42 41 12. 94	5	p62332
90	9.45	22 04 01.329	11	42 31 29. 66	9	c209542
91*	8.85	22 04 44.278	9	42 19 55. 20	6	c317530
92	9.80	22 04 05.203	4	42 41 06. 67	4	p62438
93	9.70	22 00 32.001	12	43 04 11. 13	9	p62337
94	9.30	22 02 00.974	10	43 07 57. 11	4	p62385
95	8.63	21 57 05.925	4	42 36 58. 48	2	c104614
96	7.91	21 57 13.495	7	42 05 53. 03	6	c209486
97	9.96	21 57 59.722	6	42 39 19. 71	13	c414978
98	10.73	21 58 16.512	3	42 15 35. 05	2	c414982
99	10.52	21 59 25.766	3	42 11 25. 87	2	c414991
100	10.33	21 59 50.521	5	41 47 59. 08	5	c317456

Table 3. Continued

No.	*magnitude Mpg*	*astrometric positions, FK5, J2000* R.A.	± *err*	D.E.	± *err*	*Number PPM, CMC*
101	$11^m.02$	$22^h\ 00^m\ 06^s.294$	$\pm^s.005$	$+43°\ 10'\ 53''.79$	$\pm''.5$	c414997
102	10.41	22 00 34.429	4	42 33 57.62	5	c209520
103	10.34	22 01 00.444	5	41 51 49.31	3	c415006
104	10.94	22 01 01.496	7	42 13 32.65	7	c415007
105	10.65	22 01 39.771	3	42 25 25.74	12	c415010
106	11.16	22 01 51.708	0	42 11 20.85	12	c317488
107	9.91	22 02 04.152	6	42 41 56.85	8	c415018
108	10.36	22 02 40.016	13	41 44 42.85	10	c317495
109	10.45	22 03 05.086	4	43 01 09.20	4	c415032
110	10.43	22 03 12.249	0	42 01 49.04	12	c317508
111	9.57	22 03 14.993	6	42 00 05.75	10	c415034
112	10.42	22 04 32.661	9	42 16 22.26	4	c415051
113	10.85	22 05 02.092	2	42 41 28.35	5	c317535

Note. * – a star from the RRS2 list; c, p – c for stars from the CMC; p, for those from the PPM catalogue.

Table 2 also presents systematic deviations for coordinates of stars obtained in reductions relative to both catalogues. In its first part, average deviations for PPM positions of 20 and 18 stars from those calculated in the CMC-5 reference frame are given for each plate. In its second part, average deviations were found for 21 and 23 stars for which CMC positions are not available, so their positions were derived relative to PPM. For the first field (ERS 2200+420), standard errors of mean deviations are large and we can say nothing certain about systematic errors of reduction. The large systematic errors for both coordinates found for stars in the field around ERS 2021+614, that passes zenith at Pulkovo, were unexpected. The mean deviation amounts to +0.011s for RA and to +0.26″ for DE. The standard error is sufficiently small to judge about existing systematic residuals. The deviations calculated relative to PPM are similar but they have opposite sign. Since the field was observed in zenith, the error due to atmospheric effects must be minimal. This could mean that star positions reduced to these catalogues have systematic displacements. the data for RA from deviations for stars in common for CMC and PPM confirm this fact:

for 7 common stars in the first field: -0.011 ± 0.004s, $-0.03 \pm 0.01''$

for 8 common stars in the second field: $+0.009 \pm 0.005$s, $-0.02 \pm 0.08''$.

These stars have no significant systematic deviations in declination. Own systematic errors of our catalogue need investigation. The internal accuracy of star positions (Tables 3, 4) generally amounts to 0.005–0.012s for RA and to 0.04–0.11″ for DE.

In order to obtain the photographic magnitudes, 24 comparison stars have been selected from the PPM catalogue. The images obtained with short exposures were used to extend the characteristic curve for faint stars. The accuracy of magnitudes amounts to 0.03–0.05m for 10–11m stars and to 0.07–0.15m for 14–15m stars. Ex-

Table 4. Accurate coordinates and photographic magnitudes for stars in the field around ERS 2021+614

No.	*magnitude*	*astrometric positions, FK5, J2000*				*Number*
	Mpg	*R.A.*	± *err*	*D.E.*	± *err*	*PPM, CMC*
01	+14.13	20 21 39. 925	±.009	61 31 08.71	±.04	
02	14.34	20 21 37. 863	13	61 31 09.71	5	
03	13.88	20 21 28. 654	11	61 31 01.01	3	
04	14.32	20 21 36. 462	9	61 35 12.45	4	
05	11.58	20 21 08. 808	6	61 36 03.49	9	
06	10.88	20 20 49. 671	17	61 38 07.73	5	
07	13.93	20 21 18. 645	14	61 38 27.17	3	
08	12.40	20 21 01. 239	7	61 39 29.39	6	
09	12.79	20 21 16. 021	4	61 39 55.68	4	
10	13.78	20 21 31. 293	18	61 38 43.91	2	
11	13.42	20 21 29. 852	9	61 42 55.13	4	
12	13.97	20 21 30. 759	6	61 42 54.18	12	
13	14.18	20 21 38. 814	15	61 41 41.56	5	
14	14.47	20 21 54. 994	6	61 39 25.65	7	
15	13.18	20 22 21. 730	17	61 37 28.07	5	
16	13.65	20 22 25. 662	13	61 35 11.55	4	
17	14.21	20 22 07. 651	14	61 35 01.29	9	
18	14.63	20 22 05. 683	19	61 34 47.28	12	
19	14.16	20 21 49. 344	7	61 34 13.65	5	
20	14.14	20 22 09. 050	22	61 33 31.64	8	
21	14.05	20 21 59. 819	9	61 32 56.50	5	
22	13.66	20 20 48. 363	10	61 33 41.79	7	
23	13.43	20 21 29. 784	20	61 28 47.72	3	
24	14.43	20 21 31. 011	14	61 23 58.67	3	
25	14.13	20 21 07. 649	19	61 29 58.58	10	
26	12.90	20 20 57. 820	27	61 26 05.52	4	
27	13.02	20 21 01. 072	22	61 27 36.02	6	
28	14.01	20 20 50. 982	18	61 30 37.55	4	
29	11.91	20 20 40. 022	21	61 27 46.61	5	
30	10.86	20 20 37. 584	22	61 31 35.22	9	c413916
31	13.49	20 20 33. 544	12	61 31 20.24	2	
32	13.08	20 20 27. 331	15	61 33 42.55	2	
33	13.86	20 20 10. 373	17	61 32 52.20	9	
34	13.18	20 20 06. 001	15	61 32 46.64	5	
35	12.85	20 19 48. 851	20	61 34 42.15	4	
36	11.89	20 20 11. 981	14	61 37 21.11	4	
37	13.60	20 20 18. 393	23	61 40 04.40	4	
38	14.05	20 19 43. 712	14	61 40 44.06	1	
39	14.14	20 20 12. 629	10	61 41 23.75	3	
40	14.05	20 20 33. 605	18	61 43 03.60	6	
41	13.19	20 20 41. 989	22	61 46 24.77	3	
42	13.01	20 20 50. 080	18	61 47 11.14	8	
43	12.76	20 21 14. 498	11	61 47 04.32	6	
44	13.81	20 21 30. 638	17	61 50 25.75	4	
45	13.06	20 21 49. 806	13	61 49 10.81	4	
46	13.84	20 21 54. 232	13	61 49 36.12	6	
47	12.99	20 22 04. 239	8	61 47 08.57	6	
48	13.24	20 22 26. 671	19	61 46 58.32	3	
49	12.92	20 22 32. 818	14	61 44 27.51	4	
50	13.89	20 23 25. 694	7	61 41 20.70	4	

Table 4. Continued

No.	*magnitude* *Mpg*	*astrometric positions, FK5, J2000* *R.A.*	± *err*	*D.E.*	± *err*	*Number* *PPM, CMC*
51	12.49	20 22 50. 559	±.11	61 39 16.18	±.05	
52	13.42	20 23 40. 065	14	61 34 27.75	5	
53	13.17	20 23 40. 065	14	61 34 27.75	5	
54	12.01	20 23 29. 835	12	61 33 29.24	4	
55	13.98	20 22 45. 285	9	61 31 32.80	9	
56	14.31	20 22 51. 324	9	61 31 05.36	2	
57	14.31	20 22 15. 341	21	61 31 48.47	9	
58	13.62	20 22 26. 256	17	61 30 04.90	9	
59	13.75	20 22 12. 140	11	61 27 48.80	1	
60	14.51	20 21 41. 345	12	61 30 02.11	9	
61	14.28	20 21 43. 836	12	61 29 12.80	16	
62	13.82	20 21 47. 232	7	61 26 36.38	4	
63	9.00	20 16 51. 983	9	60 57 14.04	3	p22078
64	8.70	20 21 03. 466	15	60 48 14.80	7	p22121
65	9.50	20 15 50. 461	3	61 29 27.00	2	p22070
66	11.30	20 19 06. 445	1	61 03 20.79	5	p22097
67	10.95	20 19 18. 203	1	61 02 52.45	10	p22099
68	11.13	20 16 40. 644	10	61 11 56.75	7	p22077
69*	8.93	20 19 19. 860	14	61 17 18.87	12	c413898
70*	10.58	20 20 26. 443	5	61 43 43.79	6	c103910
71*	8.43	20 20 57. 249	8	61 02 38.69	5	p22119
72*	9.20	20 23 01. 645	5	61 34 49.32	5	c208273
73*	7.89	20 25 01. 664	17	61 17 53.56	5	c208303
74*	9.19	20 24 08. 653	10	61 28 46.50	1	c208289
75*	9.60	20 24 05. 897	13	61 58 19.61	5	p22147
76*	7.94	20 25 54. 190	11	61 33 20.79	12	c208315
77	9.10	20 26 55. 587	13	61 31 36.78	7	p22186
78	9.50	20 28 44. 065	23	61 49 30.54	7	p22203
79	10.10	20 19 42. 159	8	62 24 59.40	12	p22102
80	10.70	20 16 57. 598	10	62 07 11.72	4	p22079
81	10.00	20 17 37. 207	8	62 01 07.45	12	p22082
82*	8.70	20 17 20. 581	11	62 08 17.81	7	p22080
83*	9.80	20 20 01. 241	7	62 10 09.15	6	p22103
84*	9.00	20 23 32. 094	4	62 16 16.52	2	p22145
85	11.20	20 27 05. 479	7	62 02 20.69	5	p22188
86*	9.15	20 25 37. 450	9	62 09 08.08	7	c413983
87	9.50	20 24 47. 638	16	62 23 41.21	8	p22156
88	9.89	20 15 16. 222	3	61 07 58.18	7	c413850
89	10.57	20 17 26. 501	7	61 22 11.35	6	c413878
90	10.83	20 17 52. 693	2	61 51 33.25	3	c315979
91	11.22	20 18 16. 953	2	61 42 10.95	3	c413887
92	10.65	20 18 18. 129	8	61 36 22.76	2	c103891
93	10.49	20 18 38. 838	4	61 10 46.55	4	c315989
94	10.81	20 19 18. 816	5	61 42 23.27	3	c413897
95	10.72	20 19 32. 149	8	61 22 40.03	5	c103899
96	11.02	20 20 29. 768	7	62 08 06.16	4	c413913
97	10.86	20 20 49. 669	4	61 38 07.78	4	c413918
98	9.45	20 20 54. 575	13	61 24 12.63	2	c413920
99	10.64	20 21 36. 768	12	61 18 35.95	2	c413930
100	10.40	20 22 01. 032	10	61 50 24.07	5	c316037

Table 4. Continued

No.	*magnitude Mpg*	*astrometric positions, FK5, J2000 R.A.*	*± err*	*D.E.*	*± err*	*Number PPM, CMC*
101	9.76	20 22 09. 738	±.5	62 21 13.09	±.1	c316040
102	11.28	20 22 49. 791	4	61 10 08.81	3	c103928
103	11.36	20 22 52. 966	2	61 20 22.06	4	c316049
104	10.51	20 23 08. 245	8	61 45 49.66	2	c413948
105	10.79	20 25 03. 835	4	61 44 58.27	3	c413976
106	11.22	20 25 16. 751	2	61 26 58.47	7	c413979
107	11.63	20 25 21. 242	7	61 25 15.25	4	c316084
108	11.09	20 25 37. 313	7	61 51 10.88	4	c316088
109	11.55	20 26 04. 111	5	61 49 44.87	7	c103953
110	10.63	20 26 14. 393	9	61 08 31.74	4	c316098

Note. * – a star from the RRS2 list; c, p – c for stars from the CMC; p, for those from the PPM catalogue.

ternal errors equal to 0.21m relativele the PPM stars. The distribution of stars in the rings R1–R2 from the location of the ERSs is the following:

(R):	0–6′	6–15′	15–40′	Total
1. ERS 2200+420	29	44	40	113
2. ERS 2021+614	22	45	43	110

It is supposed that coordinates of stars for the whole programme would be obtained with account of atmospheric dispersion using spectra of reference stars. It is possible to reduce systematic errors in positions of programme stars because of dispersion for fields at great zenith distances.

Two catalogue will be the result of this work:

- a catalogue of photometric and positional measurements,
- catalogue of positions and magnitudes of the programme stars.

The catalogue of positional measurements should be used to improve the intermediate reference system using stars from HIPPARCOS satellite catalogue which has the same epoch of observations.

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