Observations of ERS from ICRF2 list using ASV 60cm and Rozhen 2m telescopes

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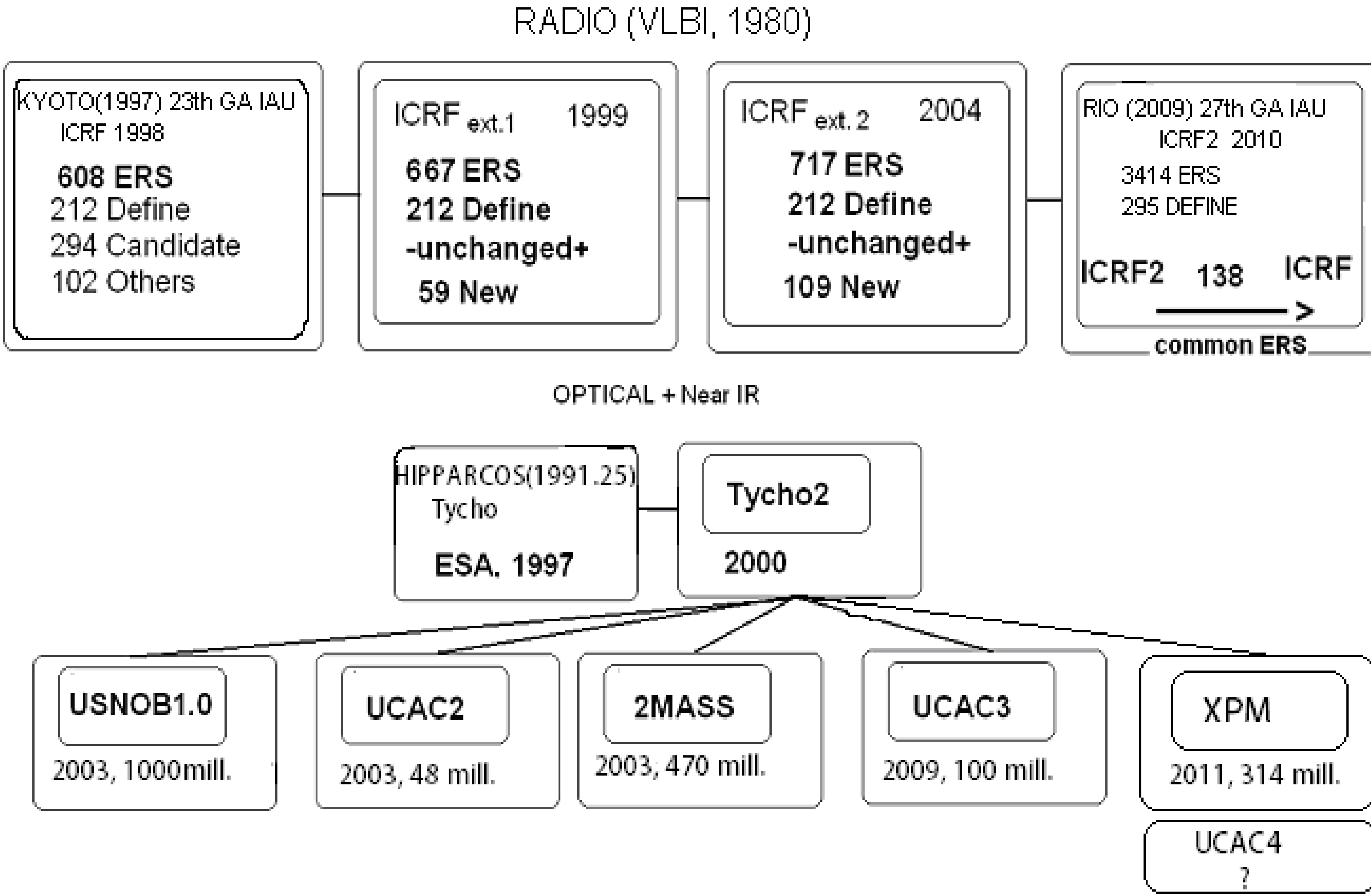
VIII Serbian-Bulgarian Astronomical Conference
May 8-12, 2012, Leskovac, Serbia

International Celestial Reference System



Introduction

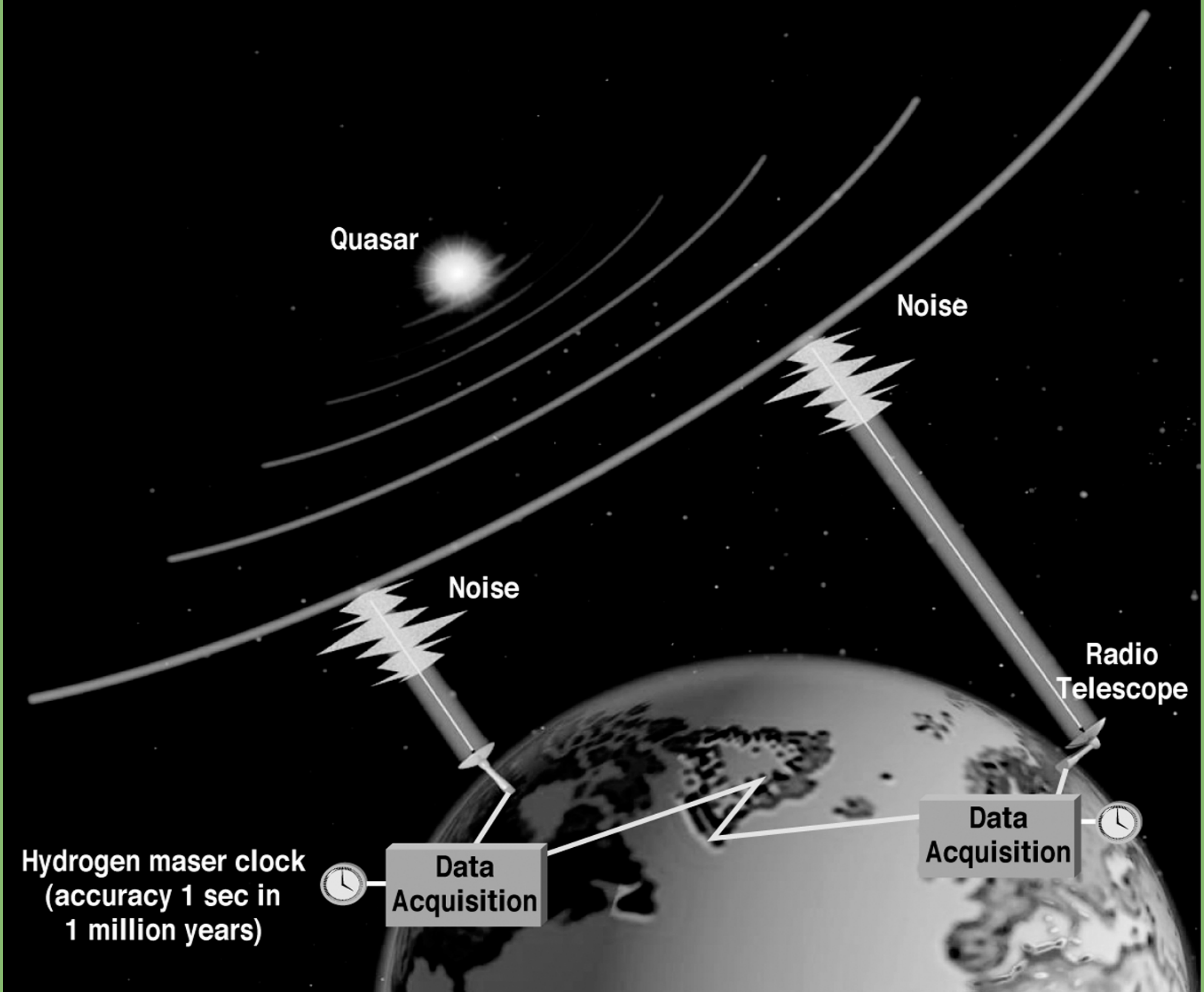
- The International Celestial Reference Frame (ICRF1) was the realization of the International Celestial Reference System (ICRS) at radio frequencies.
- It was defined by the Very Long Baseline Interferometry (VLBI) observations.
- Disadvantages:

  ICRF1 had an estimated noise floor of 250 μas and an estimated axes stability of 20 μas.

  The distribution of defining sources was very non uniform.

  Several of the original defining sources have been found to be unstable.

- The ICRF2 is found to have a noise floor of only ~ 40 μas and an axis stability of ~ 10 μas.
- Alignment of ICRF2 : by using 138 stable sources common to both ICRF2 and ICRF1-Ext2.
- The stability of these 295 defining sources and their more uniform sky distribution eliminates the two largest weaknesses of ICRF1.


Quasar
Noise
Noise
Radio
Telescope
Data
Acquisition
Data
Acquisition
Hydrogen maser clock
(accuracy 1 sec in
1 million years)

Optical observations of ERS (Extragalactic radio sources)

- We used RCC (D=2m, F=16m) telescope of Rozhen National Astronomical Observatory on Bulgarian Academy of Sciences with CCD camera VersArray 1300B (1340x1300 pixels, the pixel size is 20μmx20μm, 0.258 arcsec/pixel) from spring 2011.
- We also made the observations of ERS from the ICRF2 list with 60cm telescope at Astronomical Station Vidojevica (ASV) with CCD camera Apogee U42 (2048x2048 pixels, the pixel size is 13.5μmx13.5μm, 0.464arcsec/pixel) from summer 2011.

60cm Cassegrian telescope

Data

- Our ERS are visible in optical part of wavelenghts with the magnitudes between 14 and 17.
- The optical positions of ERS determined with respect to the reference stars of XPM catalogue (which is in ICRS).
- The exposure time for 14 mag and 2m Rozhen telescope is 5s, and for 17mag is 20s exposure.
- It is 60s for all objects observed with ASV 60cm.
- The CCD frames were measured with software AIP4WIN (R. Berry, J. Burnell 2000).
- 6 ERS were taken here in order to compare results

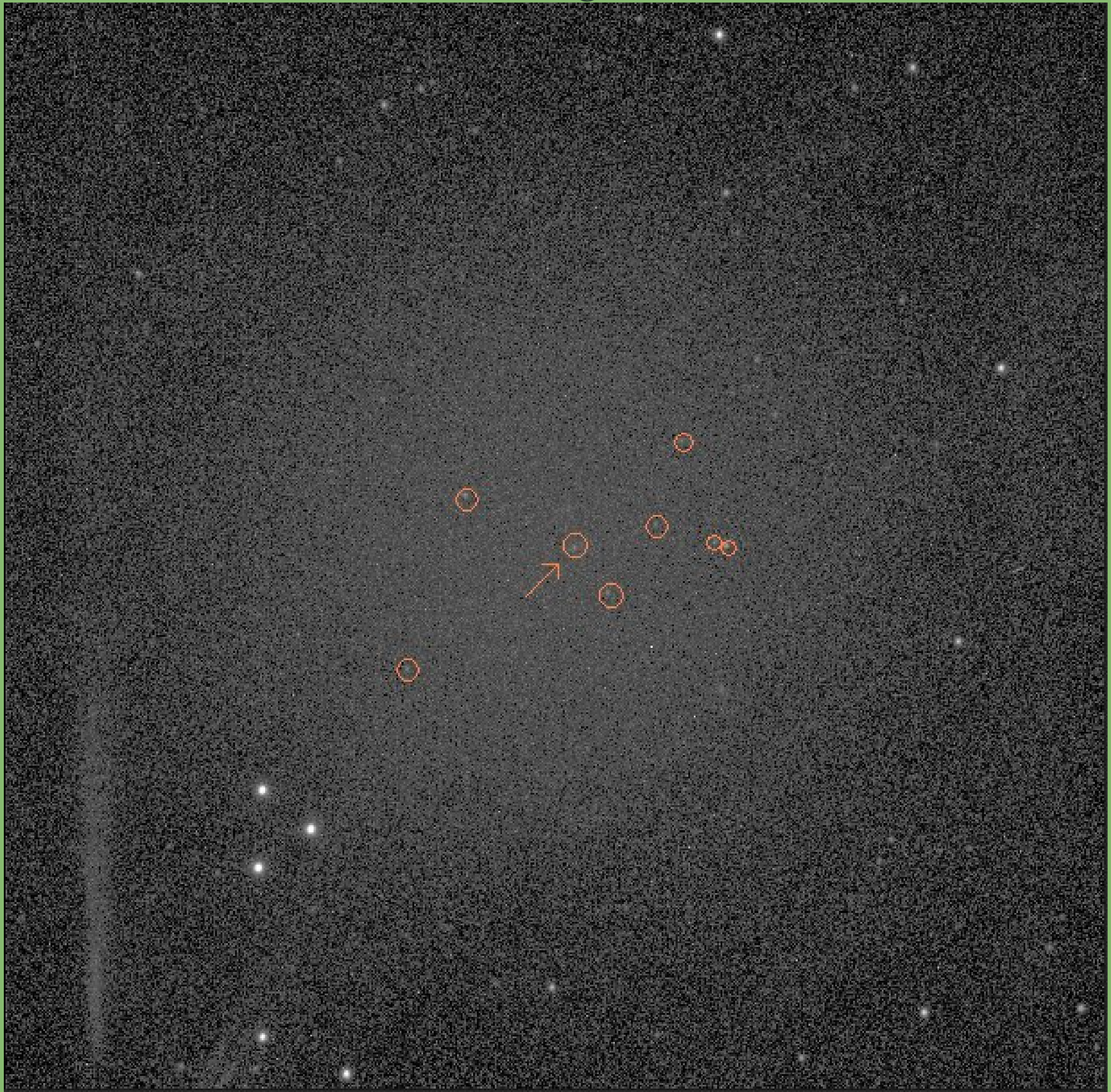
(O-R in positions) from both telescopes (6 frames for each object, 3 for R and 3 for V filter).

ERS (Rozhen)	RA (VLBI)	DEC (VLBI)	MAG	EXP(s), V	EXP(s), R
L0109+224	$1^h12^m5^s.8247$	22°44'38''.786	16.4	10	15,10
A0059+581	$1^h2^m45^s.7624$	58°24'11''.137	16.1	15	10
Q2250+190(SH)	$22^h53^m7^s.3692$	19°42'34''.629	16.7	20	20
G0007+106	$0^h10^m31^s.0059$	10°58'29''.504	14.2	5	5
L2254+074	$22^h57^m17^s.3031$	7°43'12''.302	17.0	20	20
G0309+411	$3^h13^m1^s.9621$	41°20'1''.183	16.5	15	15

ERS (ASV)	EXP(s), V	EXP(s), R
L0109+224	60	60
A0059+581	60	60
Q2250+190	60	60
G0007+106	60	60
L2254+074	60	60
G0309+411	60	60

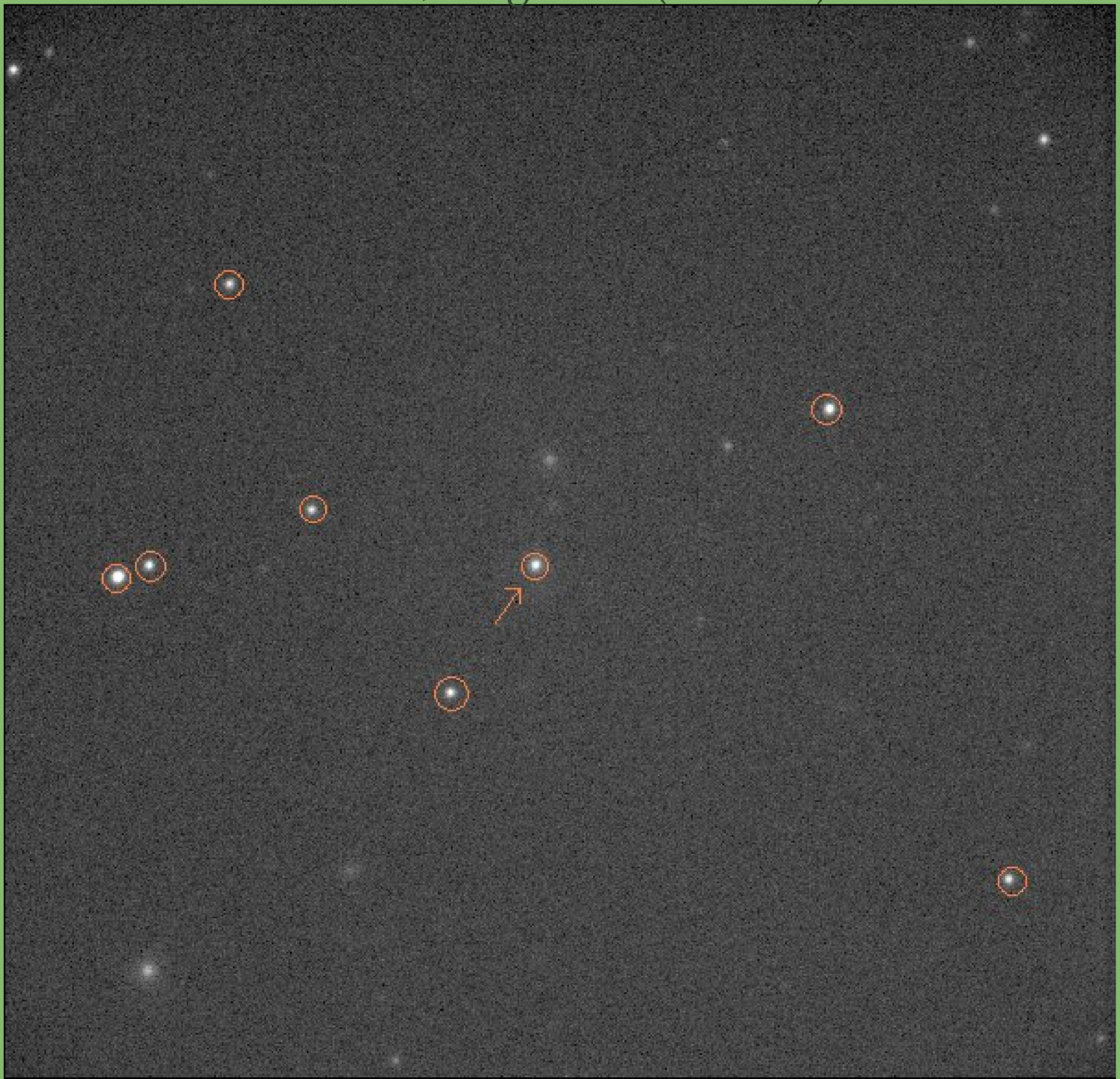
ICRF J001031.0+105829

G0007+106, mag=14.2 (ASV)



ICRF J001031.0+105829

G0007+106, mag=14.2 (Rozhen)



Calculations

- The programme for reduction of stellar apparent coordinates (Equinox method) in Fortran was written with some procedures of Sofa packages (Standards of Fundamental Astronomy).
- We had found the radio ERS coordinates in IERS Technical Note No. 35.
- **The linear six-parameter model:** $\xi = ax + by + c$ **and** $\eta = dx + ey + f$ **was used (Kiselev, 1989) with unweighted LSM method (the standard astrometric reductions with the available reference stars).**
- **This model includes effects of diferential refraction and aberations.**
- **Differential refraction is not taken into account because of small field of view-FOV (Kiselev, 1989).**

Таблица 2

Остаточная ошибка редукции линейными методами, зависящая от наклонности, дисторсии и дифференциальной рефракции

Тип остаточной погрешности редукции	Условия	Диаметр области опорных звезд					
		1°	2°	3°	4°	5°	6°
Ошибка наклонности	$\tau = 5'$	0,01″	0,05″	0,10″	0,18″	0,29″	0,41″
	$\tau = 10'$	0,02	0,09	0,20	0,36	0,57	0,82
Ошибка дисторсии ($c_3 = 10^{-7}$ мм$^{-2}$, $f_0 = 2063$ мм)	$r_0 = 1°$	0,23	0,93	2,10	3,73	5,82	8,39
	$r_0 = 2$	0,47	1,86	4,19	7,46	11,65	16,78
	$r_0 = 3$	0,70	2,80	6,29	11,18	17,48	25,16
Ошибка рефракции ($\beta = 61{,}05''$)	$\zeta_0 = 50°$	0,01	0,03	0,06	0,11	0,17	0,24
	$\zeta_0 = 60$	0,02	0,06	0,14	0,26	0,40	0,58
	$\zeta_0 = 70$	0,06	0,24	0,55	0,98	1,52	2,19

- Because of small FOV, tangential coordinates of reference stars and ERS are equal with equatorial ones (Z. Aslan at al., 2009).
- The FOV of the CCD frames are 5'.6x5'.6 (Rozhen) and 15'.8x 15'.8 (ASV).
- Min. 3 ref.stars.

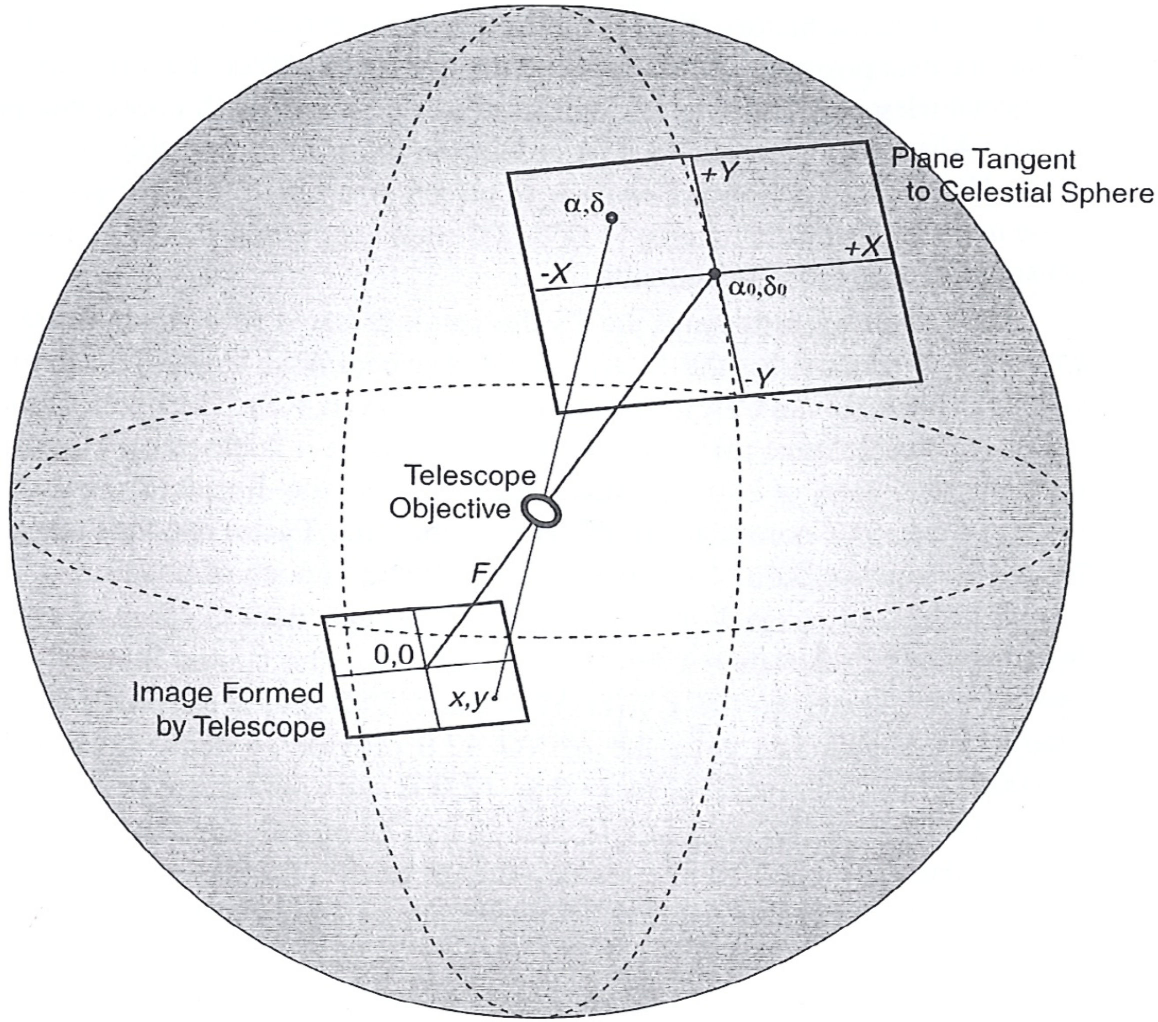


Figure 7.1 Telescopes project a section of the celestial sphere onto a flat photographic plate or a CCD chip. Shown are standard (X, Y) coordinates on a plane tangent to the celestial sphere, and (x, y) coordinates measured from a photographic plate or CCD located at the focus of the telescope.

$$X = ax + by + c$$
$$Y = dx + ey + f.$$

(Equ. 7.9)

Rozhen, mag	$(O\text{-}R)_\alpha$["]	$(O\text{-}R)_\delta$["]	σ_α["]	σ_δ["]
L0109+224, 16.4	-0.111	0.001	0.015	0.019
A0059+581, 16.1	0.138	-0.028	0.050	0.098
Q2250+190, 16.7	0.131	0.159	0.166	0.040
G0007+106, 14.2	-0.151	0.089	0.042	0.055
L2254+074, 17.0	0.074	0.007	0.095	0.040
G0309+411, 16.5	-0.347	-0.250	0.133	0.271

ASV, mag	$(O\text{-}R)_\alpha$["]	$(O\text{-}R)_\delta$["]	σ_α["]	σ_δ["]
L0109+224, 16.4	-0.049	-0.036	0.138	0.158
A0059+581, 16.1	0.026	0.317	0.226	0.495
Q2250+190, 16.7	-0.181	0.224	0.400	0.120
G0007+106, 14.2	-0.115	0.053	0.038	0.076
L2254+074, 17.0	0.145	0.180	0.381	0.556
G0309+411, 16.5	0.064	-0.353	0.315	0.263

Conclusions

- The optical observations of ERS are possible by using 2m Rozhen telescope and a good CCD camera. Also, the ASV 60cm telescope is usefull for this kind of astrometric investigations.
- The unweighted mean offsets between the ICRF2 radio positions and calculated optical ones, relative to the XPM catalogue for observations from Rozhen, are -0".044 and -0".004 in right ascension and declination, respectively, and from ASV are -0".018 and 0".064 (from presented 6 ERS objects).
- The XPM catalogue is a good densification of Hipparscos reference frame and can be used as reference astrometric catalogue even in small CCD fields.

- This results also can be usefull for improving the coordinates and proper motions of reference stars presented in the XPM catalogue and to calculate the unknown positions of every star in the neighborhood of radio-sources.
- Increasing exposure time at the telescope on ASV will allows observation of faint ERS (of magnitude greater than 17).
- After the reduction of ASV raw CCD images using bias, flat, dark and stacking, we expect better results in O-R positions of ERS. It could allow the observations of ERS fainter than 17 mag.
- ASV will get soon new star guider which will provide greater exposure time for observation of some ERS.

- Some of our results from ERS observations are comparable from both telescopes for objects with magnitude less than 17.

Reference

Aslan, Z., Gumerov, R., Jin, W., Khamitov, I., Maigurova, N., Pinigin, G., Tang, Z., Wang, S. : 2010, A&A, 510, A10

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Thank you!