MORE ACCURATE FOCAL LENGTH DETERMINATION FOR THE ROZHEN 2-m TELESCOPE

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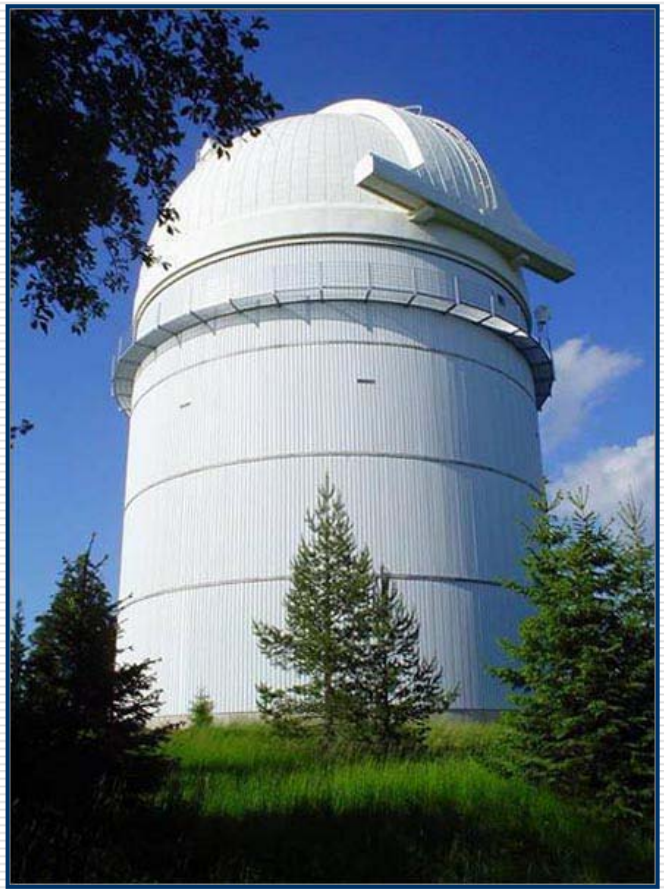
INTRODUCTION

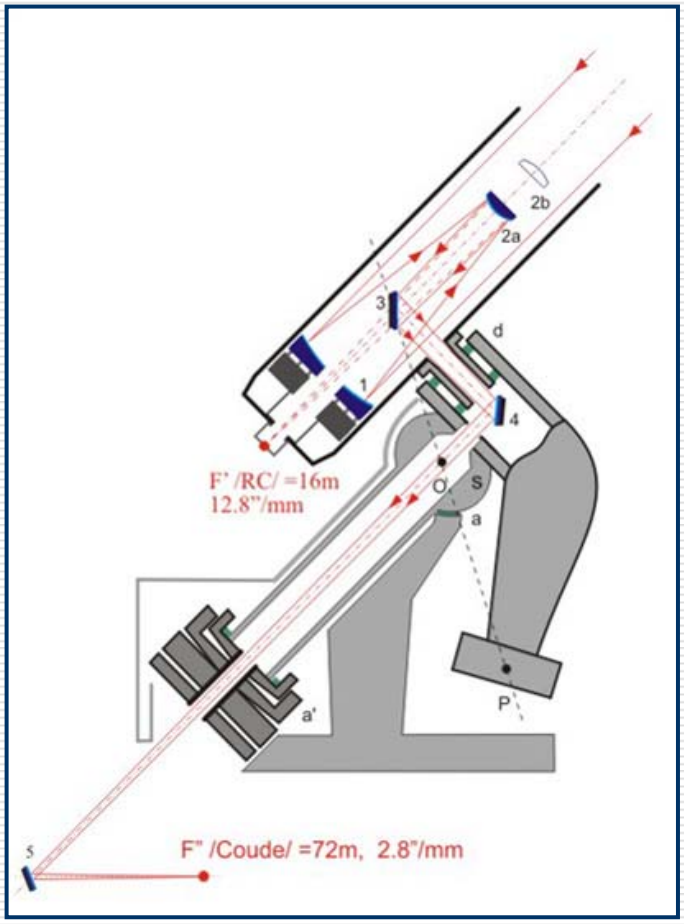
The focal length of a telescope is an important parameter in determining the relative coordinates (angular separation and positional angle) of double and multiple stars, as well as in determining the precise coordinates of radio sources that are visible in optical part of wavelengths. With the 2-m telescope of NAO Rozhen we have collected a large number of observations of these objects. In order to determine the focal length more accurately we have used CCD images obtained at Rozhen.

THE ROZHEN 2-m TELESCOPE

Ritchey-Chretien-Coude (RCC) Telescope



OPTICAL DESIGN



1 - 2m primary hyperbolic mirror

2a - RC secondary hyperbolic mirror

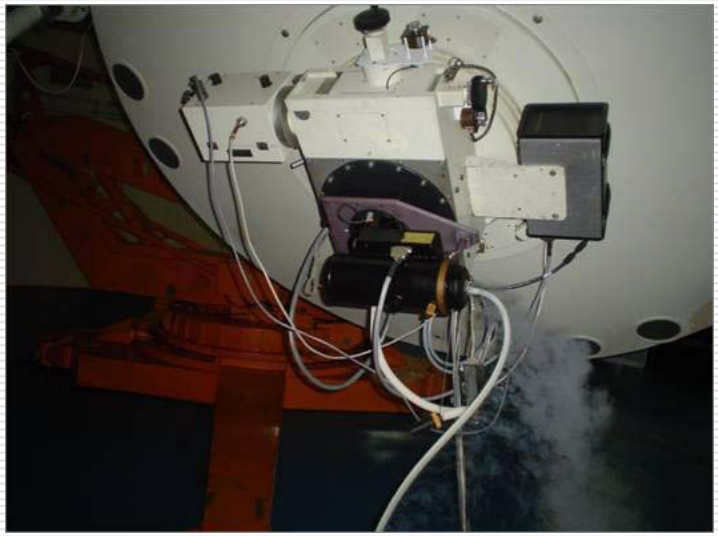
F' - Ritchey-Chretien focus

By system Ritchey-Chretien:

Focal lenght - 16 m;

Focal ratio - F/8.

CCD-Camera VersArray: 1300 B



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1340x1300 active pixels, 20x20 μm pixel size

The pixel size is 0.26 arcseconds

Cooling temperature -110^{o}C, liquid nitrogen

OBSERVATIONS

- Our team has performed 8 series of CCD observations of visual double and multiple stars at the NAO Rozhen in the period from 2004 to 2012. Also, we have performed 3 series of CCD observations of extragalactic compact radio sources (ERS) that are visible at optical wavelengths in order to investigate the relation between the optical and radio reference frames.

- The first series - in the middle of October 2004 (the frames were obtained by using the Photometrics AT200 CCD camera)
- The other 7 series of CCD observations of visual double and multiple stars:
  - in the end of October 2005;
  - on December 16/17, 2006;
  - on July 20/21, 2009;
  - on September 7-10, 2010;
  - from March 29 to April 01, 2011;
  - on October 27-28, 2011 and
  - on April 24-26, 2012.

OBSERVATIONS

- In the last seven series the frames were obtained by using the CCD camera VersArray: 1300B.
- A total of 891 pairs were measured

- The 3 series of CCD observations of ERS :
  - from March 29 to April 01, 2011;
  - on October 27-28, 2011 and
  - on April 24-26, 2012.

- About 100 ERS objects were measured

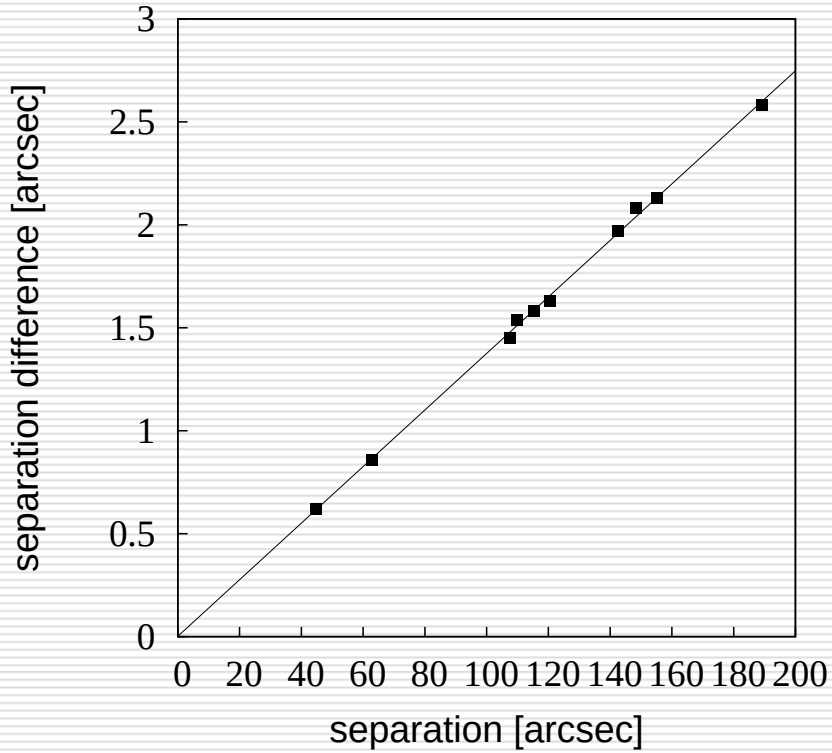
WDS 00057+4549=STT 547

WDS 00152+2722=J 868

WDS 00159+5233=ES 865

ERS L 2254+074

$$y = 0.0019 + 0.0137\,x$$

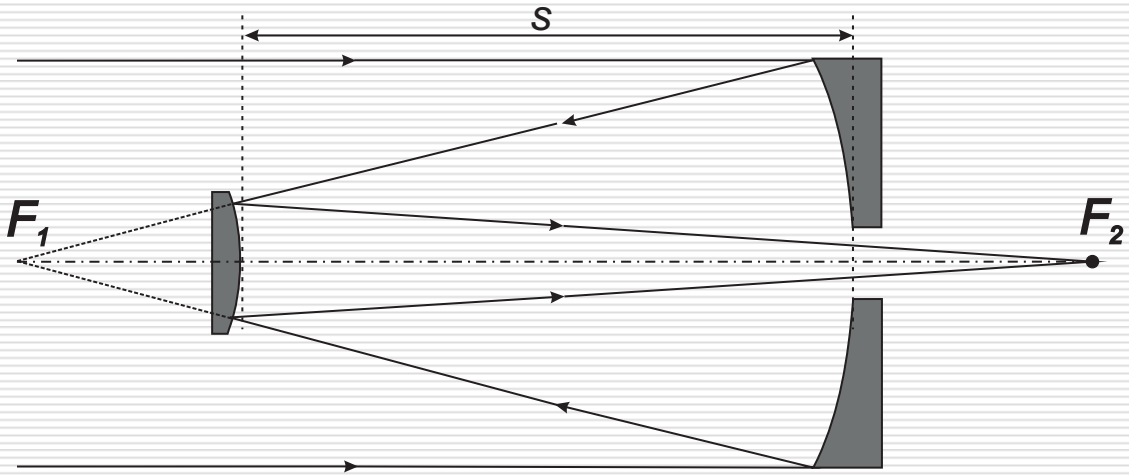


NAOR	ASV	diff.
44.61	45.23	0.62
62.90	63.76	0.86
107.41	108.86	1.45
109.72	111.26	1.54
115.45	117.03	1.58
120.59	122.21	1.63
142.43	144.39	1.97
148.39	150.47	2.08
155.05	157.17	2.13
189.11	191.69	2.58

FOCAL LENGTH

The telescope focal length is an important parameter in determining the angular pixel size. It is used for the purpose of determining the relative coordinates (angular separation and positional angle) of double and multiple stars, as well as in determining the precise coordinates of radio sources.

The effective focal length F for a two-mirror system is given by (Bely 2003):



$$F = \frac{f_1 f_2}{f_1 + f_2 - s},$$

Scheme of a two-mirror system: f1 is the primary mirror focus, f2 is the effective focus and s is the distance between the two mirrors

CALCULATION AND RESULTS

The angular separation d_c between two objects (arc along a great circle of celestial sphere) is calculated from coordinates α_i and δ_i , i=1,2 for the epoch of observations according to the formula

$$\cos d_c = \sin \delta_1 \sin \delta_2 + \cos \delta_1 \cos \delta_2 \cos(\alpha_2 - \alpha_1)$$

The measured separation d_m is calculated from

$$d_m = \frac{3600 \times 180}{\pi} \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2} \ ,$$

The telescope focal length is obtained from

$$F = \frac{d_m}{d_c}$$

Table 1. Focal length of 2 m telescope at NAO Rozhen with attached CCD camera VersArray 1300B.

pairs	α_1 [^{o}]	δ_1 [^{o}]	$\mu_{\alpha_1}\cos\delta_1$ [mas/yr]	μ_{δ_1} [mas/yr]	α_2 [^{o}]	δ_2 [^{o}]	$\mu_{\alpha_2}\cos\delta_2$ [mas/yr]	μ_{δ_2} [mas/yr]	F [mm]	year
0- 1	18.024270	22.744107	0.00	0.00	18.002064	22.755148	-3.57	-8.12	15765	2011
0- 2	18.024270	22.744107	0.00	0.00	18.042636	22.743713	-5.48	2.30	15824	2011
0- 3	18.024270	22.744107	0.00	0.00	18.013677	22.724062	-4.44	-26.81	15755	2011
0- 4	18.024270	22.744107	0.00	0.00	17.973797	22.720838	9.26	-4.07	15781	2011
0- 1	15.690677	58.403094	0.00	0.00	15.671078	58.397176	-33.78	0.87	15761	2011
0- 2	15.690677	58.403094	0.00	0.00	15.696223	58.397288	-6.16	-13.82	15769	2011
0- 3	15.690677	58.403094	0.00	0.00	15.683303	58.411670	-4.40	-1.35	15775	2011
0- 4	15.690677	58.403094	0.00	0.00	15.685314	58.385840	1.86	-2.47	15773	2011
0- 5	15.690677	58.403094	0.00	0.00	15.690276	58.373386	0.16	-1.28	15770	2011
0- 6	15.690677	58.403094	0.00	0.00	15.706665	58.378832	30.57	13.97	15783	2011
0- 1	343.280705	19.709619	0.00	0.00	343.270844	19.688776	7.53	2.00	15812	2011
0- 2	343.280705	19.709619	0.00	0.00	343.254917	19.704537	26.80	-5.09	15775	2011
0- 3	343.280705	19.709619	0.00	0.00	343.277107	19.723909	45.25	-3.12	15722	2011
0- 4	343.280705	19.709619	0.00	0.00	343.297852	19.733495	0.06	-14.81	15758	2011
0- 5	343.280705	19.709619	0.00	0.00	343.308839	19.738109	6.73	-0.82	15764	2011
0- 6	343.280705	19.709619	0.00	0.00	343.316243	19.739516	-4.73	-3.72	15754	2011
0-10	343.280705	19.709619	0.00	0.00	343.235601	19.744564	-6.24	-12.42	15780	2011
0- 1	344.322096	7.720084	0.00	0.00	344.314393	7.725902	16.93	-12.71	15860	2011
0- 2	344.322096	7.720084	0.00	0.00	344.299252	7.733080	0.37	-0.88	15767	2011
0- 3	344.322096	7.720084	0.00	0.00	344.291939	7.726671	-3.45	0.04	15779	2011
0- 4	344.322096	7.720084	0.00	0.00	344.340401	7.737714	7.81	4.88	15734	2011
0- 5	344.322096	7.720084	0.00	0.00	344.348585	7.724290	27.90	-7.18	15753	2011
0- 6	344.322096	7.720084	0.00	0.00	344.272324	7.730363	-19.47	-13.71	15779	2011
0- 8	344.322096	7.720084	0.00	0.00	344.319724	7.688006	9.70	-8.88	15761	2011
0- 9	344.322096	7.720084	0.00	0.00	344.322800	7.687318	22.00	-23.82	15762	2011
1- 2	1.392738	45.791748	6.47	-5.84	1.420091	45.827052	13.85	-7.68	15781	2005
1- 2	1.392738	45.791748	6.47	-5.84	1.420091	45.827052	13.85	-7.68	15781	2006
1- 2	1.392738	45.791748	6.47	-5.84	1.420091	45.827052	13.85	-7.68	15773	2010
1- 2	1.392738	45.791748	6.47	-5.84	1.420091	45.827052	13.85	-7.68	15773	2011
1- 2	1.392738	45.791748	6.47	-5.84	1.420091	45.827052	13.85	-7.68	15767	2012
1- 3	1.392738	45.791748	6.47	-5.84	1.452613	45.789707	6.68	-8.17	15775	2005
1- 3	1.392738	45.791748	6.47	-5.84	1.452613	45.789707	6.68	-8.17	15780	2006
1- 3	1.392738	45.791748	6.47	-5.84	1.452613	45.789707	6.68	-8.17	15779	2010
1- 3	1.392738	45.791748	6.47	-5.84	1.452613	45.789707	6.68	-8.17	15778	2011
1- 3	1.392738	45.791748	6.47	-5.84	1.452613	45.789707	6.68	-8.17	15780	2012
2- 3	1.420091	45.827052	13.85	-7.68	1.452613	45.789707	6.68	-8.17	15773	2005
2- 3	1.420091	45.827052	13.85	-7.68	1.452613	45.789707	6.68	-8.17	15781	2006
2- 3	1.420091	45.827052	13.85	-7.68	1.452613	45.789707	6.68	-8.17	15773	2010
2- 3	1.420091	45.827052	13.85	-7.68	1.452613	45.789707	6.68	-8.17	15772	2011
2- 3	1.420091	45.827052	13.85	-7.68	1.452613	45.789707	6.68	-8.17	15767	2012
									15774±21	