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BVR photometry of comparison stars in selected blazar fields

II. Photometric sequences for 9 quasars

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Abstract. In the course of the blazar monitoring activity at the Torino Astronomical Observatory, we obtained standard BVR magnitudes for 36 stars and standard VR magnitudes for 10 stars in the fields of 9 quasars. Observations were done during 14 photometric nights with the 1.05 m Cassegrain REOSC telescope equipped with a 1242×1152 pixel CCD camera. All stars are brighter than $V = 16.6$ and are useful comparison objects for the evaluation of the quasar magnitudes.

Key words: galaxies: active — quasars: general

1. Introduction

According to the current classification scheme for the active galactic nuclei, the class of blazars comprises BL Lacertae objects and a subset of quasars, all objects that are believed to emit their energy by a relativistic plasma moving towards us at a small angle to the line of sight. They are characterized by rapid variability, high and variable polarization, high brightness temperature, and superluminal motion of radio-emitting components (e.g. Urry & Padovani 1995).

Although several blazars have been monitored for many years, calibrated stars in the source field are still lacking for a number of them. This implies more work in order to obtain the blazar magnitude; moreover, using different reference stars may lead to different values of the blazar magnitude, thus making the comparison of data from different observers less meaningful than when a common photometric sequence is available. With this in mind, we calibrated field reference stars for a number of blazars that we are monitoring at the Torino Astronomical Observatory.

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In this paper we present calibration of 46 stars in the fields of 9 quasars of our monitoring object list. Standard magnitudes for 56 stars in the fields of 10 BL Lacertae objects are published in Villata et al. (1998a; Paper I).

2. Observations and data reduction

All data were taken with the 1.05 m Cassegrain reflector of the Torino Astronomical Observatory. The instrumentation comprises a 1242×1152 pixel CCD camera (EEV) and standard Johnson's BV and Cousins' R filters. The observations were done during 14 photometric nights, from February 1995 to May 1997. Flat field and bias frames were taken each night for the image correction; no dark current correction is needed. Several Landolt's fields (Landolt 1992) and other standard stars were observed during each night.

Frame reduction was performed with the Robin procedure locally developed, including bias subtraction, flat fielding, and circular gaussian fit after background subtraction.

Transformation of the instrumental magnitudes into standard ones was obtained with the Calib procedure (see Paper I for a description of the transformation equations).

3. Results

Table 1 lists the 9 quasars for which photometric sequences were obtained; coordinates at the 2000 equinox are given. BVR magnitudes of the reference stars are reported in Table 2, together with their uncertainties (σ) and the number of observations (N) for each band. For 10 stars VR magnitudes only are given. The magnitude and uncertainty evaluation has been performed as in Paper I.

Finding charts for the stars identification are shown in Figs. 1–9. They are 10 arcmin wide; north is up and east is on the left.

Table 1. List of the quasars for which photometric sequences are derived

Source	Name	RA (2000)	Dec. (2000)
0420−014	PKS 0420−01	04 23 15.80	−01 20 33.1
0528+134	PKS 0528+134	05 30 56.42	+13 31 55.1
0827+243	OJ 248	08 30 52.09	+24 10 59.8
1156+295	4C 29.45	11 59 31.83	+29 14 43.8
1222+216	4C 21.35	12 24 54.44	+21 22 46.9
1253−055	3C 279	12 56 11.17	−05 47 21.5
1510−089	PKS 1510−08	15 12 50.53	−09 05 59.8
2230+114	CTA 102	22 32 36.41	+11 43 50.9
2251+158	3C 454.3	22 53 57.75	+16 08 53.6

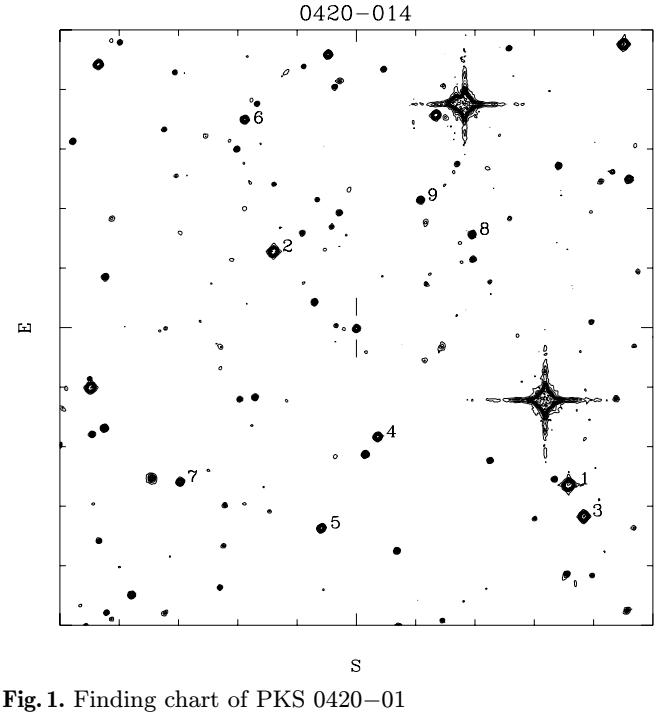

Fig. 1. Finding chart of PKS 0420−01

3.1. PKS 0528+134

The blazar PKS 0528+134 has recently been pointed for long periods of time by the Compton Gamma Ray Observatory (CGRO); consequently, international collaborations have been started in order to intensify the study of this object at different wavelengths.

We are not aware of any photometric sequence in its field, so that our work can offer a way to calibrate the large amount of optical data expected from this huge monitoring campaign.

We have to notice that Star 2 of our photometric sequence (see Fig. 2) is not a point-like source and, in good-seeing nights, it appears as a double object.

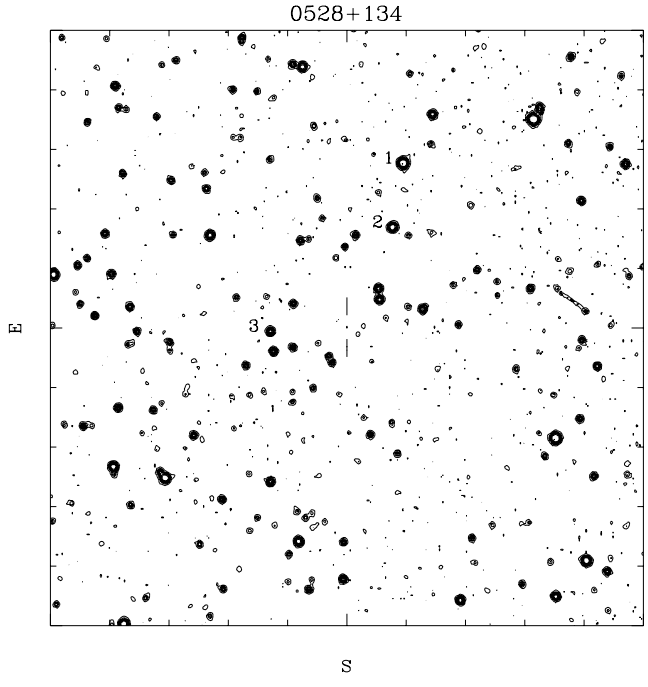

Fig. 2. Finding chart of PKS 0528+134

3.2. OJ 248

The magnitudes determined for Stars 2, 4, and 5 in the field of OJ 248 are in agreement, within the errors, with those published by Villata et al. (1997) for Stars A, C, and B.

3.3. 4C 29.45

A photometric sequence was published by Smith et al. (1985); BVR standard magnitudes of the same stars were also measured by Villata et al. (1997), substantially confirming the previous results. Stars 13, 14, and 15 in the above works correspond to Stars 2, 3, and 4 in the present paper and the calibrations agree within the errors. We add one star (Star 1), brighter and closer to the quasar.

A comparison among the different calibrations is performed in Table 3.

3.4. 3C 279

BVR magnitudes of Stars 1 and 5 are published in Villata et al. (1997; their Stars D and A); they are in agreement with the present values with the only exception of the V magnitude of Star 5.

The object "S" in Fig. 6 is characterized by large-amplitude and rapid variability. Its coordinates are RA(2000) = $12^{\rm h}\,56^{\rm m}\,8\overset{\rm s}{.}47$, Dec.(2000) = $-5^\circ\,44'\,34\overset{''}{.}5$. It has been named "Simona" in Villata et al. (1998b).

Table 2. BVR magnitudes of the comparison stars

Blazar	Star	B (σ)	N_B	V (σ)	N_V	R (σ)	N_R
PKS 0420−01	1	13.02 (0.03)	3	12.45 (0.02)	3	12.09 (0.03)	3
	2	13.64 (0.03)	3	13.15 (0.02)	3	12.81 (0.02)	3
	3	13.92 (0.03)	3	13.29 (0.03)	3	12.87 (0.03)	3
	4	15.69 (0.03)	3	14.95 (0.03)	3	14.47 (0.03)	3
	5			14.96 (0.03)	3	14.37 (0.03)	3
	6	16.03 (0.03)	3	15.18 (0.03)	3	14.70 (0.03)	3
	7			15.31 (0.03)	3	14.91 (0.03)	3
	8			15.99 (0.03)	3	15.46 (0.03)	3
	9			16.29 (0.03)	3	15.58 (0.04)	3
PKS 0528+134	1	14.06 (0.05)	3	13.20 (0.03)	3	12.73 (0.03)	3
	2	15.77 (0.03)	3	14.60 (0.03)	3	13.92 (0.04)	3
	3	16.73 (0.10)	2	15.69 (0.04)	3	15.08 (0.03)	3
OJ 248	1			14.16 (0.04)	3	13.76 (0.02)	3
	2			14.71 (0.02)	3	14.46 (0.03)	3
	3			14.76 (0.04)	3	14.32 (0.02)	3
	4			15.59 (0.02)	3	15.18 (0.03)	3
	5			15.76 (0.03)	3	15.40 (0.02)	3
4C 29.45	1	14.01 (0.06)	3	13.39 (0.05)	2	13.01 (0.02)	3
	2	16.01 (0.06)	3	15.38 (0.05)	2	15.00 (0.02)	3
	3	16.44 (0.04)	3	15.91 (0.04)	2	15.54 (0.02)	3
	4	17.15 (0.05)	3	16.60 (0.04)	2	16.28 (0.02)	3
4C 21.35	1	14.99 (0.03)	3	14.19 (0.04)	3	13.84 (0.03)	3
	2	15.45 (0.04)	3	14.86 (0.03)	3	14.56 (0.03)	3
	3			15.66 (0.03)	3	15.26 (0.04)	3
	4	17.17 (0.05)	3	16.24 (0.03)	3	15.83 (0.03)	3
3C 279	1	13.02 (0.03)	5	12.42 (0.03)	5	12.05 (0.02)	6
	2	13.73 (0.04)	4	12.99 (0.04)	3	12.56 (0.03)	4
	3	15.49 (0.03)	4	14.87 (0.03)	4	14.53 (0.02)	5
	4	16.53 (0.05)	5	15.66 (0.03)	5	15.13 (0.02)	6
	5	16.79 (0.04)	4	15.98 (0.04)	5	15.47 (0.02)	6
PKS 1510−08	1	12.13 (0.03)	4	11.54 (0.02)	3	11.14 (0.02)	4
	2	13.65 (0.03)	4	13.17 (0.02)	3	12.88 (0.03)	4
	3	15.06 (0.04)	4	14.35 (0.02)	3	13.95 (0.03)	4
	4	15.27 (0.02)	4	14.59 (0.02)	3	14.22 (0.03)	4
	5	15.43 (0.05)	4	14.70 (0.05)	3	14.35 (0.05)	4
	6	16.09 (0.04)	3	15.16 (0.02)	3	14.61 (0.02)	4
CTA 102	1	14.77 (0.04)	2	13.98 (0.03)	2	13.56 (0.04)	2
	2	16.17 (0.04)	2	14.88 (0.03)	2	14.07 (0.07)	2
3C 454.3	1	14.70 (0.02)	3	13.71 (0.02)	3	13.15 (0.02)	3
	2	14.93 (0.02)	3	13.80 (0.02)	3	13.19 (0.02)	3
	3	15.19 (0.02)	3	14.44 (0.02)	3	14.00 (0.02)	3
	4	15.91 (0.05)	3	15.21 (0.02)	3	14.79 (0.02)	3
	5	16.28 (0.05)	3	15.30 (0.02)	3	14.83 (0.02)	3
	6	16.06 (0.05)	3	15.34 (0.02)	3	14.83 (0.03)	3
	7	17.00 (0.03)	3	15.74 (0.02)	3	14.94 (0.02)	3
	8	16.85 (0.06)	3	15.94 (0.02)	3	15.34 (0.02)	3

Table 3. Comparison among different calibrations in the field of 4C 29.45

This work				Villata et al. 1997				Smith et al. 1985			
Star	B (σ)	V (σ)	R (σ)	Star	B (σ)	V (σ)	R (σ)	Star	B (σ)	V (σ)	R (σ)
2	16.01 (0.06)	15.38 (0.05)	15.00 (0.02)	13	16.09 (0.05)	15.40 (0.05)	15.03 (0.05)	13	16.02 (0.04)	15.36 (0.04)	14.97 (0.04)
3	16.44 (0.04)	15.91 (0.04)	15.54 (0.02)	14	16.47 (0.05)	15.92 (0.05)	15.57 (0.05)	14	16.41 (0.05)	15.89 (0.09)	15.53 (0.08)
4	17.15 (0.05)	16.60 (0.04)	16.28 (0.02)	15	17.19 (0.05)	16.62 (0.05)	16.30 (0.05)	15	17.14 (0.05)	16.60 (0.05)	16.30 (0.04)

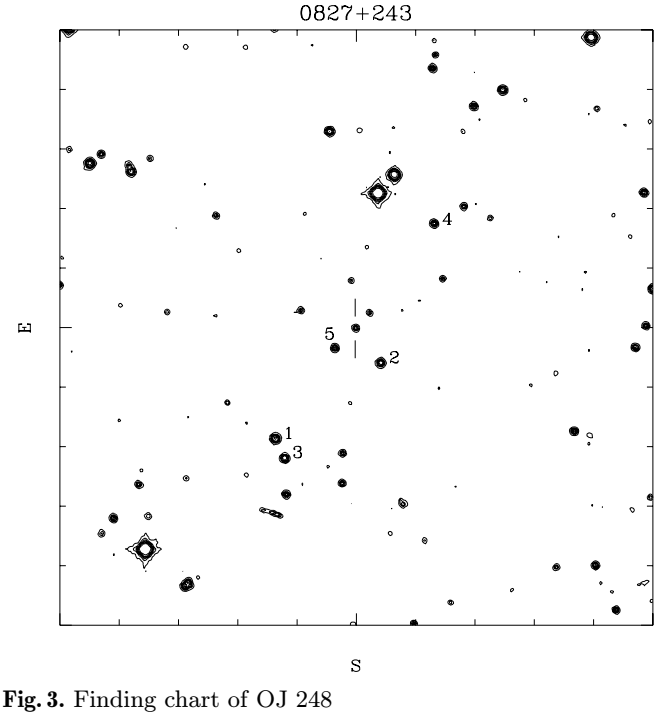

Fig. 3. Finding chart of OJ 248

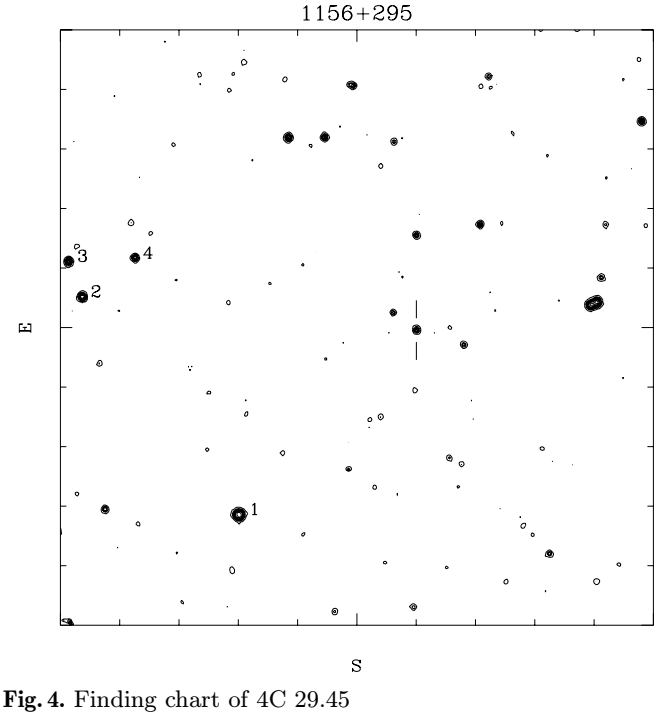

Fig. 4. Finding chart of 4C 29.45

3.5. PKS 1510−08

BVR magnitudes of two among the six comparison stars calibrated in the present work are reported in Villata et al. (1997): Stars A and B in that paper are our Stars 4 and 6. The respective magnitudes are in accordance within the errors, apart from the B magnitude of Star 6.

3.6. 3C 454.3

A UBV photometric sequence for 3C 454.3 was determined by Angione (1971); four stars of that sequence (plus another star) were recently calibrated in VRI by Fiorucci et al. (1998). A comparison among calibrations is performed in Table 4: a general agreement is found, when considering the large estimated uncertainties affecting some data. We notice that the magnitudes of Star 1 published by the quoted authors are lower than ours; we suspect that this could be due to a contribution to its flux by the fainter star close to it (see Fig. 9), when the photometry is performed with large aperture.

4. Conclusions

We have determined photometric sequences in the fields of 9 quasars that are monitored at the Torino Astronomical

Table 4. Comparison among different calibrations in the field of 3C 454.3

This work				Fiorucci et al. 1998			Angione 1971		
Star	B (σ)	V (σ)	R (σ)	Star	V (σ)	R (σ)	Star	B (σ)	V (σ)
1	14.70 (0.02)	13.71 (0.02)	13.15 (0.02)	H	13.65 (0.04)	13.10 (0.04)	8	14.62 ($\sim$ 0.02)	13.65 ($\sim$ 0.02)
2	14.93 (0.02)	13.80 (0.02)	13.19 (0.02)				4	14.94 ($\sim$ 0.02)	13.85 ($\sim$ 0.02)
3	15.19 (0.02)	14.44 (0.02)	14.00 (0.02)				3	15.18 ($\sim$ 0.02)	14.43 ($\sim$ 0.02)
4	15.91 (0.05)	15.21 (0.02)	14.79 (0.02)	B	15.21 (0.06)	14.73 (0.05)	2	15.87 ($\sim$ 0.02)	15.16 ($\sim$ 0.02)
5	16.28 (0.05)	15.30 (0.02)	14.83 (0.02)				7	16.28 ($\sim$ 0.08)	15.42 ($\sim$ 0.08)
6	16.06 (0.05)	15.34 (0.02)	14.83 (0.03)				6	16.06 ($\sim$ 0.11)	15.21 ($\sim$ 0.11)
7	17.00 (0.03)	15.74 (0.02)	14.94 (0.02)	E	15.76 (0.09)	14.92 (0.08)	5	17.10 ($\sim$ 0.14)	15.88 ($\sim$ 0.14)
8	16.85 (0.06)	15.94 (0.02)	15.34 (0.02)	A	15.86 (0.09)	15.32 (0.09)	1	16.85 ($\sim$ 0.05)	15.85 ($\sim$ 0.05)

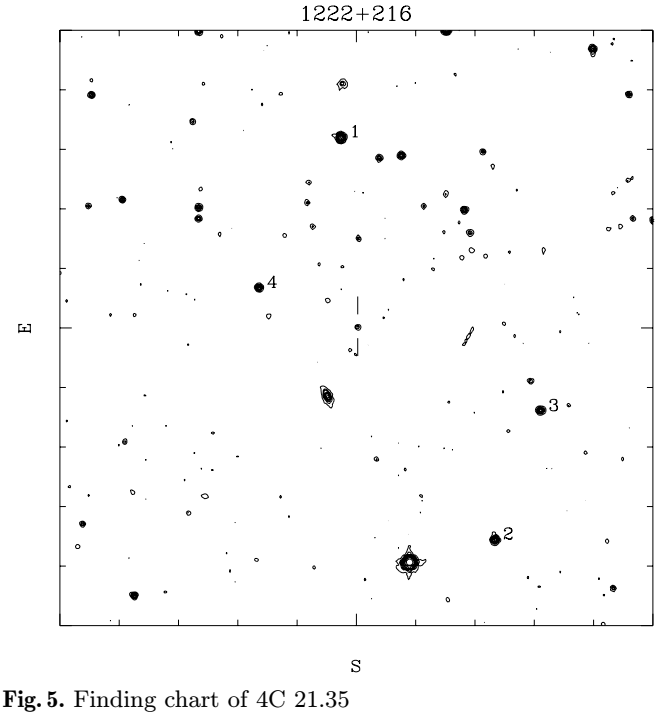

Fig. 5. Finding chart of 4C 21.35

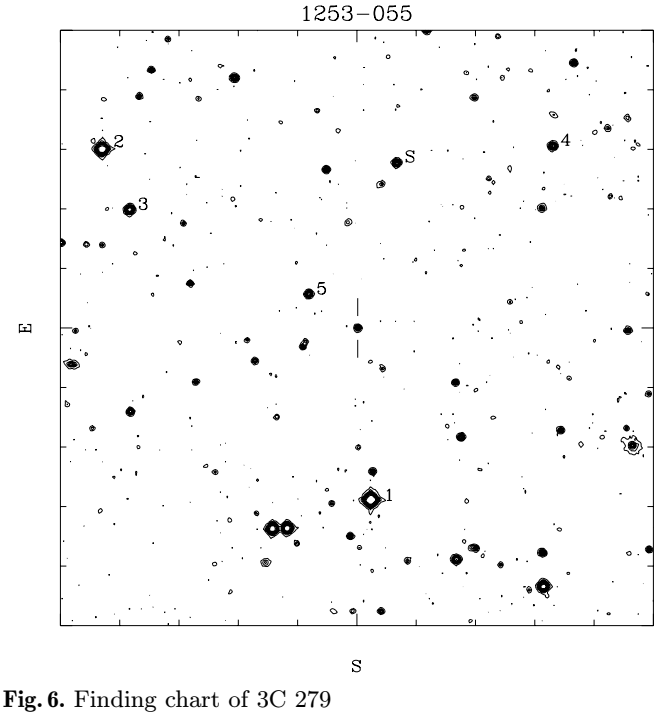

Fig. 6. Finding chart of 3C 279

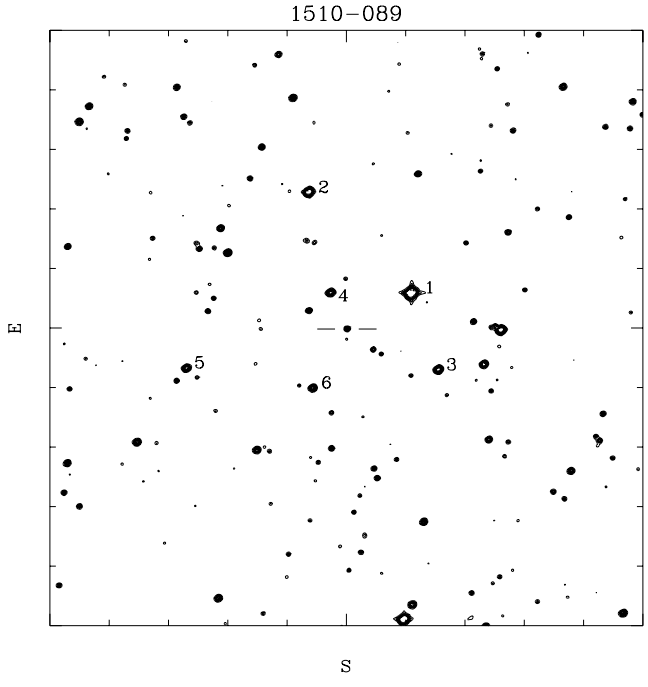

Fig. 7. Finding chart of PKS 1510−08

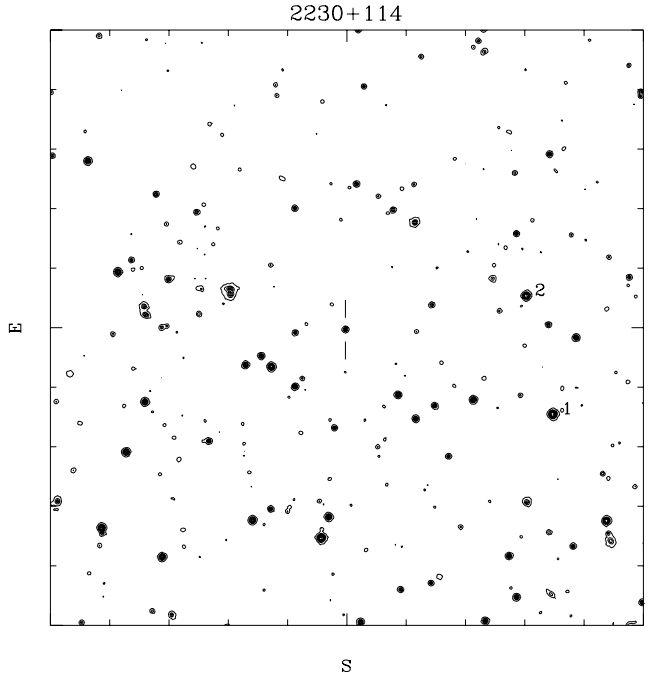

Fig. 8. Finding chart of CTA 102

Observatory. Standard magnitudes have been given for 36 stars in the BVR bands and for 10 stars in the VR ones. A comparison with other available calibrations has been performed, revealing a general agreement among data.

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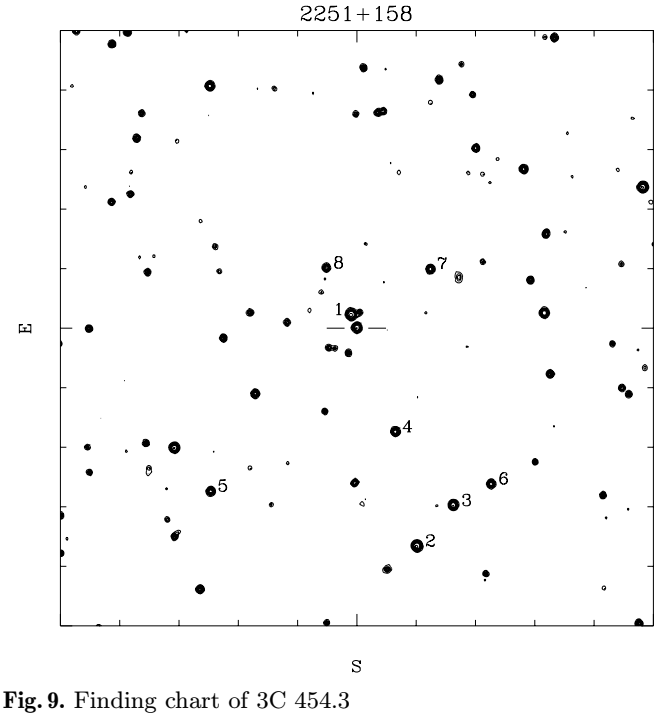

Fig. 9. Finding chart of 3C 454.3