CCD MEASUREMENTS IN OPTICAL DOMAIN AND ASTROMETRIC POSITIONS OF ICRF2 RADIO SOURCES

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ABSTRACT. At the IAU XXIIIth GA in 1997, the International Celestial Reference Frame (ICRF) was adopted; hereafter referred to as ICRF1. After the original list of radio objects there were two extensions, ICRF-ext1 and ICRF-ext2. All together, there were 717 sources: 212 defining ones, 109 new ones, 294 candidate ones, and 102 additional ones. At the IAU XXVIIth GA in 2009, the second realization of the ICRF (the ICRF2) was adopted with the list of precise positions for 3414 compact radio astronomical sources. At that moment there were nearly 30 years of VLBI observations. The ICRF2 has a noise floor of about 0.04 mas (near six times better than ICRF1) and an axis stability of about 0.01 mas (nearly twice as stable as ICRF1). Also, it is of importance to make the observations of some ICRF2 extragalactic radio sources (ERS) which are visible in the optical domain, and to compare their optical (calculated via the reference stars) and radio positions (VLBI ones). We started to do it by using the CCD camera VersArray 1300B and the RCC telescope[1] ($D/F = 2$m/16m) of Rozhen National Astronomical Observatory (Bulgarian Academy of Sciences). About 30 frames were observed at the end of March 2011. The main steps of our calculations and some preliminary results (comparison between the measured optical positions and the radio ones) for a few ERS from ICRF2 list were presented here.

1. CALCULATION AND RESULTS

Regular maintenance of the system and improvement of the frame is necessary. The ERS coordinates are continuously improving via VLBI observations (a large number of observations of defining ERS over a long data span). The frame's stability is based upon the assumption that there is no global rotation of the universe. The compact ERS are mostly quasars (quasi stellar objects – QSO), BL Lacertae (BL Lac) sources and a few active galactic nuclei (AGNs); they are far away and with negligibly small proper motions. The ERS positions are known to better than 1 mas, and the ultimate accuracy is limited because of the structure instability of ERS in radio wavelengths. The alignment of ICRF2 with the ICRS was made using 138 common ICRF2/ICRF-Ext.2 stable ERS. The two largest weaknesses of ICRF1 were eliminated (more uniform sky distribution of ERS and the position stability of the 295 ICRF2 defining sources). From 1 January 2010, the realization of the ICRS is the ICRF2.

The Hipparcos Celestial Reference Frame – HCRF (ESA, 1997) is the optical realization of the ICRS, and it was linked to the radio ICRF1 with an accuracy of ± 0.6 mas in position for the epoch 1991.25 and ± 0.25 mas/yr in rotation. That accuracy degrades over time because of the error in proper motions of stars, and it is necessary to verify and refine the relation between the HCRF and the ICRF2. It can be done via different telescopes and methods. Also, the proper motions of many double or multiple stars are unreliable due to the short epoch span of Hipparcos observations, and van Leeuwen (2007) did a new reduction (with some significant improvements, mainly for the parallaxes) of the Hipparcos data. Some of densification catalogues are: Tycho-2, UCAC3, 2MASS (near-IR), PPMXL, XPM, etc. The Tycho-2 was the first step of densification. Here, we used the XPM (Fedorov et al., 2010) one. It contains the positions and proper motions for 314 million stars for the epoch 2000.0.

The main characteristics of CCD camera are: 1340x1300 pixels, the pixel size is 20x20 mkm, one pixel is $0''.258$. The AIP4WIN image processing package (Berry and Burnell, 2002) was used. All frames were reduced individually. A total of five optical counterparts of ERS from the ICRF2 list were observed: Q 1252+119 (ICRF J125438.2+114105), L 1215+303 (ICRF J121752.0+300700), Q 1240+381 (ICRF

[1] Based on observations with the 2 m RCC telescope of the Rozhen National Astronomical Observatory operated by the Institute of Astronomy, Bulgarian Academy of Sciences.

J124251.3+375100), Q 1219+044 (ICRF J122222.5+041315) and L 1221+809 (ICRF J122340.4+804004).

We made six frames per source (three at R filter and three at V one). Figure 1 shows an example. To transform the measured CCD coordinates (x, y) to tangential ones (ξ, η) the standard astrometric "plate" reduction ($\xi = ax + by + c$, $\eta = dx + ey + f$) with the available reference stars was used. Also, the unweighted Least-Squares Method was applied. The corrections for apparent displacements (as differential refraction one) were not applied (Aslan et al., 2010; Kiselev, 1989) because of the small field of view (FOV is $5'.5$x$5'.5$).

We compared the ERS optical positions and the radio ones to determine $(O-R)_\alpha$ and $(O-R)_\delta$, and the unweighted mean offsets relative to the XPM catalogue are: $-0''.06$ in α and $-0''.05$ in δ.

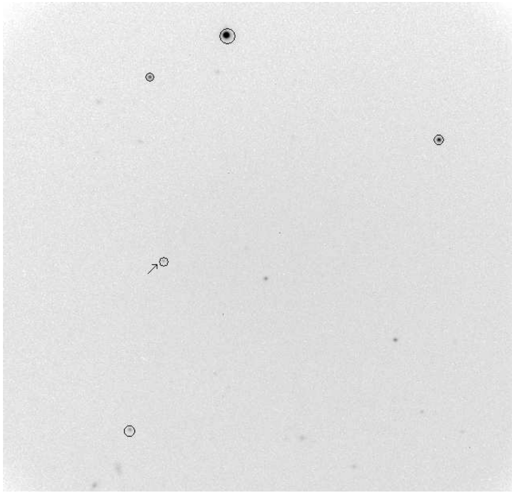

Figure 1: The observation of ERS Q 1219+044 at R filter (the ERS is marked with direction arrow and circle) and reference stars (circles); $exp = 20^s$, $mag_V = 18.0$, $mag_R = 16.8$

2. CONCLUSIONS

The optical observations of ERS are possible by using a 2-meter Rozhen telescope and a good CCD camera. The positions of ERS were calibrated with respect to the XPM catalogue, and it is possible to use XPM as the reference catalogue for astrometric reduction in small FOV of CCD observations. The XPM is with high star density and a good densification of HCRF, but a higher accuracy catalogue of higher star density is required. Even a few ERS, our calculated offsets (in α and in δ) are small. So, the link between HCRF and ICRF2 is good enough at the mean epoch of our observations; the XPM is a similar frame. Also, some problems during the calculation of ERS optical positions can be caused by: faintness of the optical counterparts to ERS, atmospheric influences and technical problems.

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