ON THE SELECTION OF RADIOSOURCES FOR THE NEXT ICRF REALIZATION

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ABSTRACT. The International Celestial Reference Frame (ICRF) is realised by high precision coordinates of a catalogue of the extragalactic radiosources observed with Very Long Baseline Interferometry (VLBI). Only radiosources with stable positions should be used in the ICRF catalogue to maintain long-term stability of the reference system. Several selection schemes have been proposed using different stability criteria. However, the problem is still open. Current daily position time series of frequently observed quasars were analysed to check the existing stability criteria. It appears that in some cases the radiosources, previously treated as 'stable', show significant variations in position on different time scales. The motions are confirmed by independent astrophysical observations. A more advanced scheme is needed for better selection of stable radiosources.

1. INTRODUCTION

Distant radiosources, quasars, are used as reference points. The radiosource positions are supposed to be stable over the long period (at least, 25 years of VLBI observations). Due to their large distance from the Earth, the quasar proper motions are negligible. However, many of the quasars demonstrate apparent positional instability. On milliarcsec level the quasars are seen as extended objects with a central core and, sometimes, several radiojets. The astrometric coordinates of an extended radiosource are treated as the centroid of its radiobrightness. Usually the radiojets move from the quasar core with superluminal velocity and rapid changes in flux density. As a result, the quasar radiobrightness centroid also varies its position. It causes apparent proper motions of the quasar on the sky plane. In this paper we show that, in opposition to the star proper motions modeled by linear function the quasar has complex apparent proper motion. Therefore, the linear approximation does not fit to the observed changes of the radiosource positions.

The apparent proper motions of radiosources, if they are not treated properly, will reduce the accuracy of the celestial reference frame. Therefore radiosources can be divided into two groups: stable and unstable objects. Positions of the 'stable' radiosources are considered as constant (global parameters) through the period covered by VLBI data. Positions of the 'unstable' radiosources are fitted independently as daily parameters. Several schemes have been developed to select stable radiosources (Ma et al., 1998; Feissel-Vernier, 2003; Fey and Charlot, 1997; Fey and Charlot, 2000). Unfortunately, many quasars are referred as 'stable' radiosources by one

criteria and 'unstable' by another one. Therefore, the determination of 'stable' radiosource is ambiguous up to now.

For operational Earth Orientation Parameter (EOP) services all radiosources imposed by their ICRF coordinates or treated as global parameters. It means that positional changes in the radiosources are not taken into account. As a result, the instability corrupts other estimated parameters due to the insufficient matrix of partials. The bias is proportional to the range of instability and the number of each radiosource scans throughout 24 hour VLBI session.

The radiosources time series of daily positions, discussed below, were estimated with OCCAM 6.1 software (Titov et al., 2001) by least squares collocation technique.

2. 2201+315

The quasar 2201+315 was classified as 'other' radiosource in the official ICRF catalogue (Ma et al., 1998) and 'stable' by Feissel-Vernier (2003). Fey and Charlot (2000) evaluated the quasar as unstable (structure index 3). The historical records used by Feissel-Vernier did not show any evidence of the 2201+315 positional instabilites. However, more recent results demonstrate the synchronous change in both coordinates after 2001.0 (Fig 1). Fig 2 shows the evolution of the 2201+315 coordinates in 2001-2004 on the sky plane as well as its approximation by 3d order polynom. The centroid of radiobrightness had moved on 500 microarcsed from its original position by the end of 2003 and returned back by the end of 2004. The positional evolution is explained by jet motion in the south-west direction over 2001-2004. The direction is confirmed by the 2201+315 radiomages in the USNO Radio Reference Frame Image Database (RRFID) (Fey and Charlot, 1997; Fey and Charlot, 2000)

3. 2145+067

The quasar 2145+067 was classified as 'defining' radiosource in the official ICRF catalogue (Ma et al., 1998) and 'unstable' by Feissel-Vernier (2003). Fey and Charlot (2000) evaluated the quasar as stable (structure index 1 or 2 for different scans). However, in the ICRF-Ext.2 it was counted as one of five unstable ICRF radiosources (Fey et al. 2004). The set of radioimages is available in the RRFID after 1994. They show a long jet in the south-east direction, moreover, structure of the jet is variable. The time series of the 2145+067 right ascension component show linear trend and quasiperiodical variations of 1.5 mas range (Fig 3), whereas its declination shows clear proper motion.

4. IMPACT ON THE NUTATION TIME SERIES

In spite of its reported positional instability the quasar 2145+067 is commonly used as geodetic radiosource for operational VLBI sessions (IRIS-A, NEOS-A, IVS-R1, IVS-R4) started in 1983. For the operational EOP analysis this radiosource is fixed or treated as 'stable', so that its coordinates are believed to be constant through the whole observational period. This approach could lead to appearance of false effects in the nutation time series with period of several years. Two different solutions have been calculated to estimate an effect of the 2145+067 instability on the nutation time series. In the first solution treated the 2145+067 positions were fixed by its ICRF2000 coordinates, in the second solution - were approximated by linear trend and harmonic variations, as shown on Fig 3. Positions of all other radiosources were fixed in both solutions. Fig 4 shows differences between the nutation time series due to the 2145+067 instability.

5. CONCLUSION

In contrast to stellar proper motions, the quasar apparent proper motions have a more complex character. The linear approximation, commonly used to model the stellar proper motions, is not suitable for modeling of the radiosource position variations.

Compactness of radiosource is usually considered as a stability criterion. However, in some cases even compact radiosources can be unstable. It is necessary to develop a combination of the statistical and astrophysical criteria for the procedure of stable radiosource selection. Unstable radiosource, being treated as stable, could bias other estimated parameters, primarily, the daily nutation offsets.

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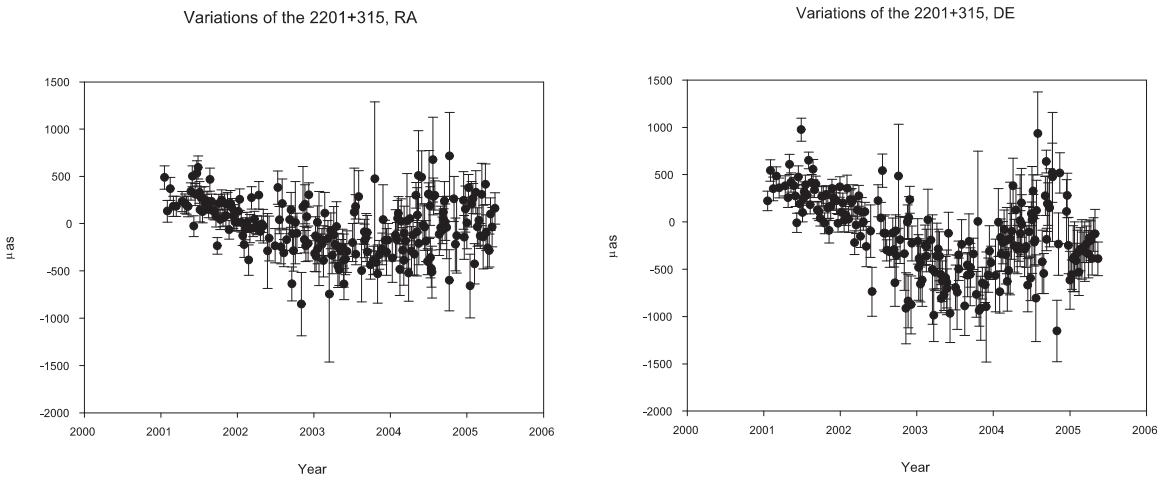


Figure 1: Time series of the quasar 2201+315 coordinates

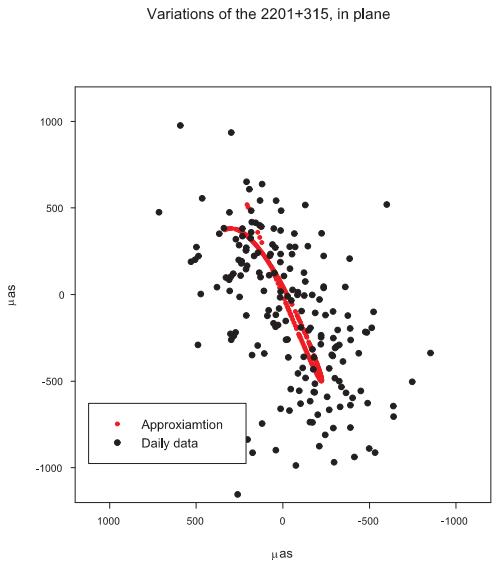


Figure 2: Evolution of the quasar 2201+315 positions on the sky plane

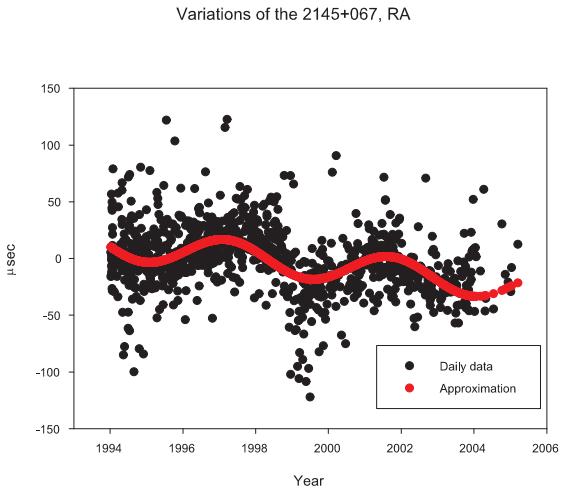
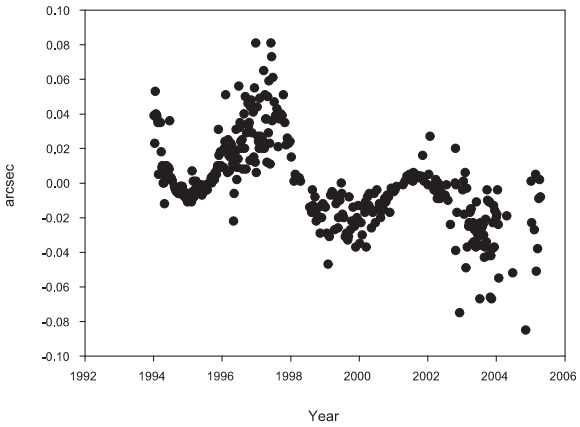


Figure 3: Time series of the quasar 2145+067 coordinates



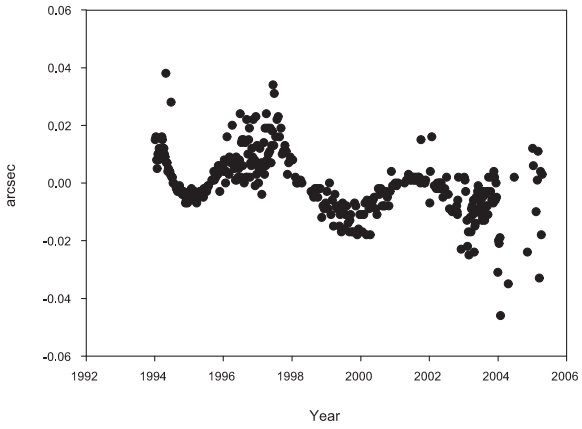


Figure 4: Effect of the quasar 2145+067 instabilities in the nutation offset time series (details in text)