V.E. Zharov, M.V. Sazhin, V.N. Sementsov,
K.V. Kuimov, O.S. Sazhina, N.T. Ashimbaeva
Sternberg Astronomical Institute

Apparent motion of quasars and its physical mechanisms.

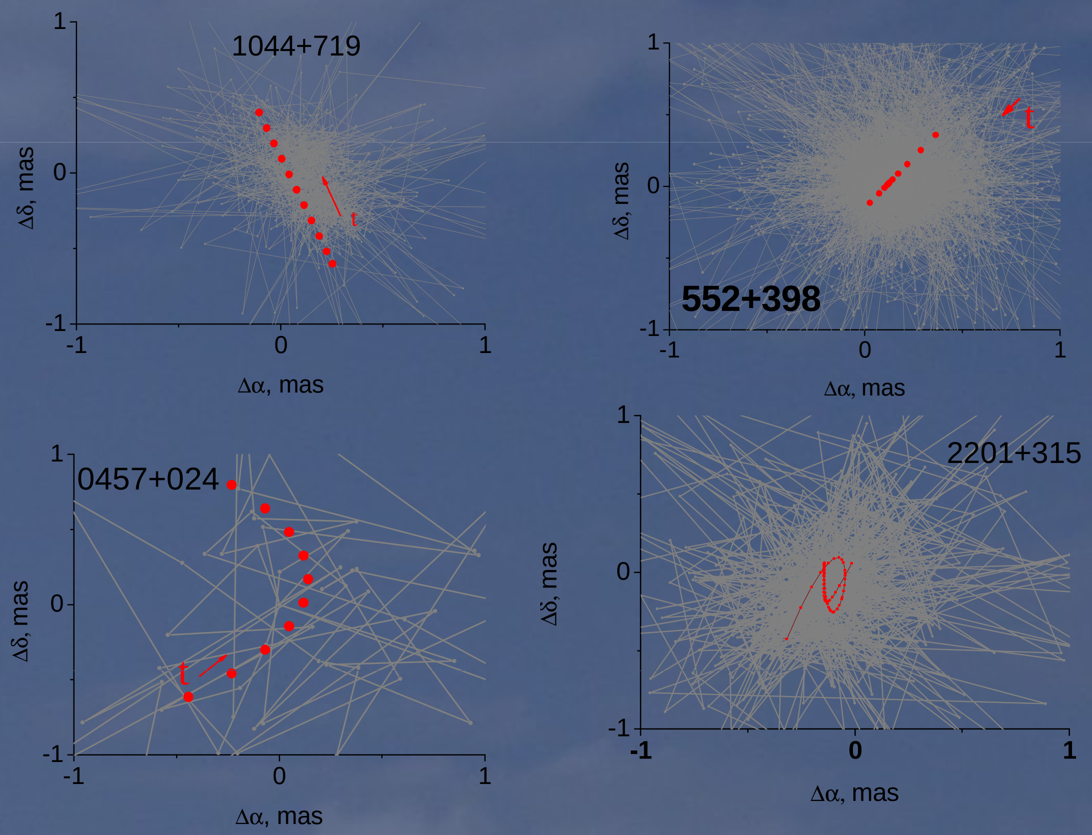
The ICRF was chosen to realize the most stable coordinate system in astronomy: its accuracy is 0.25 mas for the most frequently observed and astrometrically stable sources (Ma et al., 1998, Ma, 1999).

XXVI GA of IAU decided to create working group for compilation of new source list to create ICRF-2.

Here we discuss the physical basis on which we select these sources and present our list of ICRF-2 sources.

Modern observations reveal that some of ICRF sources move (MacMillan, 2003). In several cases their apparent velocities are larger than the speed of light. Some intrinsic processes have act to shift radio brightness center. We discuss these physical processes and select sources according to physical criteria.

Few examples of apparent motion of ICRF sources…



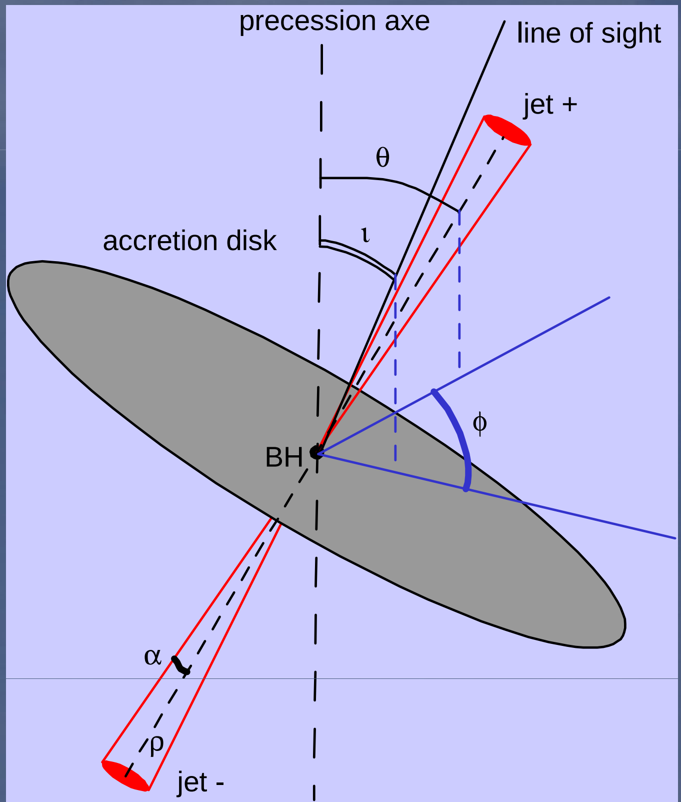
- 1044+719 — uniform motion
- 0552+398 — rectilinear non-uniform motion
- 0457+024 — motion along conic section
- 2201+315 — irregular motion

- Systematic shift can reach a few **tenths of mas** (!)

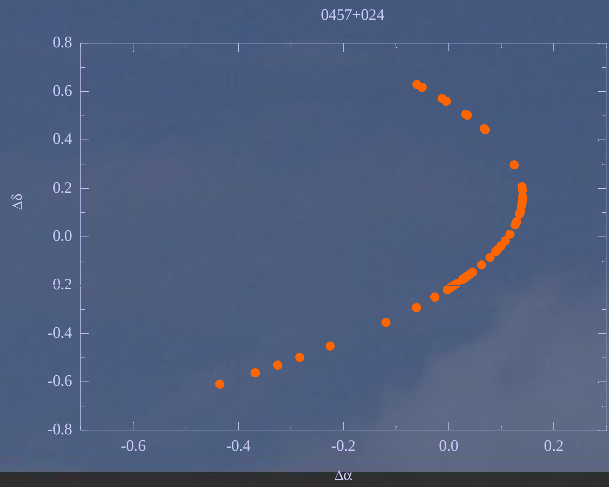
…and their numerical characteristics

Type	QSO	z	Scale, kpc/ "	|μ|, mas/yr	V_T	$\Delta_{radio-optic}$, mas	P_{PREC}, yr
uniform motion	1044+719	1.15	8.29	0.043±0.002	1.2c	165±74	730
rectilinear accelerated	0552+398	2.36	8.32	0.015±0.002	0.4c		
motion by conic section	0457+024	2.38	8.27	0.077±0.002	2.1c	15±56	
irregular	2201+315	1.21	8.41	0.05±0.03	≈1c		

Model of ICRF source: Blandford – Rees model.



- Period of precession is inside 10^3 - 10^6 yr interval, total shift is inside 100 - 1 mas



A black hole surrounded by an accretion disk is an optical source. Two jets at opposite directions form radio source. A jet directed to an observer has some distribution of radio brightness along. The maximum brightness can be considered as a hot spot and can be identified with position of ICRF radio source. As a result coordinate positions of optical and radio components of ICRF source are different.

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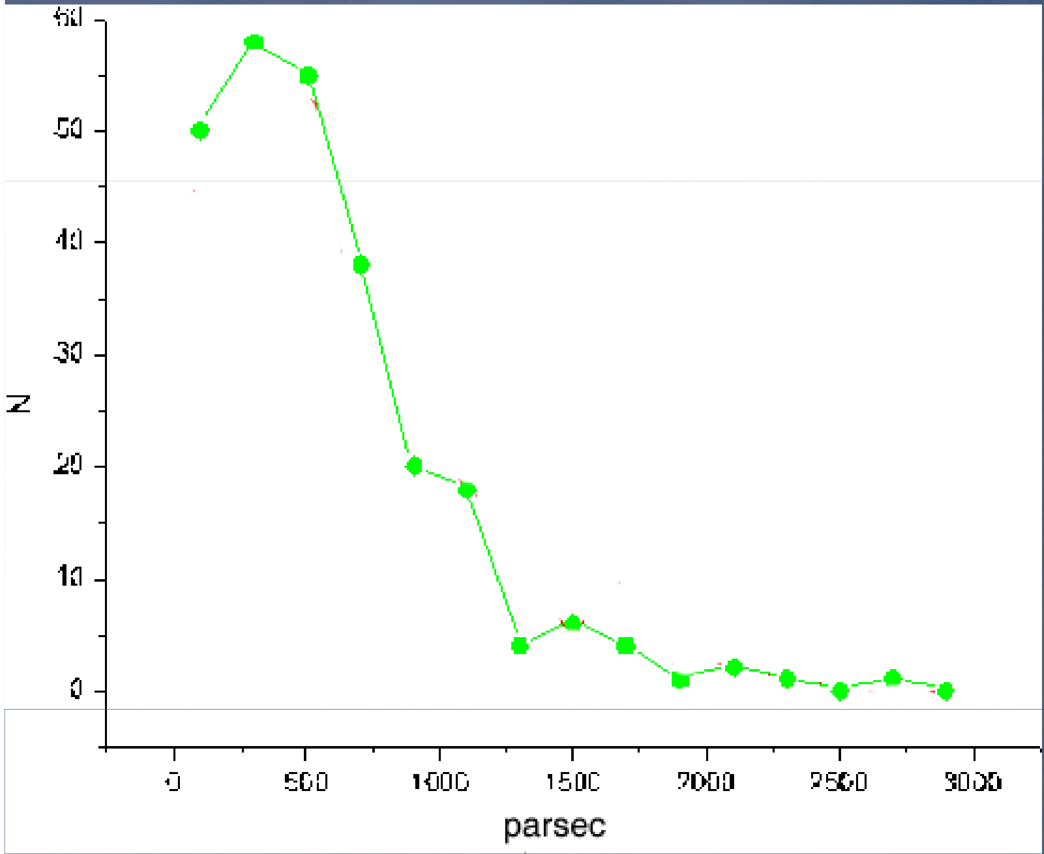
Difference in radio and optics positions



- 261 QSO (Assafin et al. 2003+Veron&Veron) were used for calculation of histogram
- Standard cosmological model was used
- Maximum of distribution corresponds linear distance of **300-500 pc** between radio and and optical sources in QSOs

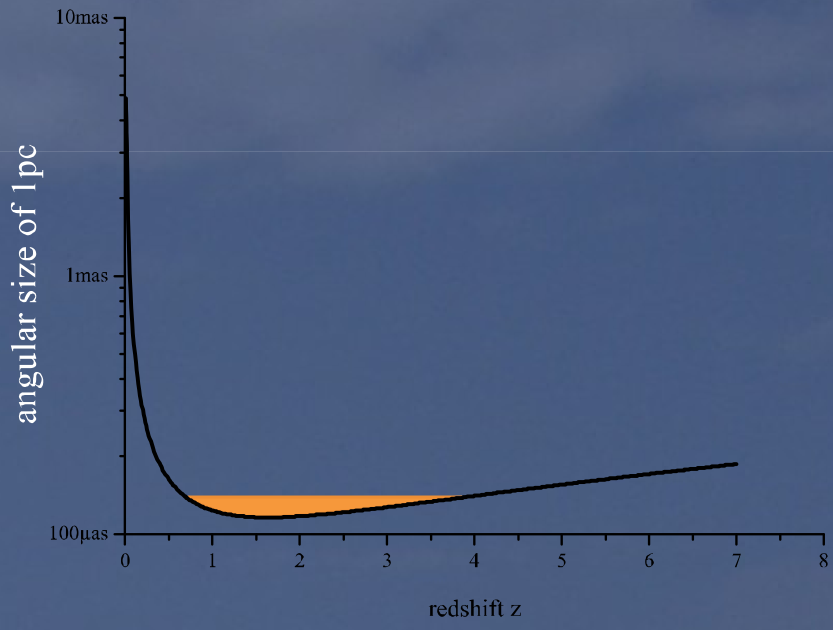
Jet precession mechanism provides almost linear motion with zero acceleration. That corresponds to "good" and predictable sources.

Sometimes clouds of interstellar media penetrate into jet and start to accelerated by jet matter. That corresponds to accelerated motion of brightness center. As far as clouds penetration is a stochastic process these sources corresponds to "bad" sources with unpredictable behavior.

As first selection criterion
we propose to select motionless sources
or sources with linear motion only.

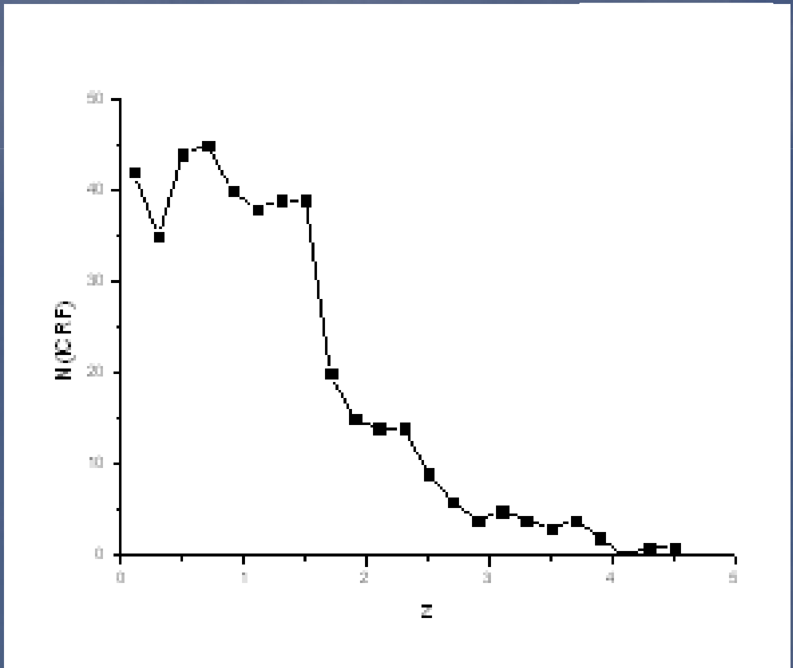
The second criterion is cosmological one. Apparent motion on some physical scale corresponds to some angular displacement. The further is source the smaller is angular displacement. That claim is true in Euclidean space and is not true in the expanding Universe. The angular size of an “standard meter” of 1 pc size is shown on the next slide as a function of its red shift.

Optimal z for observations



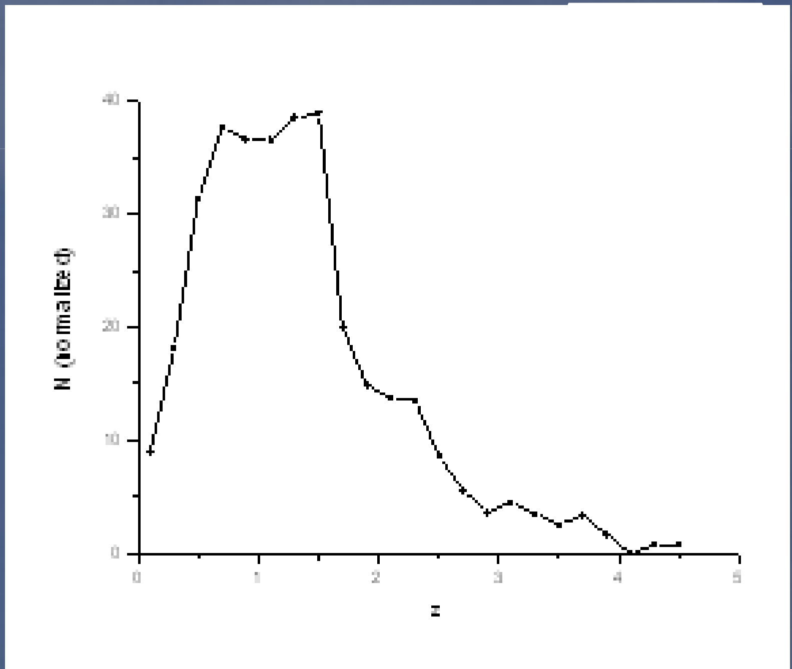
- Angular scale is equal to 116 µas of 1 pc and is optimal at z=1.63
- Inside interval z=0.8-3.0 angular size increased at 30% large than this optimum

Histogram of ICRF sources with known redshift



- 261 ICRF sources with known z «as is»

Multiplication of the histogram with weight inversely proportional to angular scale produces the cosmological criterion for source selection



- The 170 sources were chosen according to cosmological criterion (in red shift interval 0.8 – 3.0)

Second criterion: kinematical

131 sources of 170 were selected according to kinematical criterion: we select the sources with linear motion and motionless sources

Most of them (122) are QSO's, 2 are compact AGN, and 7 are BLL.

Stable subset of ICRF: SAI version

131 ICRF sources remain after kinematical criterion. All sources obey the following:

- >9 observations of each source
- Inside «good» z range
- linear motion or motionless
- They are 122 QSO’s ,2 compact AGN, and 7 BLL

Stable subset of ICRF, SAI version: we present here 11 sources as example

ICRF	src		Δα		Δδ		μα		μδ	
0013-005	*QSO*	*C*	*0.06*	*0.22*	*-0.20*	*0.32*	*0.0024*	*0.0964*	*0.0412*	*0.1328*
0016+731	QSO	O	-0.07	0.07	-0.04	0.06	-0.0088	0.0096	-0.0124	0.0088
0035+413	*QSO*	*C*	*0.09*	*0.16*	*-0.13*	*0.24*	*-0.0488*	*0.0276*	*-0.0448*	*0.0436*
0106+013	*QSO*	*O*	*0.51*	*0.02*	*-0.05*	*0.03*	*0.0424*	*0.0040*	*0.0088*	*0.0064*
0119+041	QSO	C	0.01	0.03	-0.21	0.04	0.0000	0.0048	0.0032	0.0064
0133+476	*QSO*	*D*	*-0.02*	*0.01*	*-0.09*	*0.02*	*-0.0040*	*0.0028*	*-0.0088*	*0.0036*
0146+056	*QSO*	*C*	*-0.35*	*0.15*	*0.19*	*0.21*	*0.0612*	*0.0572*	*0.1296*	*0.0808*
0149+218	*QSO*	*D*	*0.02*	*0.10*	*-0.14*	*0.17*	*-0.0236*	*0.0208*	*-0.0404*	*0.0320*
0151+474	*QSO*	*C*	*-0.35*	*0.12*	*0.20*	*0.19*	*0.0240*	*0.0212*	*0.0432*	*0.0328*
0208-512	BLL	O	0.16	0.08	-0.18	0.10	-0.0120	0.0128	-0.0124	0.0160
0212+735	*QSO*	*O*	*0.37*	*0.06*	*-0.15*	*0.05*	*0.0508*	*0.0056*	*-0.0136*	*0.0052*

- Motion:
- linear motion

(47 at 2σ,
27 at 3σ)

motionless

(84 at 2σ,
104 at 3σ)

Comparison with others lists

We cross the list of our “good’ source candidates with “bad” source candidates of other authors.

33 “bad” sources of C.Ma list are in our list of “good” sources

7 “bad” sources of M.Vernier-Feisel list are in our list of “good” sources

25 “bad” sources of Z.Malkin list are in our list of “good” sources

Our physical criterion of selection is correct and
is confirmed by the statistical criteria of other authors

We propose to include into catalogs both coordinates (α, δ) and linear velocities $(d\alpha/dt, d\delta/dt)$ of the ICRF radio sources.

thank you for your attention