IR/RADIO QUASARS FOR VLBI AND INFRARED POSITIONAL OBSERVATIONS

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A search for the ICRF radio sources that have been also observed in infrared frequency region have been undertaken. The comparison of the list of 179 quasars observed by IRAS satellite in 1983 [8] with the ICRF list of 608 radio sources [7] has been carried out and 55 common extragalactic sources were found.

INTRODUCTION

Precise enough positional observations in infrared (IR) are absent. CPIRSS, the Catalog Point Infrared Stellar Sources, is not proper usual observational catalogue. It was compiled by the way of IR/Optics counterparts identifications. The 37700 IR/Optics objects of this catalogue, which have been identified with their optical counterparts from five precise astrometric catalogues [3] are IR sources from the IRAS Point Source Catalog (PSC) [1].

In accordance with our conception [5], the CPIRSS was transformed and two level hierarchic IR reference coordinate system was created [6]. The first level IR reference catalogue includes only IR stars, which have their optical counterparts from HIPPARCOS and, therefore, it represents the ICRS coordinate system. However, the best representation of this system can be obtained if this first level IR reference catalogue will include additionally the ICRF sources that could be observed in infrared as well.

Because of this point of view an research has been undertaken to find the ICRF radio sources that were observed in infrared too. The list of 179 quasars observed by IRAS satellite in 1983 [8] and two published versions of the ICRF were used for this purpose.

Finally the comparison of the above list of 179 quasars with the ICRF list of 608 candidate sources [7] has been carried out and 55 common IR/Radio extragalactic sources were found.

CHARACTERIZATION AND COMPARISON OF TWO ICRF LISTS

International Celestial Reference Frame (ICRF) is a realization of the new International Celestial Reference System (ICRS) that has replaced from January 1, 1998 the previous coordinate system based on the FK5 Fundamental Catalogue. The list of candidate sources that has to define ICRF has two versions. The first preliminary one was prepared by IAU/WG IERS and presented to XXII IAU GA in Hague in September 1994. It was published in [9].

This list includes 606 objects which are divided into three different sorts of sources, namely d – defining sources, c – additional sources and o – optical sources. The quantitative distribution between these three categories is presented in Table 1.

Table 1: The ICRF list of 606 sources and its identification

Objects	ICRF606	IRAS179/ICRF606
d – defining sources	441	46
c – additional sources	92	4
o – optical objects	73	4
All	606	54

Besides of d, c, o classification the above mentioned list contains: IERS designation constructed from B1950 coordinates; R.A. and Dec. with $0\overset{s}{.}01$ and $0\overset{''}{.}1$ accuracy accordingly; alias names for all sources which have such ones.

A final version of the ICRF list was prepared also by the IAU/WG IERS. It has been presented to XXIII IAU GA in Tokyo in September 1997 and adopted as new conventional celestial reference frame.

This list also consists of three files. The first one has the same name "defining sources" but the second and third files have some other names: "candidate" and "other" accordingly. Besides, they have some other interpretation and an other quantitative distribution presented in Table 2.

Table 2: The ICRF list of 608 sources and its identification

Objects	**ICRF608**	**IRAS179/ICRF608**
d – defining sources	212	17
c – candidate sources	294	23
o – "other" sources	102	15
All	608	55

There are only 212 "defining sources", 294 – "candidates" and 102 – "others". But in this case there is more strong file classification in comparison with the first list version. It is result of strong solving equations of condition formed here on the base of the VLBI and precise optical observations [7].

The final list contains 608 objects and first one – 606, but there is more big difference between them. To transit from the first list to the final one 56 objects had to be excluded and 58 new ones be included. The IAU/WG IERS carried out a very vast work to create final ICRF list version.

BRIEF DESCRIPTION OF THE IRAS 179 QUASAR LIST

The list of 179 more bright quasars [8] was compiled on the base of the second IRAS programme that was named "Point observations". It was carried out apart from the main "All sky survey" IRAS programme which has been used to create PSC. Quantitative spectral distribution of 179 bright quasar catalogue is presented in Table 3.

Table 3: Astrophysical characteristics of the IRAS 179 quasars

Quasartypes	**IRAS179**	**IRAS179/ICRF608**
F – flat radio spectrum	56	42
S – steep radio spectrum	34	4
I – intermediate radio sp.	22	8
Q – radio quiet	67	1
All	179	55

As one can see, a catalogue of 179 bright quasars contains 56 sources with flat radio spectrum, 34 – with steep, 22 – with intermediate radio spectrum, and 67 sources are the radio quiet quasars[1].

IRAS(179)/ICRF(606) AND IRAS(179)/ICRF(608) CROSS-IDENTIFICATIONS

The IRAS 179 quasars catalog does not contain equatorial coordinates and has only B1950 identificator. Therefore, its cross-identifications with first and final versions of ICRF list were carried out by using only these identificator. The accuracy of such identification is not high but the errors may not exceed $7\overset{'}{.}5$ in R.A. and $3'$ in Declination. Such identification has to be qualified as preliminary one and its verification is still necessary.

As results of the first IRAS(179)/ICRF(606) and the second IRAS(179)/ICRF(608) identifications, the lists of 54 and 55 quasars were obtained. 52 quasars are common of both the first and the second ones. The distributions in relation of files classification are presented in Tables 1 and 2, and one can see that first list has a much better relation (46:4:4) in comparison with the second one (17:23:15). But only the second list of 55 common IR/ICRF sources obtained as the result of IRAS 179 quasars and ICRF 608 radio sources identifications was used for further operation. It is presented in Table 4.

[1]The quasars are named "radio quiet" if their luminosity at 6 cm is less than $10^7 L_{\odot}$.

Table 4: Flux densities of 55 common IRAS 179/ICRF 608 quasar for 12, 25, 60, and 100 μm bands in μJa

N	$ICRF(J2000)$	$B1950$	[12]		[25]		[60]		[100]		$L_{60}/L_{\odot}$	REM
1d	1031.0+105829	0007+106	99	± 6	163	±12	213	± 8	845		10.64	F,2
2o	13741.2+330935	0134+329	56	± 6	160	± 8	770	± 9	1080	±27	12.52	S
3c	20457.6-170119	0202-172	41		61		82	±21	200		12.98	F,3
4d	20504.9+321230	0202+319	20		32		30		87		12.37	F
5c	23145.8+132254	0229+131	20		45		26		79		12.65	I
6c	23752.4+284808	0234+285	35		65		187	±18	178		12.98	F,2
7c	31155.2-765150	0312-770	37		38		62		194		10.92	F
8o	33630.1+321829	0333+321	36		64		97		874		12.74	F
9c	35721.9-481215	0355-483	41		44		78		273		12.44	I
10d	40305.5+260001	0400+258	40		79		57		277		13.01	F,5
11c	40748.4-121136	0405-123	87		116	±31	126		312		12.10	F,5
12o	42315.8-012033	0420-014	25	±10	92	±17	271	±16	565	±61	12.96	I
13d	42442.2-375620	0422-380	31		36		50		158		12.00	F
14c	44017.1-433308	0438-436	25	± 8	28		120	±14	279	±47	13.62	F
15d	50643.9-610940	0506-612	26		29		48		155	±52	12.29	F
16o	53850.3-440508	0537-441	149	±10	298	±11	631	±25	808	±91	13.14	F
17c	60940.9-154240	0607-157	25		34		54	±13	147		11.20	F,3
18d	64632.0+445116	0642+449	34		51		51		155		13.42	S,2
19o	71424.8+353439	0711+356	19		33	±11	28	±9	87		12.44	F
20c	73918.0+013704	0736+017	34	± 6	77	± 9	133	± 8	564		11.11	F,3
21d	74110.7+311200	0738+313	20		39		145	± 9	282		12.25	F,3
22c	74331.6-672625	0743-673	39		41		66		245		12.74	S
23c	75052.0+123104	0748+126	37		67		205	±17	365	±51	12.73	F
24o	92703.0+390220	0923+392	15		26		27		80		11.61	F
25c	110331.5-325116	1101-325	39		52		67		225		11.38	F
26c	111826.9-463415	1116-462	41		48		86		335		12.14	I
27d	114608.1-244732	1143-245	55		78		79		247		13.07	F
28c	115043.8-002354	1148-001	45		86		64		200		12.99	F
29d	115324.4+493108	1150+497	21	± 6	25	± 7	42	±11	108		11.12	I
30c	115931.8+291443	1156+295	20		33	±11	126		85		12.33	I,8
31c	120935.2-401613	1206-399	39		55		64		404	±68	12.30	F
32o	122906.6+020308	1226+023	417	±12	941	±27	1805	±14	3109	±45	12.07	F
33c	125614.2+565225	1254+571	1856	± 9	9184	±11	35257	±16	34229	±47	12.17	Q
34o	140700.3+282714	1404+286	872		423	±11	762	±13	1052	±39	11.05	F,4
35d	143645.8+633637	1435+638	16		18		26		79		12.64	F,3
36d	144516.4+095836	1442+101	25		37		76		169		13.63	S,5
37o	150424.9+102939	1502+106	20		30		29		85		11.44	F
38c	161341.0+341247	1611+343	24	± 4	12	± 4	53		141		12.58	F,5
39o	163515.4+380804	1633+382	15		11	± 5	36	± 8	74		12.65	F
40d	163813.4+572023	1637+574	38		39		68		206		12.09	F
41o	164258.8+394836	1641+399	144	±10	338	±11	766	±18	1277	±56	12.91	F,9
42d	183250.1+283335	1830+285	38		44	±15	101		564		12.04	I,5
43d	200324.1-325145	2000-330	19		35		29		85		13.28	F
44d	210138.8+034131	2059+034	23		49	±11	174	±12	114		13.13	F
45c	212912.1-153841	2126-158	44		81		84	±20	192		13.60	F
46o	213135.2-120704	2128-123	44		96		59		185		11.64	F,3
47c	214712.7-753613	2142-758	33		37		61		220		12.43	F
48o	220314.9+314538	2201+315	62	± 6	111	± 7	126	± 9	85		11.49	F
49c	222547.2-045701	2223-052	168	±11	363	±19	951	±16	1747	±51	13.88	F
50o	225357.7+160853	2251+158	41		112	±18	179	±19	564		12.63	F,2
51d	225717.3+074312	2254+074	41		73		155	+20	366		12.05	I,3
52c	230343.5-680737	2300-683	28		32		52		172		11.61	F
53d	232917.7-473019	2326-477	43		56		60		132		12.56	F,8
54c	234636.8+093045	2344+092	19		71	±13	67	± 8	135		11.98	F,2
55o	234802.6-163112	2345-167	37	±15	94		93	±19	158		11.97	F

REMARKS: F – flat spectrum, S – steep spectrum, I – intermediate spectrum; 1-9 are circumstances of observations [8]

One can see from Tables 3 and 4, these 55 IR/ICRF quasars include 42 sources with flat radio spectrum, 4 – with steep, 8 – with intermediate and only one radio quiet quasar. Evidently the radio quiet quasars have not enough luminosity $L_{60}/L_{\odot}$ to be bright sources in infrared.

CONCLUSION

The comparison of the Neugebauer *et al.* [8] list of 179 quasars observed by IRAS satellite in 1983 with the ICRF list of 608 radio sources [7] had been carried out and 55 common extragalactic sources were found. The major part of them (42) has a flat radio spectrum. On the contrary only radio quiet quasars practically can not be bright sources in infrared.

These 55 IR/Radio sources should be included to the first level IR reference catalogue which is compiled in Kyiv.

They permit, firstly, to establish a direct connection between the infrared and ICRS coordinate systems. It can be used, secondly, to improve in future the connection between radio (ISRF) and optical (HIPPARCOS) coordinate systems [4]. We recommend, therefore, the list of 55 IR/Radio sources for VLBI (or VLA) observations as well as for infrared precise positional observations.

We are going to continue this investigation after identification of ICRF sources with their counterparts from DENIS and 2MASS, after these latters will be published [2].

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REFERENCES

[1] *Beichman C. A., Neugebauer G., Habing H. J., et al.* IRAS Catalogues and Atlases: The Explanatory Supplement / Ed. T. J. Chester.–NASA RP-1190.–1987.–**2–6**.

[2] *Epchtein N.* // Astrophys. and Space Sci. Lib.–1997.–**230**.–P. 3–9.

[3] *Hindsly R., Harrington R.* // Astron. J.–1994.–**107**.–P. 280–286.

[4] *Kharin A. S.* // Proc. 3rd Orlov Conf. / Ed. Ya. Yatskiv.–Kyiv, 1994.–P. 81–84.

[5] *Kharin A. S.* // Systems De Reference Spatio-Temporels / Eds J. Vondrak, N. Capitaine.–Prague, 1997.–P. 126–129.

[6] *Kharin A. S., Molotaj O. A.* // Systems De Reference Spatio-Temporels & IX LOHRMANN-KOLLOQUIUMM / Eds M. Soffel, N. Capitaine.–Dresden, 1999.–P. 55.

[7] *Ma C., et al.* // Astron. J.–1998.–**116**.–P. 516–546.

[8] *Neugebauer G., et al.* // Astrophys. J.–1986.–**308**.–P. 815–828.

[9] WG IERS // IAU Inform. Bull.–January 1995.–N 74.–P. 3–18.