Discovery of new bright ULIRGs from the IRAS PSC/FSC Combined Catalogue

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Abstract

High-luminosity IR galaxies (LIRGs, ULIRGs, and HLIRGs) are important for studies related to star-formation processes in the early Universe, as their luminosity allows to detect them at large distances. High IR indicates active star-formation and often starburst processes, which is typical to HII (starburst, SB) and AGN. An interesting question is whether the starburst triggers AGN or vice versa or there is no direct impact. Considering that very often such objects manifest double and multiple structure, it is also interesting to investigate the interrelationship between the SB, nuclear activity and interactions or merging. We have analyzed the IRAS PSC/FSC Combined Catalogue for search for new bright ULIRGs. By means of the SDSS DR14 data, namely redshifts for those objects having spectroscopy, we have calculated the IR luminosities and have found 114 very high-luminosity IR galaxies; 107 ULIRGs and 7 HLIRGs. Among them, 48 new ULIRGs and 7 new HLIRGs have been discovered. These objects have been studied by SDSS color-color, luminosity-redshift and other diagrams. Further studies will include the content of the sample for activity types and other available data.

Keywords: *IR sources, IR galaxies, starburst galaxies, AGN, ULIRGs, HLIRGs, interacting galaxies, mergers.*

1. Introduction

The InfraRed Astronomical Satellite (IRAS) was the first-ever space telescope to perform a survey of the entire night sky at infrared wavelengths. Launched on 25 January 1983, its mission lasted ten months. The telescope was a joint project of the United States(NASA), the Netherlands (NIVR), and the United Kingdom(SERC). It mapped 96% of the sky four times, at 12, 25, 60 and 100 micrometers, with resolutions ranging from 30 arcseconds at 12 micrometers to 2 arcminutes at 100 micrometers. It discovered about 350,000 sources given in several catalogues.

One of the most important revelations of the extragalactic observations in near- , mid- , and far- IR (NIR, MIR, and FIR) was the discovery of IR galaxies. These galaxies emit the most part of their energy in IR. The main part of galaxies that have

powerful IR emission are AGN and Starburst (SB) galaxies. David Sanders and Felix Mirabel suggested in 1996 to split high-luminosity IR galaxies into three main classes (Sanders & Mirabel 1996): galaxies with $10^{11}L_{\odot} < L_{IR} < 10^{12}L_{\odot}$ were named LIRGs (Luminous InfraRed Galaxies), galaxies with $10^{12}L_{\odot} < L_{IR} < 10^{13}L_{\odot}$ were named ULIRGs (Ultra-Luminous InfraRed Galaxies) and galaxies with $10^{13}L_{\odot} < L_{IR}$ were named HLIRGs (Hyper-Luminous InfraRed Galaxies). Sylvain Veilleux (Veilleux 2002) showed that the percent of AGNs increases parallel to IR luminosity, so among the sources that have the highest IR luminosities there are full of QSOs and Seyfert galaxies, and among the sources that have lower IR luminosities there are mostly Starburst galaxies.

The IRAS PSC/FSC Combined Catalogue contains 345,163 sources (Abrahamyan et al. 2015). The advantage against more recent catalogues is that in this catalogue FIR fluxes are also given; the sources are available in the whole sky and it is homogeneous material for extragalactic research. The coordinates of the sources of IRAS PSC/FSC Combined Catalogue have been improved by other catalogues, in particular by AKARI-IRC (Ishihara et al. 2010), AKARI-FIS (Yamamura et al. 2010) and WISE (Cutri et al. 2013) and most of the sources have accuracy of better than 1". For the first time it gives an opportunity to study IRAS sources using most recent accurate astrometry, photometry, as well as SDSS spectroscopy. We have benefited from these accurate data to correctly identify optical counterparts and select those objects having SDSS data.

2. Sample selection

From the IRAS PSC/FSC Combined Catalogue, we have taken sources that were checked by WISE considering that the accuracy of the WISE coordinates is significantly higher ($<1''$) than the coordinates of the two other AKARI catalogues.

The selected sample was cross-correlated with SDSS DR14 (Abolfathi et al. 2017). Considering that the accuracy of WISE coordinates is $\sim 1''$, and the accuracy of SDSS coordinates is $\sim 0.1''$, the cumulative accuracy will be:

$$\sigma = \sqrt{\sigma_{WISE}^2 + \sigma_{SDSS}^2}$$

$$\sigma = \sqrt{1^2 + 0.1^2} \approx 1.005$$

Corresponding 3σ was taken as the search radius. Only the SDSS objects that had spectroscopical data and were the only optical counterparts in the radius of 3σ were taken from the results of cross-correlation. This way 6,346 objects were found; galaxies brighter than 17.77^m.

Figure 1. RA and DEC differences between IRAS and SDSS positions. Most of the associations are within 1".

3. IR luminosities and ULIRGs

For the calculation of the IR luminosities of the sources the flux densities for each source in 12, 25, 60 and 120 μ bands that are given in IRAS PSC/FSC Combined Catalogue are necessary. Therefore, from the 6,346 objects only those were chosen that had the data on the flux densities in all four bands. Only 6,270 sources had such data. The IR and FIR luminosities were calculated by the following formulae (Duc et al. 1997):

$$L_{ir} = 5.6 \times 10^5 R^2 (13.56 f_{12} + 5.26 f_{25} + 2.54 f_{60} + f_{100}) L_{\odot}$$

$$L_{fir} = 5.6 \times 10^5 R^2 (2.58 f_{60} + f_{100}) L_{\odot},$$

where the R is the distance of the object in Mpc and $f_{12}, f_{25}, f_{60}, f_{100}$ are the flux densities given in IRAS PSC/FSC Combined Catalogue in 12, 25, 60, 100 μ bands, respectively. Out of 6,270 objects only those were selected having IR luminosities greater than $10^{12} L_{\odot}$ (the lower limit of ULIRG's luminosity) and having stellar magnitudes in r band greater than 17.77 m (the spectroscopic limit for SDSS galaxies).

As a result, 114 extragalactic objects were selected that have high IR luminosity and correspond to ULIRG/HLIRG classes.

4. Results

In Table 1, we give the list of 114 ULIRGs/HLIRGs found from IRAS PSC/FSC Combined Catalogue.

Table 1. *The list of 114 ULIRGs/HLIRGs found from IRAS PSC/FSC Combined Catalogue based on SDSS redshifts; Byurakan ULIRGs.*

#	IRAS coordinates			IRAS fluxes (mJy)				SDSS model magnitudes					z	LOG (L _{ir} / L _{sun})
	RA J2000	DEC J2000	r (")	F12	F25	F60	F100	u (mag)	g (mag)	r (mag)	i (mag)	z (mag)		
1	00 20 00.270	+32 08 02.82	0.19	0.29	0.19	0.33	4.76	18.97	17.53	16.70	16.16	15.87	0.110	12.059
2	00 30 25.608	-09 26 17.39	1.29	1.03	1.61	11.40	47.70	19.93	18.46	17.74	17.31	17.04	0.129	13.157
3	00 33 21.837	-05 05 44.63	2.42	0.46	5.66	27.60	99.80	19.31	17.12	16.12	15.65	15.27	0.053	12.740
4	00 44 59.123	+19 21 41.45	0.26	0.14	0.18	0.32	0.82	16.91	16.78	16.65	16.36	16.38	0.179	12.073
5	01 14 27.481	+27 21 38.98	1.33	1.34	0.76	15.60	115.00	19.33	18.07	17.16	16.55	16.13	0.109	13.277
6	01 19 56.727	+13 34 31.51	0.29	0.10	0.16	0.31	0.80	19.23	18.00	17.29	16.92	16.68	0.191	12.052
7	01 27 09.340	+08 40 15.52	2.84	0.57	0.34	2.64	39.00	19.59	17.35	16.34	15.80	15.36	0.045	12.026
8	01 37 58.267	-08 34 30.44	0.04	0.16	0.18	0.29	0.76	20.43	18.39	17.38	16.77	16.41	0.189	12.128
9	01 59 50.248	+00 23 40.98	0.12	0.12	0.54	2.22	2.16	15.93	15.70	15.52	15.26	15.30	0.163	12.444
10	02 04 22.321	-09 37 57.65	0.46	0.15	0.17	0.34	0.76	19.77	18.40	17.63	17.04	16.82	0.192	12.133
11	02 24 23.087	-02 10 30.55	0.23	0.12	0.16	0.30	0.97	20.82	19.01	17.63	17.06	16.70	0.173	12.015
12	02 28 40.542	-09 35 05.68	2.02	0.86	0.88	5.87	80.10	17.52	16.58	16.18	15.79	15.63	0.068	12.682
13	02 44 17.066	-00 30 38.22	0.26	0.11	0.16	0.48	0.83	21.51	19.00	17.65	17.11	16.68	0.200	12.147
14	03 23 22.858	-07 56 15.21	0.16	0.10	0.13	1.00	1.69	18.95	18.00	17.37	16.93	16.67	0.166	12.166
15	03 29 02.594	-00 55 39.10	0.39	0.46	0.54	1.78	12.80	17.30	15.83	15.04	14.61	14.33	0.067	12.043
16	07 37 35.222	+35 36 21.36	0.32	0.12	0.15	1.88	4.45	15.10	13.86	13.11	12.72	12.40	0.819	13.523
17	08 04 07.412	+39 19 27.69	0.20	0.23	0.13	0.27	0.73	19.73	18.38	17.54	17.05	16.76	0.163	12.064
18	08 13 31.289	+25 45 03.15	0.08	0.11	0.15	0.28	0.54	16.42	16.00	15.61	15.27	15.23	1.510	13.259
19	08 24 45.643	+15 39 43.83	0.30	0.13	0.18	0.36	0.80	20.11	18.64	17.69	17.21	16.94	0.220	12.229
20	08 31 48.881	+04 29 39.07	0.05	0.17	0.26	0.43	0.77	16.34	15.80	15.35	15.05	14.78	0.174	12.147
21	08 34 57.652	+48 45 15.63	0.19	0.09	0.09	0.34	2.43	19.19	17.60	16.70	16.21	15.93	0.175	12.101
22	08 54 48.878	+20 06 30.75	0.11	0.28	0.43	0.89	1.16	16.57	15.93	15.42	15.04	14.71	0.778	13.411
23	08 55 17.068	+13 05 09.65	0.22	0.11	0.21	0.24	1.63	19.32	18.13	17.40	16.90	16.65	0.157	12.002
24	08 57 06.358	+19 08 53.69	0.19	0.11	0.12	0.33	0.52	17.25	17.19	16.99	17.12	16.61	0.331	12.440
25	08 58 41.758	+10 41 22.04	0.16	0.11	0.19	1.12	1.95	18.93	17.49	16.62	16.08	15.81	0.148	12.134
26	08 59 23.600	+47 36 10.53	0.12	0.09	0.12	0.44	0.88	20.80	18.76	17.60	17.02	16.69	0.180	12.024
27	09 00 25.376	+39 03 54.38	0.65	0.32	1.70	7.43	4.59	18.72	17.34	16.85	16.50	16.25	0.058	12.069
28	09 05 54.723	+24 18 29.03	0.32	0.05	0.09	0.36	0.59	19.98	18.61	17.72	17.24	16.87	0.232	12.057
29	09 14 38.146	+09 33 22.95	0.12	0.11	0.15	0.28	1.19	19.54	18.27	17.26	16.78	16.43	0.246	12.300
30	09 21 59.400	+45 09 12.61	0.22	0.06	0.13	0.23	0.57	18.58	18.05	17.73	17.46	17.34	0.235	12.054
31	09 26 08.518	+28 24 02.59	0.15	0.08	0.21	0.25	0.62	19.19	18.24	17.62	17.17	17.00	0.203	12.062
32	09 58 46.856	+50 54 56.54	0.06	0.05	0.06	0.22	1.37	19.57	18.10	17.25	16.80	16.56	0.214	12.042
33	10 01 49.527	+28 47 09.01	0.10	0.16	0.26	0.23	0.34	18.54	17.96	16.83	16.63	16.81	0.185	12.100
34	10 05 32.126	+30 53 18.27	0.14	0.09	0.10	0.20	0.63	18.89	17.81	17.07	16.61	16.35	0.234	12.099
35	10 05 41.874	+43 32 40.60	0.25	0.13	0.19	0.56	0.87	16.39	16.38	16.38	16.18	16.28	0.179	12.122
36	10 26 17.480	+30 36 43.24	0.19	0.06	0.16	0.26	0.67	18.75	18.04	17.54	17.40	16.87	0.340	12.380
37	10 33 43.863	+62 11 06.27	0.56	0.08	0.08	0.20	0.57	19.76	18.49	17.57	17.12	16.84	0.229	12.038
38	10 33 59.475	+35 55 09.18	0.14	0.09	0.16	0.52	0.79	17.10	16.97	16.66	16.35	16.28	0.169	12.002
39	10 40 00.549	+48 57 44.44	0.19	0.08	0.11	0.64	0.66	19.16	18.34	17.76	17.27	17.20	0.176	12.013
40	10 52 23.573	+44 08 47.17	0.73	0.12	0.17	3.53	5.41	19.37	17.59	16.83	16.32	16.04	0.092	12.114
41	10 53 30.955	+33 13 42.39	0.14	0.11	0.13	0.21	0.54	19.77	18.56	17.63	17.20	16.90	0.244	12.170
42	10 58 39.325	+38 29 06.77	0.40	0.05	0.09	0.62	0.75	19.78	18.35	17.53	17.10	16.83	0.208	12.086
43	11 08 32.952	+40 37 31.72	0.07	0.10	0.13	0.68	1.02	19.39	18.07	17.36	16.92	16.66	0.166	12.045
44	11 12 11.118	+27 32 56.18	0.64	0.07	0.25	0.25	0.83	18.46	17.82	17.42	17.13	17.04	0.235	12.210
45	11 14 38.892	+32 41 33.60	0.10	0.17	0.35	1.59	1.52	21.22	18.94	17.13	16.09	15.80	0.188	12.447

46	11 16 03.133	+02 08 52.30	0.04	0.17	0.19	0.40	0.33	16.81	16.83	16.68	16.44	16.50	0.211	12.219
47	11 21 14.226	+03 25 46.82	0.07	0.17	0.22	0.36	1.16	17.46	17.29	17.05	16.66	16.66	0.152	12.039
48	11 22 33.084	+50 15 27.98	0.21	0.09	0.12	0.19	0.95	19.98	18.52	17.69	17.12	16.96	0.195	12.010
49	11 41 22.043	+40 59 50.39	0.16	0.20	0.14	1.02	1.51	19.99	18.33	17.42	16.89	16.55	0.149	12.156
50	11 44 30.922	+25 46 34.98	0.38	0.15	0.15	0.29	0.65	18.64	17.44	16.56	16.12	15.84	0.185	12.082
51	11 53 14.237	+13 14 27.74	0.19	0.10	0.30	2.58	3.32	19.88	18.30	17.59	17.04	16.82	0.127	12.259
52	11 57 44.359	+12 07 50.97	0.26	0.17	0.13	0.22	0.55	18.78	17.57	16.78	16.35	16.06	0.183	12.048
53	11 57 53.218	-03 15 37.03	0.21	0.12	0.30	0.33	0.63	17.91	17.74	17.20	16.69	16.82	0.214	12.231
54	11 58 16.724	+13 26 24.23	0.09	0.10	0.16	0.23	0.53	17.95	17.59	17.40	17.26	17.12	0.439	12.606
55	12 01 16.658	+23 34 52.85	0.34	0.12	0.14	0.26	0.60	19.19	18.28	17.53	17.22	16.90	0.263	12.281
56	12 02 05.612	+11 28 12.13	0.29	0.11	0.16	0.95	1.15	18.74	17.93	17.43	17.03	16.93	0.194	12.253
57	12 02 26.765	-01 29 15.35	0.13	0.36	0.54	2.41	2.72	17.28	16.96	16.62	16.27	16.10	0.150	12.506
58	12 04 24.554	+19 25 09.99	0.32	0.11	0.37	1.76	1.78	19.50	18.15	17.46	17.02	16.79	0.168	12.360
59	12 05 26.443	+22 43 37.56	0.15	0.62	0.54	0.51	21.00	19.42	17.78	16.77	16.16	15.74	0.076	12.250
60	12 11 19.098	+05 55 23.85	0.21	0.15	0.17	0.24	0.55	19.67	18.38	17.53	16.98	16.72	0.201	12.128
61	12 15 09.822	+09 27 09.37	0.27	0.09	0.27	0.21	0.45	20.15	18.66	17.61	17.17	16.90	0.263	12.286
62	12 29 06.906	+32 24 17.75	0.30	0.09	0.15	0.57	0.76	19.98	17.79	17.05	16.64	16.40	0.173	12.022
63	12 31 21.374	+27 55 23.93	0.10	0.08	0.13	0.35	0.67	20.18	18.41	17.44	16.96	16.69	0.212	12.090
64	12 37 16.002	+04 01 48.67	0.57	0.10	0.32	0.66	1.03	19.18	17.67	16.81	16.30	15.95	0.146	12.025
65	12 38 20.209	+17 50 39.22	0.16	0.14	0.13	0.26	0.39	17.22	16.61	16.43	16.29	16.24	0.452	12.658
66	12 45 26.988	+65 23 58.40	0.05	0.06	0.07	0.21	0.65	17.56	17.48	17.30	17.36	16.95	0.320	12.235
67	12 51 00.438	+66 03 26.87	0.07	0.06	0.07	0.17	0.58	16.78	16.75	16.62	16.79	16.41	0.282	12.117
68	12 51 20.052	+02 19 02.43	0.25	0.09	0.13	0.47	0.89	19.40	18.42	17.58	17.18	16.82	0.253	12.290
69	12 54 10.444	+03 59 51.70	0.20	0.12	0.29	0.25	0.82	19.65	18.30	17.47	16.89	16.58	0.168	12.032
70	12 56 04.931	+02 38 31.96	0.22	0.11	0.24	0.29	1.49	19.81	18.45	17.37	16.85	16.50	0.219	12.272
71	12 57 39.331	+08 09 31.74	0.04	0.09	0.12	0.59	0.78	17.76	17.47	17.17	17.24	16.91	0.272	12.362
72	13 01 18.171	+11 06 01.88	0.09	0.12	0.14	0.29	0.83	19.97	18.70	17.55	17.06	16.88	0.174	12.002
73	13 06 18.579	+08 52 41.43	0.21	0.13	0.26	0.29	0.62	17.78	17.55	17.29	16.92	16.95	0.172	12.041
74	13 22 11.965	+01 30 34.31	0.17	0.10	0.32	0.33	0.72	18.13	17.74	17.37	17.22	17.59	0.184	12.114
75	13 22 44.041	+63 37 25.16	0.58	0.06	0.07	0.59	0.91	19.85	18.41	17.50	17.04	16.83	0.200	12.064
76	13 24 19.895	+05 37 04.79	0.15	0.26	0.40	1.17	0.71	18.73	18.25	17.55	17.04	16.98	0.203	12.494
77	13 37 15.938	+03 09 36.79	0.33	0.11	0.16	0.22	0.69	19.11	18.12	17.33	16.81	16.56	0.192	12.035
78	13 44 42.108	+55 53 13.31	0.53	0.24	2.28	21.70	21.40	16.59	14.99	14.31	13.84	13.71	0.037	12.090
79	13 47 33.379	+12 17 24.35	0.30	0.14	0.67	1.92	2.06	18.16	16.37	15.35	14.79	14.59	0.120	12.201
80	13 48 40.199	+58 18 52.16	0.96	0.05	0.07	1.27	1.73	19.90	18.44	17.57	17.10	16.78	0.158	12.105
81	13 50 43.182	+37 24 34.11	0.18	0.11	0.09	0.30	0.94	19.46	17.97	17.00	16.60	16.30	0.248	12.239
82	13 55 50.208	+20 46 14.67	0.15	0.19	0.21	0.26	0.54	16.16	15.94	15.66	15.31	15.48	0.197	12.184
83	14 04 38.810	+43 27 07.52	0.11	0.12	0.29	0.62	0.99	16.18	15.63	15.30	15.33	14.92	0.323	12.625
84	14 18 42.223	+42 33 43.39	0.02	0.10	0.09	0.31	0.57	16.54	16.40	16.43	16.44	16.37	0.420	12.556
85	14 22 31.386	+26 02 05.42	0.39	0.18	0.15	1.49	1.99	18.28	17.49	17.08	16.70	16.54	0.159	12.287
86	14 25 16.043	+16 23 07.97	0.16	0.10	0.25	0.54	0.98	19.47	17.76	16.89	16.47	16.25	0.185	12.154
87	14 27 27.266	-00 58 41.16	0.19	0.12	0.32	0.91	1.28	20.05	18.44	17.60	17.05	16.69	0.162	12.183
88	14 35 35.554	+01 28 34.73	0.18	0.13	0.22	0.35	0.65	20.10	18.70	17.77	17.33	17.00	0.232	12.281
89	14 40 12.775	+61 56 33.19	0.20	0.06	0.09	0.32	0.68	17.20	17.01	16.83	16.97	16.55	0.276	12.198
90	14 41 04.407	+53 20 08.94	0.33	0.07	0.35	1.95	2.39	18.27	17.08	16.47	15.75	15.72	0.105	12.002
91	14 49 20.716	+42 21 01.45	0.23	0.11	0.23	0.40	0.56	19.10	18.05	17.28	16.95	16.81	0.179	12.063
92	14 50 54.177	+35 08 37.94	0.17	0.07	0.09	0.64	1.21	18.48	17.57	16.91	16.38	16.19	0.206	12.162
93	14 55 49.433	+48 54 36.34	0.08	0.08	0.20	0.53	0.54	18.82	18.22	17.36	17.28	17.07	0.247	12.281
94	15 02 59.016	+03 40 04.00	0.16	0.09	0.08	0.23	1.09	24.25	18.30	17.49	17.05	16.83	0.218	12.098
95	15 05 39.529	+57 43 07.33	0.30	0.12	0.07	1.02	1.50	19.07	18.30	17.76	17.31	17.18	0.151	12.075
96	15 13 18.050	+24 46 55.40	0.19	0.06	0.17	0.52	0.56	19.19	18.07	17.13	16.61	16.34	0.220	12.134
97	15 22 38.091	+33 31 36.10	0.25	0.08	0.35	1.77	1.89	17.31	16.79	16.45	15.89	16.06	0.125	12.109
98	15 24 43.874	+23 40 10.41	0.20	0.07	0.18	1.30	1.48	19.31	17.94	17.11	16.58	16.32	0.139	12.045
99	15 34 57.252	+23 30 11.56	1.79	0.48	7.91	104.00	112.00	15.63	13.96	13.08	12.61	12.29	0.018	12.149
100	15 43 16.002	+14 07 31.93	0.21	0.07	0.10	0.20	1.11	19.19	18.24	17.58	17.18	16.94	0.221	12.080
101	15 43 51.941	+16 24 22.26	0.21	0.08	0.12	0.23	0.55	16.93	16.45	16.25	16.12	15.90	0.848	12.924
102	15 45 30.246	+48 46 08.97	0.09	0.07	0.11	0.28	0.45	16.43	16.32	16.30	16.30	16.06	0.400	12.460
103	16 18 49.253	+44 25 17.28	0.07	0.05	0.11	0.28	0.50	17.34	16.98	16.64	16.67	16.15	0.335	12.301
104	16 32 21.419	+15 51 45.77	0.64	0.07	0.12	1.48	1.99	19.67	18.52	17.70	17.26	16.96	0.242	12.527
105	16 42 58.823	+39 48 37.07	0.17	0.11	0.29	0.60	1.38	16.16	15.68	15.39	15.10	14.86	0.594	13.047
106	17 04 41.377	+60 44 30.56	0.07	0.07	0.13	0.30	0.70	15.60	15.43	15.25	15.19	14.82	0.372	12.458

107	20 55 19.286	+00 32 26.16	0.40	1.53	1.82	44.00	58.90	16.58	15.15	14.42	14.04	13.74	0.023	12.023
108	21 48 33.443	+11 31 47.78	0.03	0.05	0.07	0.45	1.80	19.93	18.13	17.19	16.69	16.37	5.225	13.556
109	21 52 36.547	-07 42 09.35	0.26	0.35	0.47	3.77	82.70	17.13	15.54	14.77	14.35	14.03	0.035	12.071
110	22 36 06.403	+12 18 43.84	0.20	0.38	0.53	3.57	49.10	18.57	17.25	16.54	16.09	15.83	0.071	12.492
111	22 53 02.457	+17 20 18.57	0.16	0.10	0.14	0.58	2.36	19.62	18.07	17.13	16.52	16.27	0.179	12.196
112	22 58 32.466	+07 49 40.59	0.20	0.12	0.22	0.61	1.14	18.76	18.00	17.58	17.40	16.99	0.396	12.755
113	23 08 33.953	+05 21 29.87	0.10	0.20	0.43	1.15	0.83	18.38	17.42	16.53	15.91	15.51	0.173	12.335
114	23 56 13.870	-00 32 10.00	1.51	0.14	0.12	0.24	0.59	19.19	16.90	16.07	15.68	15.38	0.189	12.041

Figure 2. SDSS color-color diagram for 114 newly revealed ULIRGs and HLIRGs.

Figure 3. IR luminosity vs. redshift for 114 newly revealed ULIRGs and HLIRGs. The distribution of ULIRGs shows almost linear dependence in the range of $\text{Log} L_{\text{IR}}$ 12.0-12.8 and z 0.0-0.5. Higher redshifts are probably excluded by magnitude limit (17.77^m). Due to small numbers, the distribution of HLIRGs is not homogeneous.

As a result, the objects were classified as 107 ULIRGs and 7 HLIRGs. The objects were checked by NED (The NASA/IPAC Extragalactic Database); out of 107 ULIRGs only 59 were known before, and 2 out of 7 HLIRGs were classified as ULIRGs. As a result, 48 new ULIRGs and 7 new HLIRGs were discovered. Considering homogeneity of the sample and the prevalence on the whole sky, it is significant quantity to make statistical study on such objects.

5. Summary and Conclusion

We have selected sources from the IRAS PSC/FSC Combined Catalogue to reveal new high-luminosity IR galaxies (LIRGs, ULIRGs, HLIRGs). We benefited from the improved coordinates of this catalog to accurately identify the optical counterparts, namely objects from SDSS classified as galaxies. As a result, 6,346 objects were selected having confident optical counterparts. Objects having SDSS spectroscopy (Petrosian magnitudes brighter than 17.77^m) were considered as the main sample to calculate their distances and luminosities. 114 objects were selected, including 107 ULIRGs and 7 HLIRGs. Among them, 48 ULIRGs and 7 HLIRGs are newly discovered ones. We call these objects Byurakan ULIRGs.

Considering the number of ULIRGs at different available (bright) magnitudes, one can extrapolate and conclude what is the real number of ULIRGs at fainter magnitudes, thus estimating their abundance in the Universe.

Figure 4. The number of ULIRGs/HLIRGs vs. SDSS r magnitude.

Figure 5. The number of ULIRGs/HLIRGs vs. redshift.

An extrapolation based on figures 4 and 5 shows the trend how many high-luminosity IR galaxies might be expected at fainter magnitudes and higher redshifts.

To study the content of newly discovered ULIRGs, we plan to classify them by activity types from the SDSS spectra. These results will be given in our next paper.

References

- Abrahamyan, H. V., Mickaelian, A. M., Knyazyan, A. V. 2015, *Astronomy and Computing*, 10, 99
- Abolfathi, B., Aguado, D. S., Aguilar, G. et al. 2018, *The Astrophysical Journal Supplement Series*, 235, issue 2, article id. 42, p. 19
- Cutri, R. M. et al. 2013, *VizieR On-line Data Catalog: II/328*. Originally published in: *IPAC/Caltech*
- Duc, P.-A., Mirabel, I. F., Maza, J. 1997, *A&A Suppl.*, 124, 533
- Ishihara, D., Onaka, T., Kataza, H., Salama, A., Alfageme, C., Cassatella, A. et al. 2010, *A&A*, 514, 14
- Sanders, D. B., Mirabel, I. F. 1996, *ARA&A*, 34, 749
- Veilleux, S. 2002, *Proceedings of IAU Colloquium 184, ASP Conference Series*, 284, 111
- Yamamura, I., Makiuti, S., Ikeda, N., Fukuda, Y., Oyabu, S., Koga, T., White, G. J., 2010, *VizieR On-line Data Catalog: II/298*. Originally published in: *ISAS/JAXA*