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SEARCH FOR NEARBY GALAXIES IN BATSE/IPN SHORT GRB ERROR BOXES

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Recent observations have shown an apparent association of short duration gamma-ray bursts with a variety of host galaxies at moderate redshifts. However, a statistical analysis with a large sample of BATSE GRBs indicates that at least some fraction of short GRBs originates in the local universe. We have considered pre-*Swift* well-localized short GRBs to examine a possible association of these bursts with galaxies at low redhsifts. We have used BATSE/IPN localizations of short bursts and SDSS DR5/PSCz catalogs as galaxies surveys.

Keywords: High energy emission; gamma-ray bursts.

1. Introduction

The origin of short GRBs (S-GRBs) has been remained mysterious until recently due to their poor localization. In pre-*Swift* era several hundreds of these events were detected in the Burst And Transient Source Experiment (BATSE)[1] with a typical accuracy of few degrees and few dozen were localized by the Interplanetary Network (IPN)[2] with an arcminutes accuracy. *Swift*, *HETE-2*, *Chandra* and follow-up observations have shown an apparent association of S-GRBs with a variety of host galaxies at moderate redshifts.[3,4]

On the other hand, Tanvir *et al.*[5] have found a correlation between locations of S-GRBs and positions of galaxies in the local universe, indicating that between 10 and 25 per cent of S-GRBs originate at redshifts $z < 0.025$. They have used the BATSE GRB catalog and the PSCz catalog of galaxies.

We have considered IPN data on S-GRBs to examine possible association of the bursts with galaxies at low redshifts.

2. Search for Nearby Galaxy Hosts of Short GRBs

The IPN data[2] in the 1990-2000 are complete for 39 S-GRBs. Most of the bursts in the sample were detected by BATSE with all bursts much brighter than the BATSE threshould.

Detection of an event by two separated IPN instruments leads to a narrow annulus that intersects a BATSE error circle($R \sim$ few degrees) and reduces its area by a factor of 30. Such annulus/error circle intersection provides a GRB arcminute error box. In some cases a second narrow IPN annulus reduces the error box.

We consider the BATSE 1σ error circles whose radii are defined by $r_{1\sigma} = (\sigma^2_{stat} + \sigma^2_{sys})^{1/2}$, where σ_{sys} is the systematic error, $1.^o6$, and σ_{stat} is the statistical error. The IPN 3σ confidence annulus is given by $R_{IPN} \pm \delta R_{IPN}$. Eight error boxes in the sample are estimated to be less than 0.003 deg^2, 5 boxes are 0.003-0.1 deg^2, 20 boxes are 0.1-1 deg^2, 6 boxes are 1-10 deg^2.

We have used the SDSS DR5[6] and the PSCz catalogs[7] as galaxies surveys. The SDSS DR5 represents the most deep galaxies survey with estimated redshifts up to z $\sim$ 0.5 covering $\sim$ 1/4 of the sky. The PSCz provides redshifts for galaxies up to z $\sim$ 0.1 over 84% of the sky.

None of 39 GRBs error boxes are fully covered by the SDSS DR5. The number of partly covered error boxes is 10 while only 3 boxes have a coverage more than 50%. Hence we cannot search for hosts of a particular GRB with the SDSS.

34 of 39 GRBs error boxes are fully covered by the PSCz catalog. They are listed in Table 1. We have searched for galaxies appearing in the error boxes. We have estimated that the probability of chance coincidence for a galaxy at z $\sim$ 0.025

Table 1. The IPN short GRBs error boxes covered by the PSCz catalog.

GRB date yymmdd	Time of day	BATSE localization			IPN localization			
		α	δ	σ_{stat}	α_1 α_2	δ_1 δ_2	R_1 R_2	δR_1 δR_2
910626	07h15m13s	133.38	7.72	1.27	134.557	18.501	10.164	2E-02
920414	23h22m41s	112.5	−73.72	1.57	331.028	−9.164	87.724	7E-03
					189.386	2.413	89.759	4E-03
920903	00h49m17s	61.97	−68.37	0.75	338.732	−0.549	88.165	0.01
930106	15h37m39s	6.08	2.0	0.53	345.556	12.984	21.048	0.021
930329	03h09m25s	179.25	−8.65	0.94	148.09	−13.723	35.582	1E-02
930428	01h07m12s	129.85	−55.45	1.68	143.9	−12.085	46.202	5E-03
930905	03h26m30s	310.95	−1.22	0.63	335.615	17.389	28.629	5.8E-03
					335.616	17.397	28.635	7E-03

Table 1. (*Continued*)

GRB date yymmdd	Time of day	BATSE localization			IPN localization			
		α	δ	σ_{stat}	α_1 α_2	δ_1 δ_2	R_1 R_2	δR_1 δR_2
931017	01h17m49s	181.44	−83.11	0.65	162.389	−24.11	58.979	0.003
940717	03h24m29s	109.80	12.93	0.71	130.246	−40.076	54.328	6E-03
950108	02h04m20s	17.71	−12.94	3.58	320.718	−47.219	57.551	1.5E-02
950210	02h20m21s	154.55	−27.48	1.15	155.444	25.748	53.632	8E-03
950211	02h24m57s	9.51	52.65	1.08	335.804	−25.124	85.83	6E-03
950620	00h44m33s	45.72	6.13	1.49	21.969	64.638	61.737	1.9E-02
950805	03h44m14s	79.86	−39.38	1.75	337.035	−80.272	48.132	2E-02
960319	14h26m33s	94.84	−47.72	2.01	352.443	−73.674	48.164	5E-02
960803	18h45m22s	338.02	−50.13	1.93	340.865	−40.801	12.019	1.4E-02
961017	11h16m43s	37.16	−10.68	2.89	354.974	−32.029	40.759	2.6E-02
970704	01h08m16s	74.82	−16.00	4.14	154.193	25.359	89.853	3E-03
971209	23h10m36s	241.35	62.21	0.77	171.404	11.832	70.341	4E-03
					265.214	−21.285	83.818	0.172
980228	06h44m07s	24.51	13.43	4.67	340.357	−12.77	55.236	0.013
980310	00h36m29s	75.19	−60.72	8.84	338.174	−12.983	85.921	2.6E-02
981005	18h00m26s	275.24	44.05	1.22	260.54	−24.703	71.356	4.1E-02
990208	04h12m44s	296.10	−39.40	2.29	332.365	−7.147	46.571	2.6E-02
990516	23h54m23s	253.55	−3.64	0.77	324.654	7.122	76.968	0.004
					214.006	−20.457	40.158	0.04
990712	07h45m19s	126.52	8.65	3.63	148.289	−8.391	28.976	0.006
					83.755	28.947	43.539	0.042
991007	01h49m27s	234.18	−3.39	1.50	164.315	5.059	68.655	4.1E-02
991211	04h34m41s	215.26	11.72	6.10	215.198	−21.141	28.297	0.132
000108	16h48m07s	236.35	−78.82	0.71	164.295	−35.974	49.485	1.5E-02
000326	05h18m56s	333.36	−26.36	2.36	316.827	41.054	68.837	5E-03
					291.959	−31.367	36.005	8.1E-02
000513	11h21m35s	338.91	−45.11	2.08	310.984	−27.576	32.37	9.9E-02
000525	10h24m13s	280.22	−39.44	2.75	312.719	−26.83	30.209	0.115
000607	02h24m49s	—	—	—	310.465	32.541	79.268	0.005
					310.927	21.249	81.687	0.015
000727	19h42m36s	—	—	—	139.729	−33.865	62.002	0.006
					134.829	−24.842	58.463	0.007
001204	08h01m10s	—	—	—	25.338	74.774	62.454	0.013
					333.554	45.945	64.67	0.022

Table 2. The PSCz galaxies found in the IPN short GRB errorboxes.

GRB date yymmdd	Time of day	Error box, deg^2	Found Galaxy	Redshift of galaxy	Probab.of chance coin.
950210	02h20m21s	0.187	H/061/505	0.015	0.017
			J/078/801	0.0087	0.008
961017	11h16m43s	0.94	G/015/005	0.07	0.29
991007	01h49m27s	1.104	F/093/007	0.028	0.21
991211	04h34m41s	9.244	E/107/018	0.02	0.75
			E/107/028	0.025	0.82
			E/110/019	0.027	0.85
000513	11h21m35s	3.055	K/177/013	0.0099	0.15
000525	10h24m13s	4.571	J/139/011	0.046	0.75
			K/147/006	0.017	0.42

is $\leq 2 \times 10^{-3}$ provided that the error box is not larger than ~ 0.1 deg^2. For a closer galaxy an error box can be larger.

First, we have considered the error boxes with $S_{error\ box} \leq 0.1$ deg^2. 9 of 13 boxes are covered by the PSCz. We have found no galaxies. Then we have considered the error boxes with $S_{error\ box} \leq 1.0$ deg^2 and the full sample of 34 GRBs. We have found 3 and 10 galaxies respectively. They are listed in Table 2.

Table 2 contains GRB time identification, size of error box, galaxy name and redshift and the estimated probability of chance coincidence. The lowest estimated probabilities of chance coincidence are 0.008 and 0.017 for 2 galaxies found in the error box of GRB950210 (the redshifts are z=0.0087 and 0.015, $S_{error\ box}$ =0.187 deg^2). In most cases the estimated probability of chance coincidence for a galaxy at given redshift is $\gg 2 \times 10^{-3}$. Moreover, the found number of galaxies is less than expected in the case of chance coincidence (3.4 and 12.8 respectively).

3. Conclusions

(1) We have found **no host candidate** among nearby PSCz galaxies in each of 34 IPN short GRBs error boxes. (2) We have found **no excess of nearby galaxies** in IPN short GRBs error boxes. The 90% upper limit corresponds to 7% of GRBs originating in nearby galaxies of PSCz catalog. Taking into account the redshift distribution of PSCz galaxies, the fraction of galaxies at z $\leq$ 0.025 among GRBs hosts is less than several per cent.

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