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Soft gamma repeaters outside the Local Group

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ABSTRACT

We propose that the best sites to search for soft gamma repeaters (SGRs) outside the Local Group are galaxies with active massive-star formation. Different possibilities to observe SGR activity from these sites are discussed. In particular, we have searched for giant flares from the nearby galaxies (∼2–4 Mpc away) M82, M83, NGC 253 and 4945 in the Burst and Transient Source Experiment (BATSE) data. No candidate giant SGR flares were found. The absence of such detections implies that the rate of giant flares with energy release in the initial spike above 0.5×10^{44} erg is less than 1/30 yr^{-1} in our Galaxy. However, hyperflares similar to that of 2004 December 27 can be observed from larger distances. Nevertheless, we do not see any significant excess of short GRBs from the Virgo galaxy cluster or from the galaxies Arp 299 and NGC 3256 (both with extremely high star formation rates). This implies that the Galactic rate of hyperflares with energy release $\sim 10^{46}$ erg is less than $\sim 10^{-3}$ yr^{-1}. With this constraint the fraction of possible extragalactic SGR hyperflares among BATSE's short GRBs should not exceed a few per cent. We present the list of short GRBs coincident with the galaxies mentioned above, and discuss the possibility that some of them are SGR giant flares. We propose that the best target for the observations of extragalactic SGR flares with *Swift* is the Virgo cluster.

Key words: galaxies: starburst – gamma-rays: bursts.

1 INTRODUCTION

Soft gamma repeaters (SGRs) are one of the most puzzling types of neutron star (NS). At present, at least four of these are known in our Galaxy and in the Large Magellanic Cloud (LMC) – hereafter, we refer to all of these, including those in the LMC, as 'Galactic' – and there are also two candidates.[1]

SGRs show three main types of bursts (however, these types form a continuous spectrum of transient behaviour):

(i) weak bursts, $L \lesssim 10^{41}$ erg s^{-1};
(ii) intermediate bursts, $L \sim 10^{41}$–10^{43} erg s^{-1};
(iii) giant flares, $L \lesssim 10^{45}$ erg s^{-1}.

The weak bursts are relatively frequent. About several hundred have been detected from four sources during ∼25 yr, i.e. the average rate is a few per month per source. For example, Cheng et al. (1996) report observations of 111 bursts from SGR 1806−20 during ∼5 yr; see also Göğüş et al. (2000) where the authors presented hundreds of weak bursts and performed detailed simulations of their recurrence time. However, these bursts appear in groups during the periods of activity of a SGR, so the rate is higher during these periods and lower between. The duration of a burst is very short, <1 s.

The intermediate bursts have typical durations of ∼ few seconds and are much more rare. The extremely energetic giant flares (GFs) are very rare – only three (or four, as suggested, for example, by Mazets et al. 2004)[2] have been observed. These bursts have a very intensive initial spike with the duration of a fraction of a second and a pulsating tail with a significant energy fluence but with a much lower intensity – for the hyperflare (HF) of SGR 1806−20 the energy emitted in the spike was much higher than the energy in the tail. Further, we consider only the initial spikes as they can be confused with the short gamma-ray bursts. The rate of GFs is very uncertain because of the lack of detections; usually it is estimated to be about (1/25–1/50) yr^{-1} per source (Woods & Thompson 2004).

The latest GF was observed on 2004 December 27 (Borkowski et al. 2004). There have been a number of papers analysing this burst (Hurley et al. 2005; Mazets et al. 2005; Mereghetti et al. 2005;

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[1] Here and below we refer to Woods & Thompson (2004) for the recent summary of all properties of SGRs.

[2] Many authors do not include the burst of SGR 1627−41 on 1998 June 18, as it was slightly dimmer than others and had no pulsating tail. This is why it is often claimed that only three GFs have been detected and we accept this value in the rest of the paper.

Palmer et al. 2005). The burst energy release is above 10^{46} erg (if the distance estimate of 15 kpc is correct; see discussion in (Cameron et al. 2005; McClure-Griffiths & Gaensler 2005)). It is two orders of magnitude higher than the energy release of the other GFs. It has been suggested to be a representative of the fourth class of bursts, 'supergiant flares' or HFs. In principle, this burst could form a continuous distribution together with the other GFs. However, the huge difference in the luminosity is the reason to consider this kind of events separately and use the term 'hyper'.

As well as being very interesting, SGRs are also very rare, probably because of their short life cycle, $\sim10^4$ yr. It is suggested that about 10 per cent of all NSs were born as magnetars (Kouveliotou et al. 1998) and appeared as SGRs in their youth. It would be very important to detect these sources outside the Local Group. Especially, it is interesting to understand the birth rate of SGRs and the fraction of the NSs that produce these sources.

Here, we would like to discuss the possibility of observing SGRs outside the Local Group (for previous discussions of extragalactic SGRs, see Mazets et al. 1982; Duncan 2001, and the recent paper by Nakar et al. 2005). The detection of such objects will give us an opportunity to study the properties of SGRs with larger statistics. In this paper we focus mainly on the regions of active star formation. The connection between SGRs and star formation is obvious. Being very young objects, SGRs have to trace the regions of massive star production. The higher the star formation rate (SFR), the larger the number of SGRs. In addition, recently, several authors have suggested that magnetars should be born from the most massive stars that still produce NSs (Figer et al. 2005; Gaensler et al. 2005).[3] Thus, there is a clear relation between the SGR formation rate and the SFR of massive stars (and so the supernova rate).

We discuss three types of sites for the observations of extragalactic GFs and HFs:

(i) close-by (<5 Mpc) galaxies with high SFR should give the main contribution to the detection of GFs and HFs;
(ii) few galaxies with extreme values of SFRs (so-called 'supernova factories') are the best sights to search for rare HFs;
(iii) HFs also can be expected to be detectable from the Virgo cluster of galaxies.

In the next section, we focus on the first topic, the remaining two are discussed in Sections 3 and 4. We also discuss the use of the Burst and Transient Source Experiment (BATSE) data[4] as an archive to search for GFs and HFs. So far, this experiment has provided the best possibilities for detection of bursts of high-energy radiation because of its half-sky exposure, long observation time and high sensitivity.

2 GIANT FLARES FROM NEARBY GALAXIES

As discussed by Heckman (1998), inside the 10-Mpc radius, 25 per cent of star formation is due to just four well-known galaxies: M82 ($d = 3.4$ Mpc), NGC 253 (2.5 Mpc), NGC 4945 (3.7 Mpc) and M83 (3.7 Mpc). Obviously, inside $\sim$4–5 Mpc (this is the limiting distance for the BATSE detection of a GF; see Fig. 3 and the discussion in the text) their contribution is even higher. The main idea which we put forward here is the following. In BATSE data, the close-by galaxies with a high present-day SFR are the best sites to search for SGRs outside the Local Group.

We scale the SGR activity by the rate of supernova bursts, assuming that the number of SGRs is proportional to the supernova rate and the activity of each source is identical. Usually, uncertainties in supernova (SN) rates vary by a factor of 2–3. As a simple estimate, let us use the following values: 0.4, 0.2, 0.3 and 0.1 SN per year for M82, NGC 253, NGC 4945 and M83, respectively. These values are obtained by scaling the mean SN rate of NGC 253 (0.2 SN per year; Engelbracht et al. 1998; Pietsch et al. 2001) using the far-infrared luminosity data given in Bregman, Temi & Rank (2000). Several investigations (see, for example, references in Bregman et al. 2000) have shown that the method based on the far-infrared luminosity allows us to estimate the relative SN rate with a high precision. Thus, the main uncertainty is the SN rate in NGC 253; however, this is a well-studied galaxy, and all estimates of the SN rate given in the literature are close to 0.2 SN per year.

In comparison with the Galactic SN rate, these galaxies have significant enhancement (roughly factors of 12, 6, 9 and 3, respectively). In total, the SN rate in the four galaxies is $\sim$30 times higher than that in the Milky Way. We can expect a proportionally higher number of SGRs (and GFs) from them. With the Galactic rate of about three flares in 25 yr, for BATSE (4.75 yr equivalent of all-sky coverage) we can expect roughly six to seven GFs from M82, three to four GFs from NGC 253, five to six from NGC 4945 and one to two GFs from M83 (in total about 15–20 GFs from four galaxies during the BATSE life cycle).

Could BATSE observe GFs from these galaxies? This is not a simple question. Surprisingly, we have no reliable estimate of the peak luminosity of the initial spikes in giant SGR flares. The problem is that they are so strong that all detectors become severely saturated during Galactic GFs. The situation was slightly better for the event of 1979 March 5 (Golenetskii et al. 1979; Mazets et al. 1979), as it occurred at a larger distance (in the LMC). Nevertheless, Venera 11 and Venera 12 detectors were still saturated. Using the raw count rate detected by Konus (see Fig. 1, lower curve), we obtain the maximal energy flux of $\sim0.3 \times 10^{-3}$ erg cm^{-2} s^{-1}. Golenetskii et al. (1979) estimate the peak flux to be 1.5×10^{-3} erg cm^{-2} s^{-1}. This estimate

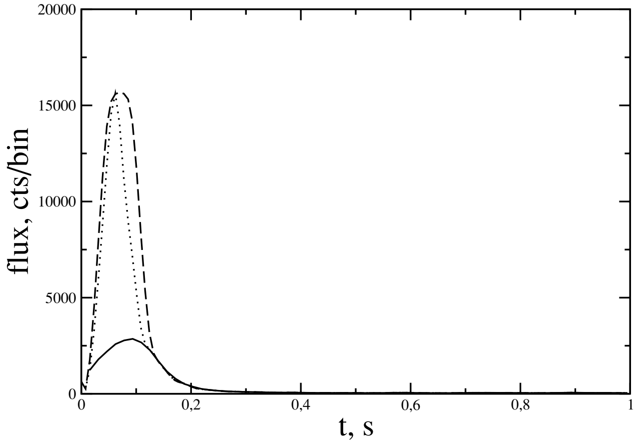

Figure 1. Assumed time profiles of the initial spike of the 1979 March 5 event. Different versions of the reconstruction are shown: solid curve, the raw count rate (subject of saturation); dotted curve, the reconstruction up to 1.5×10^{-3} erg cm^{-2} s^{-1} as a narrow top spike; dashed curve, the reconstruction to the same level but as a wider top spike. Curves are smoothed.

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[3] Note that the NSs originated from massive progenitors are expected to be massive themselves (Woosley, Heger & Weaver 2002). There are many properties that distinguish massive NSs. Here we want to mention the possibility of solid core formation (Alpar & Ho 1983), which can lead to an opportunity to support strong glitches.

[4] See http://cossc.gsfc.nasa.gov/batse/.

corresponds to the luminosity of 0.8×10^{45} erg s^{-1}. The difference between these two values is probably a result of the correction for the dead time.

To estimate the distance from which such an event can be observed by BATSE, we use the spectrum measured by Golenetskii et al. (1979) (there exists, however, a different reconstruction of this GF spectrum by Fenimore, Klebesadel & Laros 1996; see discussion below) and different versions of the count rate curve (see Fig. 1). The first version is just the raw count rate and can be considered as a conservative lower limit. It corresponds to the energy release in the initial spike 2×10^{43} erg. The second version is a narrow top spike reaching the level of count rate 10^6 cts s^{-1} corresponding to the peak flux 1.5×10^{-3} erg cm^{-2} s^{-1} and 0.45×10^{44} erg energy release. The third version corresponds to the same peak intensity but with a wider top, and therefore to a larger total energy release 0.6×10^{44} erg. The reconstruction of the profile is somewhat arbitrary (the third version is the closest to the reconstruction by Golenetskii et al. 1979) and should be treated simply as an illustration of possible variations.

In each case, the spectrum by Golenetskii et al. (1979) was folded with the BATSE detector response matrix (Pendleton et al. 1999) at a random orientation of the satellite relative to the burst arrival direction. Then, the simulated counts were added to one of the real background fragments sampled from the BATSE continuous archive records with simulated Poisson noise in 64-ms bins. Finally, the BATSE triggering scheme was applied to each synthetic burst. The probabilities of BATSE triggering versus the distance to the source are given in Fig. 2. Curves in this figure (and in Fig. 3) are normalized in such a way that the asymptotic value, which is reached at small distances, represents the sky coverage of detectors.

In the first case (solid curve, the Konus raw counts), the only large galaxy in the detectable range is M31. No appropriate candidate for the GFs from M31 has been detected by BATSE (Bisnovatyi-Kogan 2001). This is not surprising as it is not expected that the SGR activity in M31 is higher than in our Galaxy, and BATSE during its lifetime observed only one GF – the doubtful event from SGR 1627−41, which is not considered to be a real GF by many authors. In the second and third cases (dotted and dashed lines), GFs from the four nearby galaxies with high SFR mentioned above are detectable, albeit as fairly weak bursts with a poor angular accuracy.

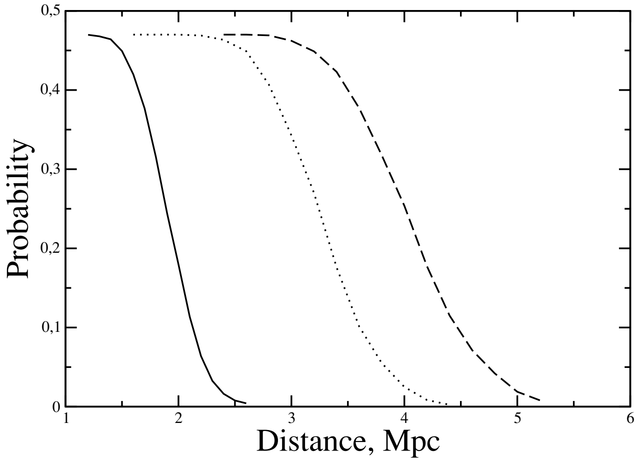

Figure 2. The probability of the BATSE detection of a GF similar to the 1979 March 5 event as a function of distance. The real BATSE exposure factor, the representative background sample, the detector response matrix and the triggering procedure are taken into account. The curves correspond to different versions of the time profiles shown in Fig. 1. For small distances, the curves approach the asymptotic value defined by the sky coverage of BATSE.

It is useful to check whether there are potential SGR candidates in these four galaxies in the BATSE catalogue. We have to look for short bursts with T_{90} less than 2 s at least (the burst from SGR 1627−41 was longer than initial strong spikes from the three other SGRs). In the duration table of the BATSE catalogue, the number of GRBs shorter than 2 s is 500. The expected number of chance overlaps of their error boxes with the four galaxies is 9.4 (2.36 per local object). Actually, we have 12 overlaps of 11 GRBs, which is consistent with the expectation for chance coincidence. We have added a few overlapping GRBs that are not in the duration table but have an approximate estimate of duration within 2 s. All these short GRBs are given in Table 1. For each burst, we give its trigger number, coordinates, error box radius, T_{50} and T_{90}, energy release in the source at the distance corresponding to the galaxy with which the error box overlaps, and hardness ratios – counts in BATSE channels 2 (50–100 keV) and 3 (100–300 keV), respectively, to that in channel 1 (25–50 keV). Coordinates and error box radii are given in degrees.

Can some of these events be the GFs originated in the four galaxies? Their energy releases are comparable to that estimated for the 1979 March 5 event.

If we accept the requirement that the time profiles of GFs should be smooth structureless pulses the same as the 1979 March 5 event, then we have to exclude four events (triggers 3895, 6255, 6547 and 7385) from the list because they have a substructure. If we require that the duration of GF spikes is between 0.1 and 0.3, as that of the three detected GFs, then we have to exclude triggers 2054, 7297, 6447, 7361 and 3895. If we suggest that the spectrum, measured by Golenetskii et al. (1979), represents a typical spectrum of a GF, then we have to exclude almost all events.

Indeed, this spectrum, once folded with the BATSE detector response matrix, gives the following count ratio in the three energy channels (1 : 2 : 3): 1 : 1.36 : 0.58. All events are much harder except triggers 7970 and 7591, which are just slightly harder.

To what extent should we rely on the spectrum by Golenetskii et al. (1979)? Fenimore et al. (1996) reanalysed the ISEE-3 data for this event and obtained a much harder spectrum, which is inconsistent with the Konus data. It should be noted that both reconstructions have their own problems. The Konus data are integrated over the 3.28-s time interval and are contaminated by approximately 1/3 of photons from the softer pulsating tail.[5] The ISEE-3 detector observed the flare through the spacecraft, and the reconstruction relies on the difficult simulation of the photon transfer through the instrument with a complicated matter distribution.

We should recognize that we have no solid hypothesis of the GF spectra: the data are available for only one event and are rather ambiguous. If we still rely on the Konus spectrum as on that obtained in a more straightforward way, then we have to accept two events as a conservative upper limit to the observed number of GFs from the four galaxies. In this case, the 90 per cent upper limit on the expected number of observable GFs (i.e. with the energy release $>0.5 \times 10^{45}$ erg; see Fig. 2 and Table 1) in these galaxies during BATSE exposure is ∼5 (i.e. ∼1 yr^{-1} for all four galaxies). The rate of such GFs in our Galaxy (not per source) should be ∼30 times less, or ∼1/30 yr^{-1}. This is smaller than has been observed.

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[5] See the raw count rate curve at http://www.ioffe.rssi.ru/LEA/SGR/Catalog/Data/0526/790305.htm.

Table 1. GRBs coincident with SF galaxies.

Trigger number	α	δ	Error box	T_{50} (s)	T_{90} (s)	Energy $\times 10^{44}$ erg	Ratio 2/1	Ratio 3/1
M82	148.95	69.68						
2054	164.33	66.15	17.91	–	$\sim$1	–	–	
3118	117.57	80.37	23.0	0.136	0.232	1.1	3.4	5.0
6255	148.68	60.79	12.71	–	$\sim$0.4		1.2	1.6
6547	155.18	62.23	13.58	0.029	0.097	0.37	1.7	2.1
7297	140.07	76.39	9.53	0.438	1.141	2.1	2.	3.4
7970	136.87	64.49	8.48	0.157	0.387	1.3	1.1	0.9
M83	204.25	−2987						
1510	198.84	−3435	7.29	–	$\sim$0.1	–	1.3	1.7
2384	203.8	−1821	17.81	0.128	0.192	0.50	1.3	1.3
2596	211.51	−2707	19.74	–	$\sim$0.3	–	2.0	3.0
5444	199.44	−3151	4.94	–	$\sim$0.1	–	1.6	1.4
6447	191.44	−366	14.77	0.256	1.024	1.2	1.5	1.9
7361	204.17	−2829	7.28	0.960	1.856	1.6	1.9	3.1
7385	203.02	−2781	3.59	–	$\sim$0.2	–	1.4	1.4
8076	199.39	−2998	7.39	0.075	0.218	1.4	1.9	7.9
NGC 253	11.9	−253						
2312	14.72	−3356	8.93	0.112	0.272	0.87	1.2	12.2
7591	15.75	−3266	8.03	–	$\sim$0.5	–	0.9	0.9
NGC 4945	196.5	−495						
2800	200.29	−4794	15.92	0.320	0.448	1.3	1.6	2.1
3895	189.39	−4772	6.99	0.384	0.768	1.3	$\gtrsim$1.4	$\gtrsim$2.0
6447	191.44	−366	14.77	0.256	1.024	1.2	1.5	1.9

If we admit an arbitrary hardness for GFs, then we have 10 candidates with suitable time profiles and durations and the above constraint relaxes to $\sim 1/10\ \mathrm{yr}^{-1}$, which is in good agreement with the observations.

3 HYPERFLARES IN THE 50-MPC VICINITY

The situation with supergiant flares like that of 2004 December 27 is quite different because the BATSE sampling volume for such events is larger by more than three orders of magnitude (i.e. accessible distance is larger by a factor of 10). The data indicate that the spectrum of this flare is much harder than that of the 1979 March 5 event: according to Hurley et al. (2005), the spectrum of the initial spike of the 2004 December 27 flare can be described by a blackbody with a temperature of 200 keV. It seems only natural that the events that differ by two orders of magnitude in the energy release have different spectra. Fig. 3 shows the probability of detection of a 2×10^{46} erg flare by BATSE for two spectral shapes: as suggested by Hurley et al. (2005) and for the spectrum of the 1979 March 5 event from Golenetskii et al. (1979). The sensitivity is lower in the case of a harder spectrum because of a smaller number of photons in the 50–300 keV band at the same energy release.

The largest structure inside the sampling distance $R \sim 50$ Mpc is the Virgo galaxy cluster (the cluster centre is $\sim$17 Mpc away, and the approximate coordinates of the centre are $\alpha = 187°.5$, $\delta = 12°.5$). It contains about 1300 galaxies including 130 spirals (see Binggeli, Tammann & Sandage 1987 for details). The total SFR in the cluster is a few hundred times larger than in our Galaxy. BATSE should be able to detect supergiant flares from the Virgo cluster as fairly strong bursts. We selected short GRBs detected by BATSE with $0.05 < T_{50} < 0.7$ s. There are 402 such events. Only two of these are projected on to the Virgo cluster (assuming it as a circle with 10° radius).[6] Their trigger numbers are 2896 (coordinates, $\alpha = 180°$, $\delta = 8°.92$; energetics, 1.8×10^{46} erg at 17 Mpc) and 6867 (coordinates, $\alpha = 185°.37$, $\delta = 10°.02$; energetics, 0.3×10^{46} erg). Three more events have error circles overlapping

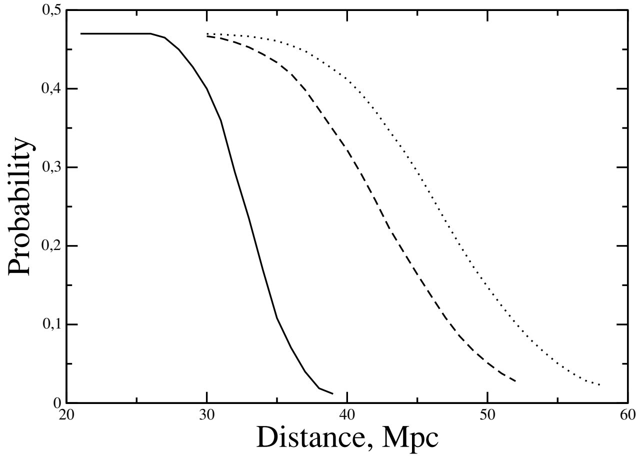

Figure 3. The same as Fig. 2, but for a HF with the energy release 2×10^{46} erg in the initial spike and the same spectrum as for the GF of 1979 March 5. The dashed and dotted curves correspond to different time profiles as shown in Fig. 1. The solid curve corresponds to the thermal spectrum with $T = 200$ keV, as suggested in Hurley et al. (2005); for this curve the time profile corresponds to the dotted curve in Fig. 1.

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[6] The expected number of chance projections is about three.

with Virgo. This result, again, is within the expectation for a chance projection. Again, we have no evidence of any HF detections, and this allows us to put a 90 per cent upper limit on the event rate: $\sim$2 HFs in the Virgo cluster during the BATSE exposure (assuming two detected at three expected coincidences and two expected intrinsic). This implies that on 2004 December 27 an exceptionally rare event was observed. The rate of such bursts (with energy release in the initial spike above $\sim 5 \times 10^{45}$ erg) is below $10^{-3} \times SFRV_{500}$ yr^{-1} per galaxy, where $SFRV_{500}$ is the SFR rate in the Virgo cluster divided by 500 galactic SFRs: $SFRV_{500}$ = (SFR in Virgo)/(SFR in the galaxy × 500). This constraint coincides with that by Nakar et al. (2005) using a different method. When this work was completed in its original form, the paper by Palmer et al. (2005) appeared. These authors presented (without a detailed discussion) a similar constraint, still three times higher, using the Virgo cluster argument.

There are two other promising candidates for the HF detection within 50 Mpc outside the Virgo cluster. These are Arp 299 (Neff, Ulvestad & Teng 2004) and NGC 3256 (Lipari et al. 2004), two galaxies with extreme SFRs (‘supernova factories’). The total SFR in these galaxies is a few times lower than that in the Virgo cluster, and therefore they are a less probable source of HFs in the BATSE data.

Nevertheless, these galaxies are of great interest because they are well localized and can lead to measurements with a better angular resolution. A number of candidates for HFs from these galaxies are given by Popov (private communication[7]). It is interesting to note that the same two galaxies were discussed by Smialkowski, Giller & Michalak (2002) and Smialkowski et al. (2003) as possible sources of ultrahigh-energy cosmic rays. Together with the recent suggestion by Eichler (2005), this brings another flavour to the problem of the high-energy activity of magnetars and its link with star-forming galaxies.

4 DISCUSSION

We do not see any convincing BATSE detections of SGR GFs from the nearby star-forming galaxies. This non-detection allows us to put a constraint on the total galactic rate of GFs and HFs with the energy release in the initial spike $>0.5 \cdot 10^{44}$ erg. This rate has to be less than 1/25 yr^{-1} (note that this estimate is based on the assumption of a low hardness of GFs; see Section 2). The observations of flares from the sources in our Galaxy indicate that the rate of GFs + HFs is higher; still, we can conclude that most of them have energy release in the initial spike $< 0.5\times 10^{44}$ erg. The only evident exception is the flare detected on 2004 December 27; therefore, this upper limit is not in conflict with the data.

The absence of detections of HFs from the Virgo cluster makes the recent HF of SGR 1806−20 an exceptionally rare event. A possible beaming of the emission does not change the conclusion: in this case we just have to state the same about the observational probability of such event. However, the conclusion is based on the flare energetics calculated for the SGR 1806−20 distance estimate of 15 kpc. If it is less than 5 kpc, then BATSE could not observe HFs from the Virgo cluster and the constraint should be relaxed. However, recent analysis (McClure-Griffiths & Gaensler 2005) suggests that the distance is >6 kpc.

In any case, the conclusion by Hurley et al. (2005) that a large fraction of short GRBs detected by BATSE can actually be the initial spikes of extragalactic HFs seems too enthusiastic. If the distance estimate of 15 kpc is correct, then the Virgo constraint is valid and we can renormalize it to the sampling sphere of the radius of 50 Mpc. The average total SFR in this sphere is $\sim$ a few thousand M$_\odot$ per year. This estimate can be obtained in several ways. For example, Duncan (2001) uses the following expression to obtain an estimate of a number of galaxies similar to the Milky Way: $N_{\rm Gal} = 0.0117\, h_{65}^3\, R_{\rm Mpc}^3$. For $R = 50$ Mpc we obtain about 1500 galaxies. So, for 4.5 yr of observation we can expect nearly 800 GFs and about 200 HFs assuming three GFs and one HF observed in the Milky Way in 25 yr. Similar estimates can be obtained using the estimates of Brinchmann et al. (2004) and Gallego et al. (1995). Brinchmann et al. (2004) provide the following value for SFR density at $z = 0.1$: 0.01915 M$_\odot$ yr^{-1} Mpc^{-3}. Inside 50 Mpc it gives $\approx 10^4$ M$_\odot$ yr^{-1} Mpc^{-3}. The SFR for the Milky Way is estimated to be a few solar masses per year. So, the ratio is about a few thousand. Gallego et al. (1995) estimate the SFR in star-forming galaxies for $z \lesssim 0.045$ as 0.013 M$_\odot$ yr^{-1} Mpc^{-3}. This gives $\approx$6800 M$_\odot$ yr^{-1} Mpc^{-3} inside 50 Mpc. All three estimates are in good agreement. Comparing these values of SFR with a few solar masses per year in our Galaxy, we conclude that BATSE could observe $\sim 30 \times SFRV_{500}$ supergiant flares during its 4.75 yr of full-sky exposure, i.e. not more than a few per cent of the total number of short GRBs. If the distance to SGR 1806−20 is within 5 kpc, then the sampling volume reduces and we arrive at approximately the same estimate.

In this paper, as in the previous literature, we assume the rate and luminosity of GFs to be constant. However, this should be considered as only a zeroth approximation, because all types of NS activity usually decrease with time (for example, the rate of glitches; Alpar & Ho 1983). If we hypothesize that the rate of GFs decays with time as $\propto t^{-\alpha}$, then two interesting consequences can be discussed. The first is the following. For $\alpha > 1$, it becomes more probable to discover a younger magnetar (if the energies of flares are the same for all ages). In this case, we can safely claim that in our Galaxy there are no magnetars younger than the four known. Then it is necessary to note that, for larger α, the rate of flares in the magnetar youth becomes so high that the energy of the magnetic field, $\sim 10^{47}\, B_{15}^2$ erg, is not sufficient to support numerous GFs with luminosities similar to that of 1979 March 5. This can explain the fact that no good GF candidates were found from star-forming galaxies. In the four nearby star-forming galaxies there should be SGRs $\sim$10 times younger than the Galactic ones; in galaxies such as Arp 299 and NGC 3256 we expect to find magnetars with ages of about a few tens of years. If they produce frequent bursts, then non-detection should mean that their luminosities are lower than those exhibited by the galactic sources.

As noted by Hurley et al. (2005), *Swift* gives an excellent opportunity to observe extragalactic GFs and HFs of SGRs. We would like to emphasize that the most promising targets for such observations are the Virgo cluster (for HFs) and galaxies M82, M83, NGC 253 and 4945 (for GFs).[8] Of course, because of the large field of view of *Swift*, several objects can be observed simultaneously. The possibility to detect a very strong HF from a young SGR, as discussed by Hurley et al. (2005), is much higher in the case of galaxies with extreme star formation. Arp 299 and NGC 3256 can be good targets for such observations.

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[7] See Popov (2005).

[8] Long pointings of the *International Gamma Ray Astrophysics Laboratory* (*INTEGRAL*) in the direction of the Virgo cluster potentially can also result in the detection of GFs or/and HFs. Unfortunately, *INTEGRAL* Galactic plane scans do not cover Virgo or any of the six galaxies discussed in this paper.

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