Anomalous grouping of some short BATSE GRBs

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The power spectra of the short BATSE bursts' lightcurves were analyzed. The sky distribution of the GRBs with high harmonic power shows an extraordinarily strong dipole moment.

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Abstract

The power spectra of 457 short BATSE bursts were analyzed, focusing on the $64ms$ lightcurves' tails in the low energy bands. Using MC simulations, 22 GRBs were identified with unusually high harmonic power above $0.03Hz$. The sky distribution of these bursts shows an extraordinarily strong dipole moment with a 99.994% significance.

Data processing and power spectrum analysis

The shape of the gamma-ray burst's lightcurves of the BATSE Gamma-Ray Burst Catalog (Meegan et al. 2000) carry an immense amount of information. Here we focus on the possible SGR-like contamination in the BATSE data. We created our data from the BATSE DISCSC $64ms$ dataset keeping in mind that the distant SGR signals could be very similar to the short GRBs: a bright short peak and a - probably weak, noisy - extended periodic emission in the low energy bands. Therefore during the processing

- the three background-subtracted lowest energy bands (below $320keV$) were joined to reduce the noise.
- we've used FFT to calculate the power spectrum with a window size of 1024 samples ($65.536s$). The lowest frequency was $f = 0.03052Hz$ ($T = 32.768s$), and the highest is $f = 7.8125Hz$ ($T = 0.128s$).
- the first $8.192s$ data was excluded from the signal after the trigger ($T0$): this ensures that the strong, short GRB lightcurve does not interfere with any possible tail signal.
- the starting time of the 1024-sample-sized sliding window increases with 256 samples ($16.384s$) until the window's endpoint reaches the end of the data.
- to reduce the power spectrums sensitivity to edge effects a Blackman window was used: this data windowing prevents leakage from the nearby frequency components (Press et al., 1992). This also reduces any spurious effects originating from the non-perfect background subtraction.
- each data block was whitened before the FFT. No data winzorization was applied.

The data are very noisy (of course most of them probably contains of noise only!), therefore we used a MC simulation to determine the significance of any probable signal.

For each block 500 random signals were generated by shuffling the data: the maximum value in the power spectrum of each this MC signal was compared with the real signal's maximum value. We select only bursts where the real signal's maximum value is bigger than any maximum in the MC signals. We also require that the candidate trigger should produce such harmonic power signal at least for two different window starting point (but overlapping windows were not excluded).

These requirements select 22 GRBs with unusually high harmonic power above 0.03 Hz. Fig. 1. shows the power spectra of these bursts with the corresponding window start times.

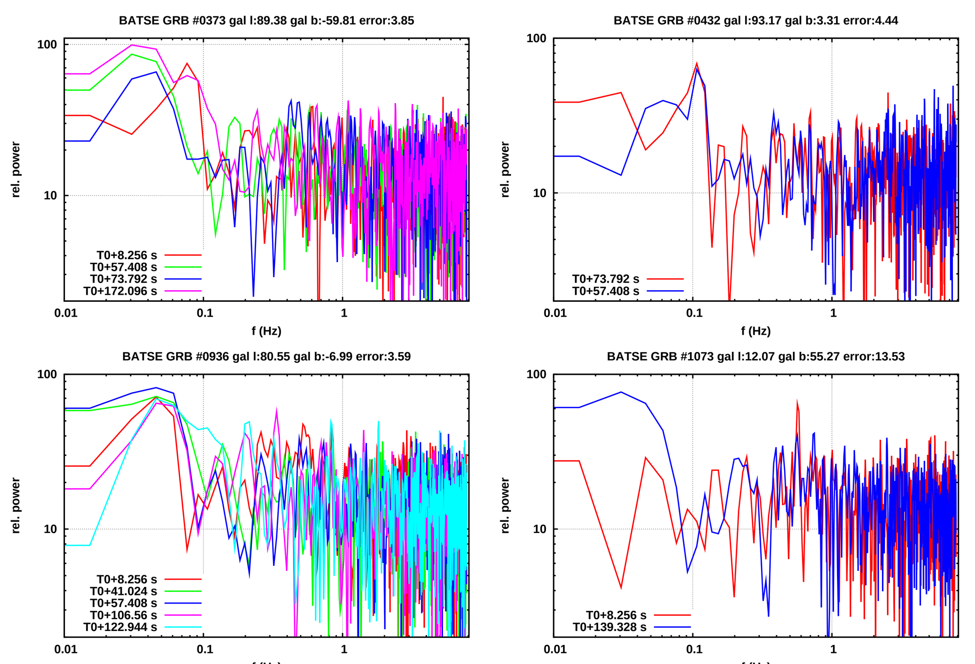

Fig. 1.: Power spectra of the selected 22 BATSE triggers with different window start points.

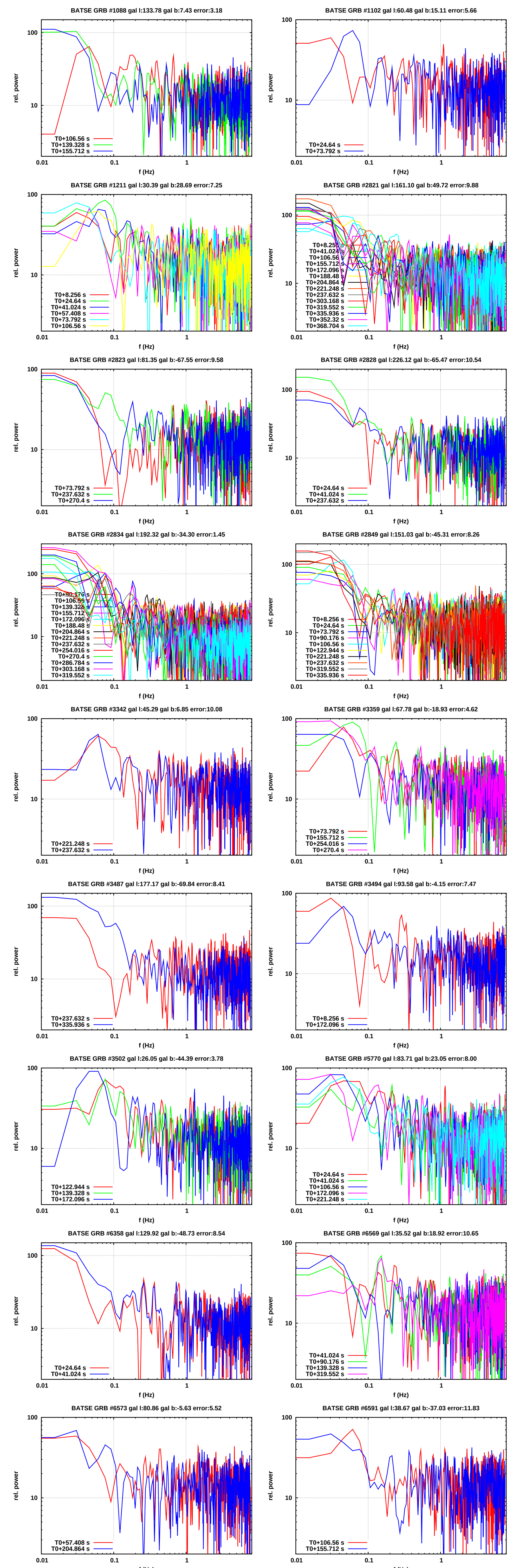

Fig. 1. (continued)

Discussion

On Fig. 2. we show some triggers' folded phase-frequency diagram and (selected) folded pulse shape. One can observe that some of the signals appears to be periodic: however we should keep in mind that for these triggers have only one kind of observation with fixed time resolution ($64ms$), so it is very hard to assign real significance levels to these curves.

The sky distribution of the selected 22 triggers is plotted with on Fig. 3. with the BATSE GRBs. To check the randomness we calculated the dipole components from the selected subset and from 50000 cases of a random 22-element sample drawn from the complete BATSE database: this method fully eliminates the non-uniform sky-exposure function. We've got only 3 random cases where the dipole's magnitude was bigger than the 22 triggers' dipole, giving an extraordinarily strong dipole moment with a 99.994% significance (approx. 4σ). The direction of the dipole is $l \approx 82^o, b \approx -19^o$.

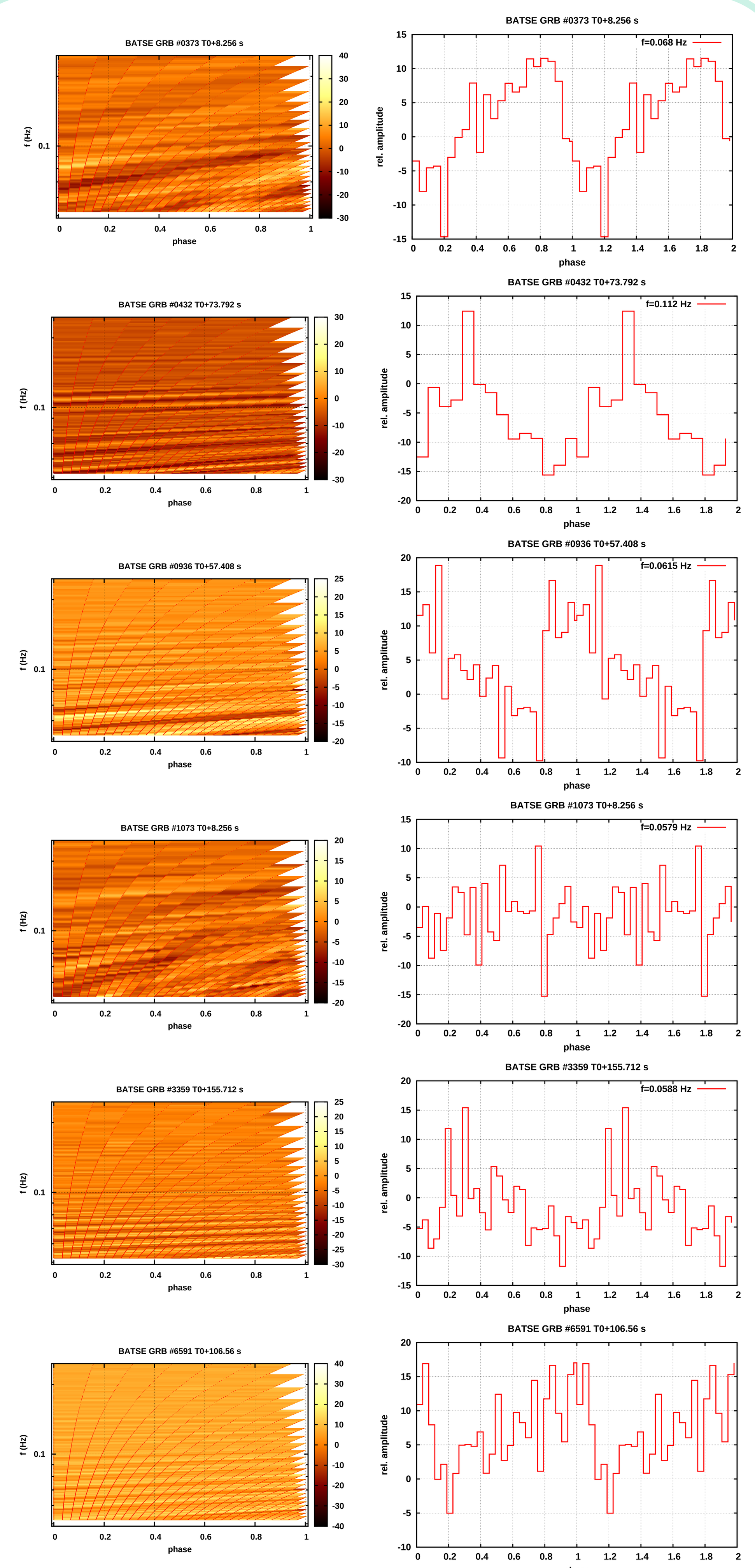

Fig. 2.: Some folded phase-frequency diagrams and folded pulse shapes of the selected triggers.

The celestial distribution of the short BATSE bursts shows anisotropic behavior (e.g. Mészáros et al. 2000, Vavrek et al., 2008). Our results suggests that maybe some anomalous subgroups are responsible for this effect: for a more detailed answer a deeper study of this effect is needed, which is planned to be provided in a forthcoming paper.

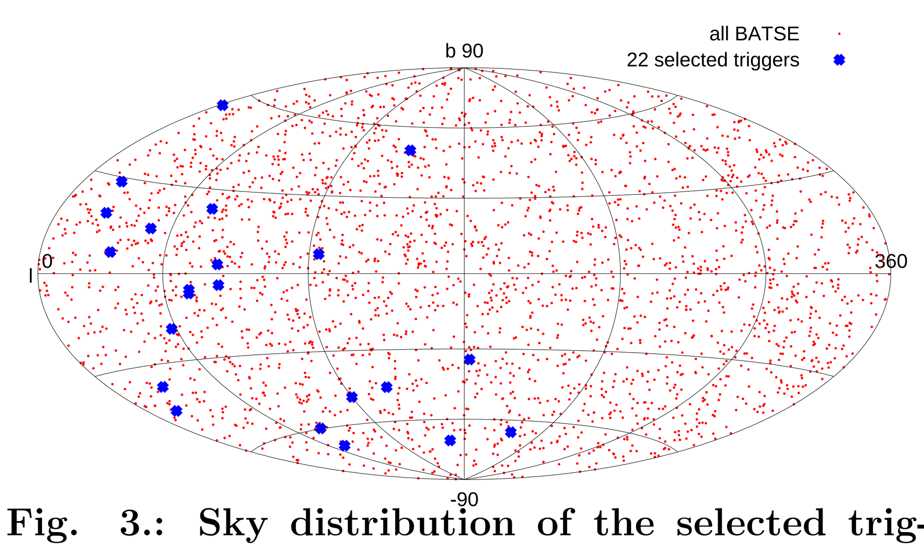

Fig. 3.: Sky distribution of the selected triggers.

Acknowledgements

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