Correspondence of gamma radiation coming from GRBs and magnetars based on the effects of nonlinear vacuum electrodynamics

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Introduction

Magnetar is a young neutron star. They emit a variety of electromagnetic waves: X-ray and gamma-ray spectrum. These bursts lasts from millisecond to a month [Kaspi, Beloborodov 2017]. Magnetar's bursts are powered by the powerful magnetic field inside of it. By taking into account the probability of boosting of core circular magnetic field covered by forceful reaction in a protoneutron star coming after a core-collapse supernova the magnetar model was created[Duncan and Thompson, 1992]. Historically magnetars were initially presented by covering the name Soft gamma repeaters(SGR) and anomalous X-ray pulsars(AXP) [Olausen and Kaspi (2014)]. There are 34 objects that are considered to be detected as magnetars: 10% of them might be young neutron star populations. There are 23 confirmed magnetars: 8 are found in supernova remnants, other 2 magnetars are likely identified in supernova remnants [Kaspi, Beloborodov 2017].

The first catalogue of observed magnetar models and their complete characteristics were made by Olausen and Kaspi, in 2014. Height scale of the known magnetar was detected to be about 20-30 pc (parsec). This scale height confirmed the magnetars to be young. Majority of magnetars from the catalog, made by Olausen and Kaspi [Olausen and Kaspi (2014)], were discovered by their X-ray bursts by the sensitive all-sky monitors such as Burst Alert Telescope (BAT) boarded in Swift Gamma-Ray Burst Mission and Gamma-Ray Burst Monitor (GRB) boarded in Fermi Gamma-Ray Space Telescope. As well as magnetars X-ray burst activities they make X-ray pulsation in the period of range of 2-12 s[Kaspi, Beloborodov 2017].

Introduction

It appears that studying the data from the catalogue of Gamma-Ray Bursts (GRBs) can be used to study the birefringence phenomenon in the magnetosphere of the magnetars. By analysing the data from the McGill Online Magnetar and HEASARC Fermi Burst Catalogues, in this work we studied the angular distances between the nearest GRBs and magnetars in projection, built their distribution map as detected by 2020, and the relative lag time periods of lights coming from GRBs and magnetars. It is confirmed that there are 29 galactic magnetars and their candidates, while the other two are located out of the Milkyway. The maximum separation angle for GRB and Magnetar projectiles was 3.76 degrees (4U0142+61 and GRB110818860), while minimum angular resolution was 0.54 degrees (SGR 1627-41 and GRB090829672). Currently, we discuss the relationship of GRB light intensity by their lag time as it would come after bending by the magnetosphere.

Sky distribution of the 2915 GRBs(Gamma-ray bursts) in the fits catalogue on an Aitoff-Hammer projection in Galactic coordinates

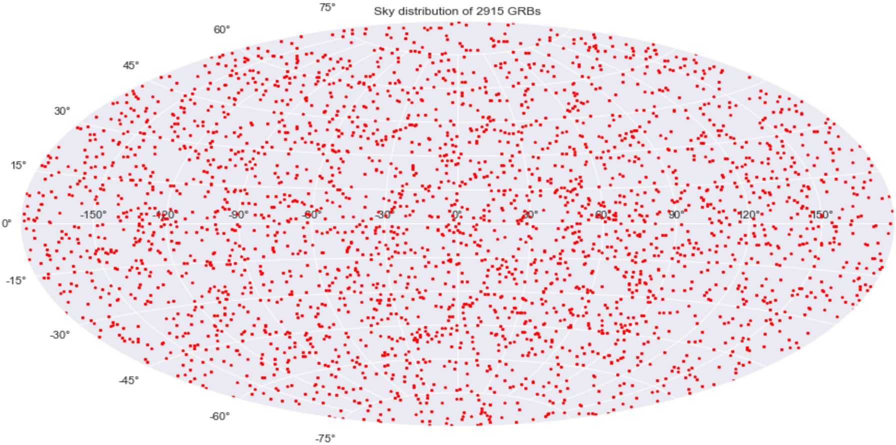


Figure: This sky distribution of GRBs is made by downloading a fits file from HEASARC Catalogue search website (heasarc.gsfc.nasa.gov) in November, 2020 observed by Fermi's Gamma-ray Burst Monitor (Fermi-GBM)[A. von Kienlin et.al 2020]

Sky distribution of the 31 magnetars on an Aitoff-Hammer projection in Galactic coordinates

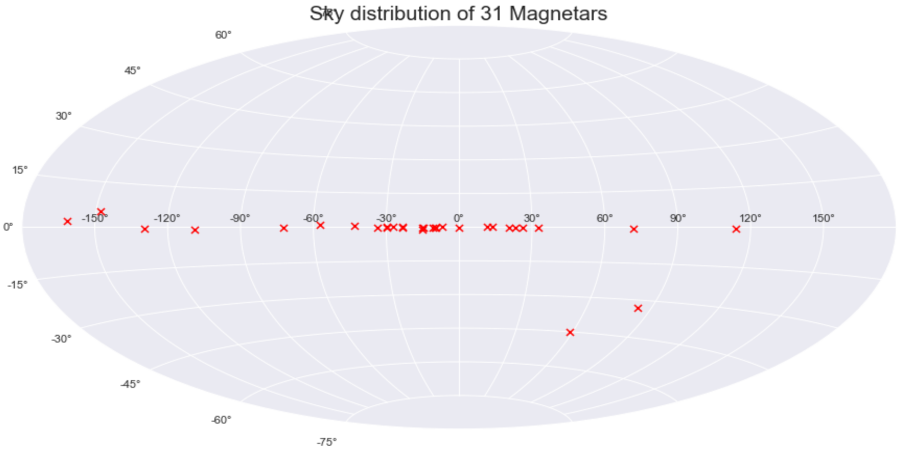
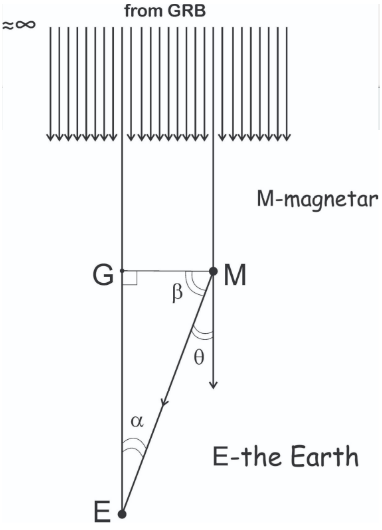


Figure: This sky distribution of the known magnetars and their candidates is made by downloading the data from McGill Online Magnetar Catalog in November, 2020 from McGill Online Magnetar Catalog website (http://www.physics.mcgill.ca/ pulsar/magnetar/main.html)[A. von Kienlin et.al 2020]

Light propagation scheme



Light from GRB source comes to the Earth by passing through a magnetar with lag time. This lag time gives us confirmation of light birefringence in the magnetosphere.

Minimum projection distance between the magnetars and GRBs

GRBs	Magnetar	Alpha
GRB080905570	CXOU J010043.1-721134	2.9234704881725913
GRB110818860	4U 0142+61	3.767978585313013
GRB130304658	SGR 0418+5729	1.089316641751766
GRB110319628	SGR 0501+4516	1.9631572054873685
GRB181026540	SGR 0526-66	2.547729164878236
GRB141102536	1E 1048.1-5937	0.6566874156571401
GRB170803415	1E 1547.0-5408	3.1998094223969407
GRB140619490	PSR J1622-4950	2.592769128269518
GRB090829672	SGR 1627-41	0.5472111752760878
GRB190630257	CXOU J164710.2-455216	1.5136564604965215
GRB120711446	1RXS J170849.0-400910	2.9581220244849953
GRB140511095	CXOU J171405.7-381031	3.985935427990667
GRB160819852	SGR J1745-2900	1.0518603224852783
GRB160819852	SGR 1806-20	1.937537866327015
GRB160819852	XTE J1810-197	2.64305773138453
GRB160819852	Swift J1818.0-1607	2.139826610641807
GRB140627401	Swift J1822.3-1606	1.9029105517340408
GRB150811849	SGR 1833-0832	1.9280541559108166
GRB150811849	Swift J1834.9-0846	1.697742830421751
GRB171010792	1E 1841-045	1.4936299439495893
GRB150705588	3XMM J185246.6+003317	2.4123994836491907
GRB140723067	SGR 1900+14	1.250321684302351
GRB140723067	SGR 1935+2154	3.1833074345130083
GRB140723067	1E 2259+586	2.926173052515109
GRB120224898	SGR 0755-2933 #	2.3800831451396873
GRB171120556	SGR 1801-23 #	1.934459650364455
GRB180517309	SGR 1808-20 #	1.7004876760564158
GRB151118554	AX J1818.8-1559 #	1.9513409886251882
GRB130404877	AX J1845.0-0258 #	1.9421856334357939
GRB170511477	SGR 2013+34 #	3.2905129043370898
GRB151212064	PSR J1846-0258 ##	2.2823978757600987

Here, firstly, we defined angular distance between the GRBs, as well as for magnetars. Then we calculated minimum projection distance between the magnetars and GRBs

Lag time for light bend on magnetars

Magnetars	Lag time, ly
CXOU J010043.1-721134	264.87343753612197
4U 0142+61	25.38127530684909
SGR 0418+5729	1.1788968453768347
SGR 0501+4516	3.8286730255960038
SGR 0526-66	172.80263536515537
1E 1048.1-5937	1.927994353232809
1E 1547.0-5408	22.88223672556337
PSR J1622-4950	30.050154230262688
SGR 1627-41	1.6362509616985454
CXOU J164710.2-455216	4.438585606767802
1RXS J170849.0-400910	16.51467036756156
CXOU J171405.7-381031	104.13816080044568
SGR J1745-2900	4.561762344903259
SGR 1806-20	16.222914461191102
XTE J1810-197	12.143809398051896
Swift J1818.0-1607	10.91688009036491
Swift J1822.3-1606	2.8778451722059155
SGR 1833-0832	nan
Swift J1834.9-0846	6.013287093043652
1E 1841-045	9.41956763383781
3XMM J185246.6+003317	20.52311399111039
SGR 1900+14	9.70704223956588
SGR 1935+2154	nan
1E 2259+586	13.608373077807125
SGR 0755-2933 #	nan
SGR 1801-23 #	nan
SGR 1808-20 #	nan
AX J1818.8-1559 #	nan
AX J1845.0-0258 #	15.926099668981207
SGR 2013+34 #	47.319605247074094
PSR J1846-0258 ##	15.524840356920727

Lag time for the nearest GRBs and magnetars were calculated by the formula of

$$\Delta L = ME - ME\cos\alpha$$

ΔL is late distance for GRB

Conclusion

It is confirmed that there are 29 galactic magnetars and their candidates, while the other two are located out of the Milkyway. The number of GRBs we studied is 2915. The maximum separation angle for GRB and Magnetar projectiles was 3.76 degrees (4U0142+61 and GRB110818860), while minimum angular resolution was 0.54 degrees (SGR1627-41 and GRB090829672). There are five candidates of lag time period for GRBs (GRB130304658, GRB110319628, GRB141102536, GRB090829672, GRB140627401) and corresponding magnetars(SGR 0418+5729, SGR 0501+4516, 1E 1048.1-5937, SGR 1627-41, Swift J1822.3-1606) we expect to study in the future. Currently, we discuss the relationship of GRB light intensity by their lag time as it would come after bending by the magnetosphere.

References

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Thank you!