GRBs and SGRs as precessing gamma jets.

D. Fargion
Physics Dept. Rome, Univ. 1; INFN, Rome; Ple A. Moro 2, Italy
Physics Dept. Technion Institute, Haifa, Israel

Abstract

The GRB980425-SN1998bw association put in severe strain and contradiction the simplest “candle” fireball model for GRBs. We probed that statistically the association is reliable, the energy luminosity and probability puzzles between cosmic and near by GRBs find a solution within a precessing gamma jet model either for GRBs and SGRs. The expected repetitiveness for GRB980425 has been already probably observed on GRB980712.
1 Introduction

1.1 The GRB luminosity/energy puzzle

The recent GRB980425 event [2] has been observed in apparent peak gamma flux comparable with previous exceptional GRB971214 [1] one: \( < l_{1\gamma} > \simeq 1.2 < l_{2\gamma} > \). However these two GRBs locations are extremely different: the GRB980425 event, if associated with nearest SN1998bw explosion and its host galaxy ESO 184-G82, took place at near redshift \( Z_1 = 0.0083 \), while the far away host galaxy for GRB971214 burst is found at redshift \( Z_2 = 3.42 \).

Consequently their intrinsic average gamma luminosity \( < L_{\gamma} > \) and energies \( < E_{\gamma} > \) ratio and the peak gamma luminosity \( L_\delta \) (defined by the peak GRB flux in the sub-burst events), following standard cosmological models, are huge (for isotropic burst) because of their extremely different distances:

\[
\frac{< L_{1\gamma} >}{< L_{2\gamma} >} = \frac{< l_{1\gamma} > \left[ z_1 + (1 - q_0^{-1}) (\sqrt{2q_0 z_1 + 1} - 1)^2 \right]}{< l_{2\gamma} > \left[ z_2 + (1 - q_0^{-1}) (\sqrt{2q_0 z_2 + 1} - 1)^2 \right]}
\]

\[
\simeq \frac{< l_{1\gamma} >}{< l_{2\gamma} >} \frac{< l_{1\gamma} >}{< l_{2\gamma} >} \simeq 2 \cdot 10^5
\]  

(1)

\[
\frac{< E_{1\gamma} >}{< E_{2\gamma} >} = \frac{\int L_{1\gamma} \, dt}{\int L_{2\gamma} \, dt} \simeq \frac{\Delta \tau_1}{\Delta \tau_2} \frac{< l_{1\gamma} >}{< l_{2\gamma} >} \simeq 4 \cdot 10^5
\]  

(2)

\[
\frac{L_{1\gamma}}{L_{2\gamma}} \simeq \frac{l_{1\gamma}}{l_{2\gamma}} \frac{z_1^2}{z_2^2} \simeq 10^7 \div 10^8
\]  

(3)

where \( \Delta \tau_1, \Delta \tau_2 \) are the observed GRBs durations. The approximations hold because of the negligible dependence on \( z \) and on the deceleration parameter \( q \) (for any deceleration values smaller than unity) in the squared bracket in equation 1. Most observed cosmological parameters do require \( q \leq 1 \).

1.2 The credibility of GRB980425-SN1998bw association

These five-six order of magnitude for near-far GRBs gamma average luminosity ratio put serious doubt on the existence of any unique isotropic "can-
dle GRB-model”, as the most celebrated fireball-hypernovae ones. Before questioning the credibility of those models, let first inquire the credibility of GRB980425-SN1998bw association. The last near GRB has been found in only in the wide field (WF) Beppo-Sax camera contrary to better localized optical transient (OT), all at optical association, within the SAX narrow-field detector (NF): GRB970228 [3],GRB970508 [4],GRB971214 [1] and recent GRB980703 [5]. In particular let us compare again the April 98 and December 97 GRB event probability $P$, ratio $R \equiv P_1/P_2$ to find any OT within each of them by chance at SAX narrow-field solid angle $A_1 = \theta_1^2 = (1')^2$, at SAX wide field (WF) solid angle $A_2 = \theta_2^2 = (8')^2$ and at their corresponding redshift ($z_1 = 3.42, z_2 = 0.0083$) volumes:

$$R_{1/2} = \frac{P_1}{P_2} \simeq \frac{A_1 z_1^3}{A_2 z_2^3} \simeq 1.1 \cdot 10^6 ;$$

this huge number implies that it is more reasonable and honest to wonder on the ”cosmic” associations than to negate the local GRB980425/SN1998bw one (whose probability to occur by chance is smaller than $10^{-4}$). Even restricting the cosmic GRBs area $A_1$ at tiny optical sizes (arc seconds) one still finds a large probability (> 300) ratio favoring the April 98 association respect to any cosmic one. In brief it is statistically significant the GRB980425 location at SN1998bw at a distance within about 40 Mpc. The same cannot be said for the cosmic GRBs events.

2 GRBs open questions and the crisis of the fireball model

Once we agreed on the nature of nearest April 98 GRB event and taking for grant the far cosmic GRB locations, we face, following ”candle” models, again the luminosity/energy puzzle in equations (1) and (2). Maybe we are just observing two different kind of GRBs ? Maybe the nearest one (if isotropic and ”homogeneous” in all the wavelength emissions) is weaker than the far event at $z=3.42$ ? At least the optical intensity state the opposite: the GRB April was comparable with the far away one on December 97. Indeed their average peak optical intensities (intrinsic $L_{OT}$, apparent $l_{OT}$) ratio are:
where $M_2 \simeq 12.5$, $M_1 \simeq 21.5$ are the observed peak magnitudes in R band of the OTs; therefore the peak gamma luminosity (equation 3) and the optical ratios exhibit strident opposite behaviours for any “candle” fireball source. Finally we notice that the integral optical luminosity $< L_{OT} >$ for the two events is comparable while their gamma fluxes are extreme (equation 4). Moreover the ratio between peak gamma luminosity over OT one is:

$$\frac{L_{1\gamma}}{L_{2\gamma}} : \frac{L_{OT_1}}{L_{OT_2}} \geq 10^7$$

(6)

How can one concert so many order of magnitudes in an unique ”candle” isotropic GRB model? In astrophysics one may be allowed to play one-two order of magnitudes, no more. Therefore ”classical” standard fireball model is no longer acceptable. However we notice, like for a Fenice, the arise, by some authors of new ”generations” of GRBs classes of ”fireball scaled” models [6]: S-GRBs for near SN GRB, C-GRB for Cosmic GRBs. These model proliferation is analogous to what already occurred before for Soft Gamma Ray Bursts. Originally these bursts whose nature was also bursting and sudden like GRBs (as well as their overeddington luminosity), where all within GRB dictionary. Once their local (galactic) and softer repeatability nature was better defined, the theorists split their fate from all other ”mysterious” GRBs. The SGRs are not yet well understood as fireballs, even new ”isotropic” models (magnetar starquake) attempted to solve their origin. We do believe SGRs are linked to GRBs. There may and indeed exist an unified GRB model able to answer most of the puzzling questions above as well as the related following ones.

2.1 The GRB signature puzzle

Let us look deeper on GRBs puzzling nature of the near/far GRBs within an isotropic candle model.

a) Why the nearer GRB was ”softer” than the cosmic ”harder” far anyway ones ? The observed soft-hard nature of nearer April GRB and cos-
mic far GRBs is in strident disagreement with cosmological expansion predictions: any red shift for cosmic GRB fireball, with candle spectra, would always appear softer (at least by a factor $\Delta \nu / \nu \simeq (1 + z_1) \sim 4.4$) and not, as observed, harder than near ones.

b) Why the time structure of near GRB was smoother than the rapid structured cosmic GRB on December 1997? The cosmic expansion, once again, would lead to an opposite behaviour: a standard red shifted GRBs must appear relativistically Doppler-shifted and time diluted $(\Delta \tau / \tau \simeq (1 + z_1) \sim 4.4)$ while the GRB980425-GRB971214 data smoothly structured show exactly the opposite.

c) Why the intensity of GRB where in opposite ratio (as already noticed in Eq. 1-2) while a single candle model would just naturally imply the opposite (larger gamma flux for nearer burst) by a factor $z_2^2 / z_1^2 \sim 1.7 \cdot 10^5$?

d) Why statistically, we were able to observe so "many" (even just one) near GRBs in such a nearby small redshift volume? A simple statistical argument imply that if GRB are homogeneous in space and time the far GRB should be much more numerous than few (or just unique) observed ones as GRB980425. For our two extreme events:

$$\frac{P_1}{P_2} \simeq \frac{z_1^3}{z_2^3} \simeq 7 \cdot 10^7$$

(7)

Some strong bias must suppress this huge number for far gamma GRBs. Otherwise we were exceptionally lucky to see a nearest GRB980425. As God does not like to play dice, neither GRBs do.

e) Why GRBs are not (always) time coincident with the rise of the optical transient? This is well known and observed for GRB970508 (which grew in optical intensity days after its GRB) as well as for the extrapolation of optical-radio flux of GRB980425. A gamma fireball would not wait so long to lead to an optical signal. Anyway within “one shoot” fireball model an unique trigger time for OT, X, $\gamma$ and radio events would be naturally expected.
f) Finally, if local GRBs are not a rare event, and if they are isotropic, one must find a "growth" in the number count-flux diagram at lowest flux above the inhomogeneous decay. Indeed the number of SGRs (near GRBs) at redshift $z \geq 0.0083$, might pollute the lowest region of number count test.

This imply that the "cosmological" (or space-time) inhomogeneity in number count may be hidden by a more significant nearby source population, contrary to the naive cosmological interpretation of GRB counts.

3 Toward the answer: a beaming gamma jet

The first simplest solution to solve the GRB luminosity puzzle within an unified GRB model is to look for a "geometrical" enhancement (by a narrow beam) able to lead, when observed at different angular sides, to large intensity modulations. This beaming occur naturally for relativistic jet with angle $\theta \sim 1/\gamma$ originated by micro-quasars like objects as those recently discovered in our galactic halo. Any "large" cone beam ($\theta \geq$ few degree size), is not able to reconcile at least the six or seven order of magnitudes in extragalactic GRBs intensities.

A tiny highly collimated beam is necessary ($\theta \sim 10^{-3} \div 10^{-4}$) also within an inverse Compton Model for GRBs able to scatter low energy photons (I.R. or BBR) to highest energies. Moreover if one desire to correlate the GRB nature with their soft-gamma SGRs sources an intensity decay must be required to scale the GRB power toward S-GRB with time.

3.1 Are GRBs an episodic beamed pulse?

Is GRB just an impulsive (unique burst) [7] beamed event? If this is the case we may increase by many orders ($8 \div 10$) its apparent luminosity but we face a "probability puzzle" related to the rarity to observe (within a cone $\theta^2 \sim 10^{-7} \div 10^{-9}$) a SN burst jet at low redshift (for the optical burst there is no need or indications for beaming), pointing toward us.

Moreover this "burst" solution will not explain the fine structured and fast variable nature of some GRB neither the puzzling repeating nature of SGRs.
4 GRBs and SGRs as multiprecessing Gamma Jet

Therefore we are forced [8] to consider the GRBs as due to multiprecessing Gamma Jets (as the recent discovered microquasar objects in our own galaxy). In our first approach we believed that all GRBs were all like SGRs, i.e. within a wide galactic halo. Until February 97 GRB we were afraid to require, for a mini-jet power, too large energies rate comparable with SN ones. We now consider their nature (following latest evidences for some cosmic location) either at their oldest stages in our own galactic halo [9] in the role of Soft Gamma Repeaters (SGRs) and, at their earliest epochs, near their SN-like birthdate, while at their peak intensity. The most powerful Gamma Jets beamed to us are observed far away (cosmic C-GRBs), while nearer and local ones (S-GRBs like SN1998bw) are more rare for statistical reasons (smaller volume). Repeaters are due to their nearer location and consequent more intense apparent gamma flux, which may be seen also at wider beam periphery.

The Inverse Compton Scattering, probably fueled by high energy electron pairs, converts low energy photons (infrared or cosmic black body ones) into a coaxial collimated gamma jet at MeV energies. The relativistic kinematics imply that the inner jet cone contains most intense and hardest radiation. The photons at outer coaxial jet cones are less abundant and less energetic. Nearest sources (galactic-local SGRs / S-GRBs) may be observed either bursting, rarely, in their peak inner core or, often, blazing and/or flaring from wider peripheral jet regions. Far away cosmic GRBs are observable (by present detectors) only during their peak apparent intensity no longer than their gamma jet birth, marked by optical SN explosion, within their inner and harder beam jet. The energy decay of the jet output makes far away GRBs observable within few days from SN optical transient, which explosion is a nearly isotropic burst, and whose consequent radio tail is partially beamed by synchrotron radiation.

Let us describe more in quantitative detail the GRB genesis and evolution
towards SGR regime. We first imagine a star collapse or, better, a binary stellar system feeding a collapse and explosion. The asymmetry of the system defines an axis of the relic compact object (a neutron star NS or black hole BH) which becomes the source of a thin jet. The exact acceleration and collimation of the jet is still a mystery; ultrarelativistic beamed cosmic rays source (from the compact NS and BH) or electromagnetic acceleration and confinement is needed. The recent observational evidence of the reality of such microquasar jets in our Milky Way as GRS 1758-258, GRS 1915+105 and GRB J1655-40 is well based and widely accepted. The ejected matter contains an ultrarelativistic electron pair beam which is highly collimated, \( \theta \leq \frac{1}{\gamma_e} \); the Inverse Compton Scattering of these electron pairs on thermal photons (I.R. or cosmic BBR) is a source of a new collinear gamma jet (along the electron pair one). As an order of magnitude we assumed the electron pair energy \( E_\gamma \sim 10 \text{ GeV} \) and their target thermal photon just like the 2.75 \( K \) Black Body Radiation; then \( K_B T \approx 2.75 K \), \( \gamma_e \approx \frac{E_e}{m_c c^2} = 2 \cdot 10^4 \). It is possible to show [9],[10] that the differential number distribution for gamma jet photons from Inverse Compton Scattering of monochromatic ultrarelativistic electron pair on isotropic BBR is:

\[
\frac{dN_1}{dt_1 \, d\epsilon_1 \, d\Omega_1} \simeq A_1 \epsilon_1 \ln \left[ \frac{1 - \exp \left( \frac{-\epsilon_1 (1 - \beta \cos \theta_1)}{k_B T (1 - \beta)} \right)}{1 - \exp \left( \frac{-\epsilon_1 (1 - \beta \cos \theta_1)}{k_B T (1 + \beta)} \right)} \right] \left[ 1 + \left( \frac{\cos \theta_1 - \beta}{1 - \beta \cos \theta_1} \right)^2 \right] \tag{8}
\]

where \( A_1 \) is a normalization factor defined by the intrinsic electron jet flux intensity, \( \epsilon_1 \) is the electron pair energies, \( T \) is the target thermal photons, \( \theta_1 \) is the angle between the electron jet axis and the observer. After the energy integral \( \epsilon_1 \), the adimensional differential number rate becomes [9]

\[
\frac{\left( \frac{dN_1}{dt_1 \, d\epsilon_1} \right)_{\theta_1 (t)}}{\left( \frac{dN_1}{dt_1 \, d\epsilon_1} \right)_{\theta_1 = 0}} = \frac{1 + \gamma^4 \theta_1^4 (t)}{\left[ 1 + \gamma^2 \theta_1^2 (t) \right]^4} \sim \frac{1}{(\gamma \theta_1)^4} \tag{9}
\]

where the value at fixed angle \( \theta_1 = 0 \) is the peak gamma flux and \( \beta, \gamma \) are the ultrarelativistic velocity and Lorentz factor of electron pairs. Consequently the adimensional photon number as a function of the small precessing angle \( \theta_1 \) grows as
\[
\frac{\left(\frac{dN}{dt_1 \, d\theta_1}\right)_{\theta_1(t)}}{\left(\frac{dN}{dt_1 \, d\theta_1}\right)_{\theta_1=0}} \approx \frac{1 + \gamma^4 \theta_1^4(t)}{[1 + \gamma^2 \theta_1^2(t)]^4} \theta_1 \approx \frac{1}{(\theta_1)^3},
\]

the last approximation holding for \(\gamma \theta \gg 1\). This number density rate is proportional to the observable gamma luminosity of GRBs (peak luminosity in equation 3). Finally the total photon gamma fluence outside the beam cone at maximal impact angle \(\theta_{1m}\) recorded from GRBs (due to such precessing gamma jets) is

\[
\frac{dN}{dt_1}(\theta_{1m}) \approx \int_{\theta_{1m}}^{\infty} \frac{1 + \gamma^4 \theta_1^4}{[1 + \gamma^2 \theta_1^2]^{1/4}} \theta_1 \, d\theta_1 \approx \frac{1}{(\theta_{1m})^2}.
\]

In a first approximation this influence is proportional to the observed GRB energy.

Now let us assume for the gamma jet power an initial "standard candle" power of intensity \(I_1\). We assume, for sake of simplicity, an initial beam power comparable to the maximal optical power associated with the isotropic SN/GRB jet birth:

\[
I_1 \approx 10^{44} \text{ erg s}^{-1}.
\]

The above gamma beam power \(I_1\) is proportional to \(A_1\) the electron jet one in equation 8. Their proportionality is related to ICS efficiency which here is assumed within unity.

A jet power like this, while beamed within a thin jet cone of angle \(\theta_e \approx 10^{-4} \text{ rad}\) may explain an apparent power as large as \(P \sim 4\pi I_1 \theta_e^{-2} \approx 10^{52} \div 10^{53} \text{ erg s}^{-1}\). Our assumption in equation 12 is based on a very reasonable energy equipartition argument.

Let us also assume a decay power law \(\left(\frac{t}{t_0}\right)^{-\alpha}\) for the jet intensity; a conservative one, inspired by optical GRB evolution, implies \(\alpha \geq 1\).

We may calibrate the characteristic power time scale requiring that the initial young GRB intensity at later stages will correspond, as an order of magnitude, to the ones (\(\sim 1000\) years old) observed gamma precessing jets which
behaves, in our own galaxy, as SGRs. This power is nearly $10^{38} \text{erg s}^{-1}$. Therefore the jet power at any time $t$ is:

$$I_{jet} = I_1 \left( \frac{t}{t_0} \right)^{-\alpha} \simeq 10^{44} \left( \frac{t}{3 \cdot 10^4 \text{s}} \right)^{-1} \text{erg s}^{-1}$$

(13)

where $t_0$, in the last expression, is derived assuming a power exponent $\alpha \approx 1$. The beaming angle is assumed below $10^{-4} \div 10^{-3}$ radiant, depending on exact relativistic jet nature. The apparent GJ power is $4\pi \gamma_e^2$ enhanced corresponding to peak luminosity $L_\gamma \simeq 10^{53} \div 10^{54} \text{erg s}^{-1}$.

5 The Jet Beam probability to hit the observer

The above model tools allow us to understand the puzzling low probability in equation (7) ($\sim (7 \cdot 10^7)^{-1}$) to observe the near April GRB respect to cosmic GRBs; we remind that, after one year of Beppo Sax era, one found, within nearly 300 GRBs, only one such a GRB. Therefore one need an amplification factor $A_2$, related to a wider observation area cone, amplification able to complements the puzzling ratio in equation 7:

$$A_2 \simeq 7 \cdot \frac{10^7}{300} \simeq 2.5 \cdot 10^5 .$$

(14)

This geometrical solid angle amplification factor is naturally related to a corresponding observation angle $\theta_1$ for April event respect to a very narrow observation angle for cosmic thin beamed GRBs:

$$a_2 \simeq \sqrt{A_2} \sim 500 .$$

(15)

Assuming for a December GRB event an angle $\theta_{Dec} \simeq \frac{1}{\gamma_0} \sim 10^{-4}$, this implies that near April GRB event was seen within

$$\theta_{Apr} \simeq a_2 \theta_{Dec} \simeq 5 \cdot 10^{-2}$$

(16)

a cone only few degrees wide. In the frame of one “shoot” GRB model we would observe the GRB event with a low probability ($2 \cdot 10^{-4}$). On the
contrary within a continuous precessing gamma jet model one finds additional probabilities due to the integral time. As a first approximation the probability to be blazed and flashed by such a "wide" precessing beam cone, assuming a characteristic time delay between the supernova event (and its optical light beginning) as observed ($\Delta \tau \approx 2$ day) and a characteristic GRB duration ($\Delta \tau_{GRB} \sim 20$ s), is

$$P \simeq \left( \frac{a \theta_{Dec}}{4 \pi} \right)^2 \frac{\Delta \tau}{\Delta \tau_{GRB}} \simeq 1 .$$  \hspace{1cm} (17)

Within a two-day period ($\sim 4 t_0$) the gamma jet intensity decreased and the final probability in the above approximation will be smaller but still within unity. Therefore the precessing GJ on April 25 had the possibly to blaze (as indeed happened) Earth within its wide light-house gamma beam. Could such a powerful jet repeat the hit? We know that SGRs (nearest sources) can. As we shall see in paragraph 7, the GRB possibly repeated on 12 July 1998.

6 The Gamma Jet intensity and its Repeater Nature

Let us verify if the near/far GRBs intrinsic luminosities within the present standard candle precessing gamma jet values are comparable to the observed ones. For an amplification angle $a \simeq 500$ one would expect a total number photon fluence ratio (between December cosmic event toward April near event) to be compared with average energy ratio in equation 2

$$\frac{N_{\gamma 1}}{N_{\gamma 2}} \simeq \frac{< E_{\gamma 1} >}{< E_{\gamma 2} >} \simeq a^2 \simeq 2 \cdot 10^5$$  \hspace{1cm} (18)

while the "peak" luminosity intensity as defined in equation 3 (related to the structured nature of the GRB, i.e., to the intrinsic peak luminosity at each internal GRBs mini-burst) is

$$\frac{L_{\gamma 1}}{L_{\gamma 2}} \simeq a^3 \simeq 10^8 ,$$  \hspace{1cm} (19)

11
these values are well within the observed ones. Moreover the characteristic time scales for near/far GRB signals must reflect (assuming a common precessing angular velocity) their different impact angle parameters: $\theta_{Dec} \approx \frac{1}{\gamma}$; $\theta_{Apr} \sim \frac{2}{\gamma}$. Indeed the minimal observed time scales of December rapid structured event is $\Delta \tau_{Dec} \simeq 10\, ms$ while the April smooth event, observed at a wider impact parameter is observed at time scales $\Delta \tau_{Apr} \simeq 20\, s$. Their ratio is, as an order of magnitude:

$$\frac{\Delta \tau_{Dec}}{\Delta \tau_{Apr}} \approx \frac{1}{a}.$$  

These general features, while giving an answer to most puzzles, favor the GRB interpretation as due to a precessing gamma jet in an unified model.

7 The probable repeating nature of GRB980425: GRB980712

Because the higher probability to observe again a near (intense) Gamma Jet, we may wait for a second GRB flash from GRB980425. Indeed the probability $P$ to re-observe the GRB within BATSE sensitivity is

$$P \simeq \int N \theta^2 \, dt \simeq \int \theta^{-2} I_0 t^{-\alpha} \theta^2 \, dt \approx t^{-\alpha + 1}$$  

(21)

where the intrinsic gamma luminosities and flux are $I \sim I_0 \, t^{-\alpha}$; $N \simeq \theta^{-2} \, I$. Therefore, even if $\alpha \geq 1$, we may re-observe the GRB within diluted time scales. One may easily notice a remarkable event just few days after the GRB980425: the GRB980430 (trigger 6715). It is the fourth GRB after SN1998bw and its location is within $\sim 4\sigma$ from the April event direction (whose error angle is $3.5^\circ$). The Poisson probability to occur by chance is not negligible ($\leq 2 \cdot 10^{-2}$). However the recent GRB event GRB980712, Batse Trigger 6917 only within $1.6\sigma$ from the angular direction of GRB980425 is also very possibly ($\leq 3 \cdot 10^{-2}$) a repeater signature of the precessing gamma jet. The additional association of a GRB trigger 6918 nearly 15 hours later, with a wider error angle makes this combined probability to occur a rare
chance \((10^{-4} \div 10^{-3})\). The duration time of the intrinsic time scales of progenitor GRB980425 and secondary repeater GRB980712 are related to the corresponding amplification on factor defined as in equation 13

\[
\frac{\Delta \tau_{04}}{\Delta \tau_{07}} \simeq \frac{20 \, s}{4 \, s} = 5 \simeq \frac{a_2}{a_1}
\]  

where \(a_2 \simeq 500\) and now we derive \(a_3 \simeq 100\). This value offers an indication of the gamma jet intensity evolution. Indeed the peak luminosity flux scales as:

\[
\frac{L_{04\gamma}}{L_{07\gamma}} \simeq \frac{I_2}{I_3} \frac{\theta_2^{-3}}{\theta_3^{-3}} \simeq \left(\frac{t_3}{t_2}\right)^{-\alpha} \left(\frac{a_2}{a_3}\right)^3 \leq 3.5
\]  

where \(t_3 \sim 78 \, \text{day} \sim 7 \cdot 10^6 \, s\) while \(t_2 \sim 2 \cdot 10^5 \, s\). The total fluence is

\[
\frac{N_{04}}{N_{07}} \simeq \frac{\langle L_{04\gamma} \rangle}{\langle L_{07\gamma} \rangle} \frac{\Delta \tau_{04}}{\Delta \tau_{07}} \simeq \left(\frac{t_3}{t_2}\right)^{-\alpha} \left(\frac{a_2}{a_3}\right)^2 \frac{\Delta \tau_{04}}{\Delta \tau_{07}} \geq 3
\]  

These values are at least comparable with the observed ones and offer a first suggestive probe of the GRB980425 repeater nature and the imprint of a precessing gamma jet blazing at least twice to us. The repeater nature of GRB980425 implies a clearer link between GRB and SGRs. The latter are old decayed precessing gamma jets observable in their SNR regions only within our extended galactic halo, and possibly at lower fluxes, from nearby galaxies within local group.

8 The SGR-GRB link, the new SGR1627-41 and the multi precessing gamma jet (GJ).

The discover of four identified SGRs in the last 20 years: SGR0526-66, located in Large Magellanic Cloud, and three galactic sources SGR1806-20, SGR1900+14 and the recent discovered SGR1627-41 toward galactic centre offer a deeper understanding of a precessing gamma model. The old jet stages, after a first SN event, as a precessing gamma jet, is possibly fed by
an accretion disk and/or a companion star (white dwarfs, NS ...) whose presence modulate the gamma jet directions in a precessing (quasi periodic) processes. In the most naive approximation the angular size between the jet and the source-Earth axis, \( \theta_1 \) (equations 8-11), is evolving by the binary angular velocity \( \omega_b \) as \( \theta_1(t) = \sqrt{\theta_{1m}^2 + (\omega_b t)^2} \); [10]. The time \( t=0 \) corresponds to the maximal intensity at minimal impact angle \( \theta_{1m} \). The GJ differential fluxes (equations 8-9-10) would be, in this case, very smooth and periodic. However the pulsar (or BH) source of the Jet must reflect its spin (\( \omega_{psr} \)) frequency in angle \( \theta_1(t) \) evolution if his angular momentum axis is not coincident with the GJ axis. This fast spinning will, usually, imprint the “trembling” millisecond behaviour of most structured GRBs. Finally the possible anisotropy of the GJ object (related for instance to its own different inertial momentum, orthogonal and parallel, to the spin axis \( I_\perp, I_\parallel \)) would modulate by nutation the beam-observer angle \( \theta_1 \) by an angular velocity \( \omega_N \sim \omega_{psr} I_\perp - I_\parallel / I_\parallel \). The combined multi-precessing and spinning beam angle will describe in the sky a multiple cycloidal (or epicycloidal) trajectory (almost stochastic) described 

in present approximation by 

\[
\theta_1(t) = \sqrt{[\theta_{1m} + \theta_{psr} \cos(\omega_{psr} t + \phi_{psr}) + \theta_N \cos(\omega_N t + \phi_N)]^2 + 
[\omega_b t + \theta_{psr} \sin(\omega_{psr} t + \phi_{psr}) + \theta_N \sin(\omega_N t + \phi_N)]^2}.
\]

These 4 amplitude angle parameters and their 3 arbitrary phases offer a wide arsenal to mimic most GRBs morphology and signature.

For the SGRs the event is, usually, less structured than GRBs and it simply implies a smaller (or null) angle \( \theta_{psr} \) between jet and angular momentum directions. Otherwise \( \theta_{psr} \gg \theta_b, \theta_N \). However the crossing of a precessing gamma beam toward observer is observable (because of the nearer locations of the sources) even at wider jet cone envelopes. This implies, as observed, softer spectra for SGRs and less structured one. A first rough estimate of the beaming solid angle is offered by the ratio \( \Delta \tau_{GRB} / \Delta \tau_{SGR} \approx \frac{10^{yr}}{1 s} \sim 3 \cdot 10^8 \sim \theta^{-2} \), in agreement with assumed Lorentz factors \( \gamma_e \approx 10^4 \). In particular the jet signature would be observable for nearest SGRs. Indeed the last SGR1627-41 is found in a supernova remnant G337.0-41 near galactic central regions. Its radio (843 Mhz) plerion image suggests the presence, in between the two radio lobes, of a jet source (of the plerions). Indeed the SGR1627-01 loca-
tion (R.A. $247^\circ$, Dec $\sim 47^\circ33'$) lays between the two lobes but above them. What is a possible reason of the slight asymmetry of the bent jet?

We already proposed long ago as evidence for precessing gamma jets, the spectacular [12] image of the twin rings around SN1987A. We understood their puzzling existence as the spraying of a conical precessing jets on spherical remnant of the red giant progenitor: we suggested that dipolar interaction of the jet object with magnetic field of the binary companion, at nearest perihelion, is responsible for large bending of the jets and consequent slight asymmetry of the two twin rings.

Here in analogy, we do understand the asymmetry on the SGR1627-41 location as due to the GJ binary interactions. In a rough approximation one may imagine the jets as “rowing” at any companion encounter and propelling the NS jet in opposite plerion directions [13]. This may also explain the predictable high velocity needed to push the SGR1627-41 far away from its original birth place just in between the plerion SNR centre.

9 Conclusions.

We questioned on the huge ratio between observational probability, luminosity, energy for GRB events far away or nearby as GRB971214 versus GRB980425. The six-seven order of magnitude ratios is against any ideal fireball/hypernova candle model. Some authors are still dubious on GRB nature of near events. New populations of fine tuned GRBs has been already proposed [6]. Here we have shown the general credibility of GRB980425 - SN1998bw connection, greatly more reliable than any cosmic associations (equation 4). We proposed to solve the multiples GRBs puzzles within an unique GRB model: a precessing gamma jet.

Its different geometrical observational features may solve, at once, opposite puzzles: the mysterious and unexplained rarity of near GRB (April) event (seven orders of magnitude in equation 7) compensated by its apparent low peak gamma luminosity (seven orders of magnitude in equation 3); the nearby SN1998bw has been observed at the wider jet cone periphery (increasing the observational probability) but its gamma flux is (in comparison with better on-line GRB981214 jet event) more weak and diluted and softer event. In a sentence, near GRB980425 pays its extreme statistical rarity by
blazing us just out of the beam, with an extremely low gamma flux. GRBs and SGRs are within an unique precessing gamma jet model observed at different beam-angle and at different ages. Extreme powerful beamed cosmic GRBs are hidden at highest redshift by dust and luminosity dilution. While at birth (near their isotropic SN optical event) they are observable if at cosmic distances within the GJ inner beam, at older ages their gamma intensities are decayed and the GJ are lost in the background noise. On the contrary nearby and/or young GJ may blaze us twice or more. This might be already occurred for recent GRB980425. Indeed GRB980430 Batse trigger 6715 is found within 4σ error angle from SN1998bw five days later and in particular GRB980712 (trigger 6917 and, possibly, 6918) is located within 1.6σ error angle from SN1998bw. These correlated events are favoring a GJ model over any one shoot fireball/hypernova S-CGR “candle” models. Our present solution of a unique GRB-SGR model is able to satisfy at once the rare probability (from Eq.7 to Eq. 17) puzzle as well as the far/near gamma luminosity puzzle (from Eq.2-3 to Eq.18-19) and the duration times scales (equation 20).

The present dynamic model similar to earlier stationary cosmic [15] and galactic [8-14] models prescribes repeatability [16] of nearest GJ and their non-thermal equilibrium. Indeed predicted intensity evolutions seem to satisfy observations (equations 22,23,24). Spectacular evidences of the precessing jet are found in the recent SGR1627-41 radio plerions, originated by its SGR jets; we proposed also optical evidences [12][13], related to SN1987A rings, as recently noticed [13-14-17-7]. We foresee the presence of a runaway pulsar relic in south-east direction respect to the original SN1987A centre (in opposite direction respect to intuitive expectation) and an optical jet source at SGR1627-41 centre. We might expect SN1998bw bursting again in gamma within a year from now. Finally the detailed images of nebula NGC6543 shown by Hubble (“Cat Eye” nebula) and its thin luminous jets fingers , the exceptional and inexplicable double cone sections found in Egg Nebula CRL2688 are probably the most detailed view showing an active precessing GJ in space seen on a lateral side.
Acknowledgments

The author wishes to thank Prof. G. Salvini for kind support, Drs R. Conversano, F. Chiarello, A. Salis, A. Aiello for useful conversations and help.

References

[1] Kulkarni S. R. et al. Identification of a host galaxy at redshift \( z = 3.42 \) for the \( \gamma \)-ray burst of December 1997. Nature 393, 35-39 (1998). Halpern J. P., Thorstensen J. R., Helfand D. J. & Costa E. Optical afterglow of the \( \gamma \)-ray burst of 14 December 1997.

[2] Galama T. J. et al. Discovery of the peculiar supernova 1998bw in the error box of GRB980425. astro-ph/9806175

[3] Costa E. et al. Discovery of an X-ray afterglow associated with the gamma-ray burst of 28 February 1997. Nature 387, 783-785 (1997). Van Paradijs J. et al. Transient optical emission from the error of the \( \gamma \)-ray burst of 28 February 1997. Nature 368, 686-688 (1997).

[4] Metzger M. R. et al. Spectral constrains on the redshift of the optical counterpart to the gamma-ray burst of 8 May 1997. Nature 387, 878-880 (1997).

[5] Smith D. A., Levine A. M. & Muno M. for RXTE/ASM teams: GCN GRB observation report n. 126 on 98/09/06. Galama T. J. et al.: GCN 127 on 98/09/06.

[6] Bloom J. S. et al. Expected characteristics of the subclass of Supernova Gamma-Ray Bursts (S-GRBs). astro-ph/9807050. 5 July 1998.

[7] Wang Lifan & Wheeler J. C. The Supernova-Gamma Ray Burst Connection. astro-ph/9806212

[8] Fargion D. The Inverse Compton Scattering and the Gamma Ray Burst Puzzle. Proceed. The Dark Side of the Universe. R. Bernabei, World Scientific, p.88-97, 1994.
[9] Fargion D., Salis A. Precessing Gamma Jets in the extended and evaporating galactic halo as the sources of GRBs. 3rd Huntsville Symposium GRB: AIP. Conf. 384; p.754-758 (1996).

[10] Fargion D., Konoplich R. V., Salis A. Inverse Compton Scattering on laser beam and monochromatic isotropic radiation. Z.Phys. C74; 571-576 (1997).

[11] Fargion D., Salis A. Time evolution of GRB spectra by a precessing light house Gamma Jet; 3rd Huntsville Symposium GRB: AIP. Conf. 384; p.749-753 (1996).

[12] Fargion D. GRB 980425/980712 repeater nature: GRBs as precessing Gamma Jets. The Astronomers Telegram. Atel # 31. 15July 1998.

[13] Fargion D., Salis A. Inverse Compton Scattering, Galactic Jets, GRBs and the Rings around SN1987A. Nuclear Phys B (Proc. Suppl.) 43, 269-273 (1995).

[14] Fargion D., Salis A. Precessing Gamma Jets, GRB and the twin Rings around 1987A. Astrophysics and Space Science, 231: 191-194, (1995).

[15] Blackman E. G., Yi I., Field G. B. Relativistic Precessing Jets and Cosmological Gamma-Ray Bursts. Ap.J. 479, L79-L82 (1996).

[16] Quashnack & Lamb D. Q., MNRAS, 265, L45-L50 L59-L64 (1993).

[17] Fargion D., Salis A. Gamma Ray Bursts, Inverse Compton Scattering and the precessing jets in galactic halo. Ed. Signore M. et al., NATO ASI, The Gamma Ray Sky - Vol 461, 397-408 (1995).

[18] Fargion D., Salis A. Inverse Compton Scattering onto BBR in high energy physics and gamma MeV-TeV Astrophysics. astro-ph 9605168; in press Uspekhi Physics (1998).