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The local-Galactic interpretation of the gamma-ray bursts

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Abstract. In this talk, I shall update my 16-year old claim that all the (thousands of) observed GRBs - both long and short, repeating or (so far) not - come from the surfaces of Galactic neutron stars, often called 'magnetars', or 'throttled pulsars'.

Key words. Gamma-ray bursts – Pulsars — Magnetars

1. Introduction

A fresh attempt is made to convey the message that all the detected and catalogued γ-ray bursts (GRBs) come from nearby Galactic neutron stars – rather than from cosmologically distant sources of similar type – as has already been thought during the 1980s. This conviction is sustained by their otherwise gigantic energies radiated at almost microscopic time scales, and their occasional extremely hard spectra, reaching and exceeding TeV energies. Relativistic redshifts stem not only from cosmic distances, but can likewise be generated by nearby Galactic neutron stars.

2. The GRBs, their afterglows, and their distances

Here at Vulcano, I have repeatedly talked about GRBs coming from nearby Galactic neutron stars, at distances between 10 and 500 pc, preferentially between 100 and 200 pc (Kundt, 2006, 2008a, 2009), so I will skip the historical part this time. I still like the generally accepted Galactic-neutron-star interpretation from the 80s, but not its later 'improvements' which were suggested by (i) the high isotropy of their celestial distribution, (ii) their cosmologically large redshifts, (iii) their occasional host galaxies, and (iv) their occasional (though rare) supernova-like appearances.

Item (i), the high 'isotropy', clearly asks for either a very near, or else a very far source population. Guided by their energetics, my preference is for the former: The sources fit nicely into the Milky-Way disk, with typical distances $\lesssim 10^{2.3}$pc, see Fig.1c. Why do we not observe a strong enhancement in directions of the Milky-Way disk? Not only because the farther the sources the dimmer, but also because the old neutron stars' low-mass accretion disks – assembled from the ISM – tend to be oriented preferentially at right angles to the Galactic disk (through which all stars oscillate). Their individual emissions are expected to be mildly beamed w.r.t. their disk planes, hence their superposition slightly beamed perpendicular to the Milky-Way disk, as already quantified in Kundt & Chang (1993). Note

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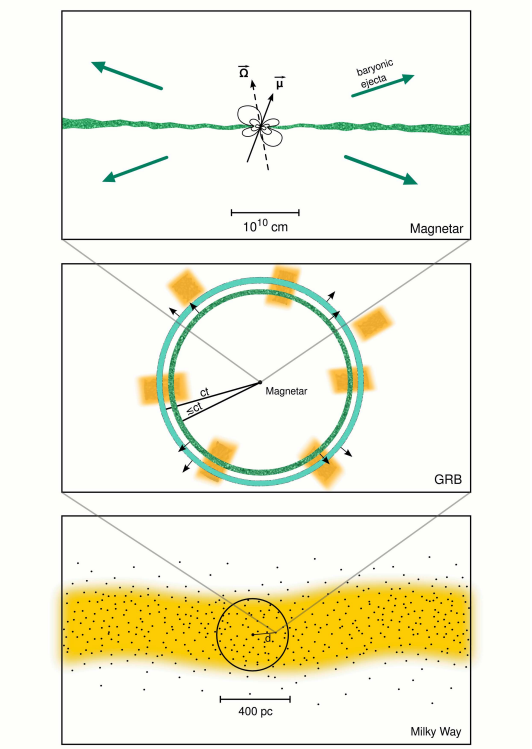

Fig. 1. Sketch of the (preferred, nearby Galactic) source morphology of all the GRBs. (a) The corotating magnetosphere of a throttled Galactic pulsar, or magnetar – usually of age some $10^{6.4}$ years, spin period between 5 and 12 sec – is strongly indented by its low-mass accretion disk, of typical mass some $10^{-5}M_\odot$. A GRB is emitted when a large chunk of (decelerated) matter, of mass some 10^{15}g , falls down upon its surface, from the inner edge of its (throttling) disk, and part of the chunk's matter is centrifugally re-ejected at transrelativistic speeds, across speed-of-light-cylinder distances, of order $10^{10.5}$cm. In this scenario, ions and electrons can be boosted to energies $\Delta W = e\int(\vec{+}^{E}\ \vec{\times}^{\beta}\ )^{B}\cdot d\vec{=}^{x}\ 10^{21}\mathrm{eV}(\beta_{\perp B})_{12}(\Delta x)_{6.5}$. (b) The disturbed magnetar emits a quasi spherical, γ-ray-hot electromagnetic flash (blue) closely followed by a trans-relativistic baryonic flash (green), both of which interact with the magnetar's CSM (of individual morphology, drawn yellow), and radiate the burst's afterglow. This scheme of interaction is thought to hold for all types of GRBs, both the short and the long ones, and also the SGRs (which are nearest to us). (c) These sporadic γ-ray bursters are comparable in number to the (Galatic) pulsars, in total some 10^7, and form an almost spherical distribution around the Sun for distances $\lesssim$ 0.3 kpc, whereby deviations from strict isotropy should increase with increasing distance, hence with decreasing brightness.

that with increasing sensitivity and duration of our surveys, the log(N)-log(S) diagram has increasingly evolved towards a (Euclidean) $S^{-3/2}$ distribution whose lower and upper turnover intensities $S_{\min}$ and $S_{\max}$ have moved apart from each other with observation epoch, corresponding to a growing distance ratio $d_{\max}/d_{\min}$ of the detected sources – because of $S \sim d^{-2}$ – from an initial 2 to a later 10, see Fig.13 in Fishman & Meegan (1995). There are many more faint bursts in the sky than were initially known, whose distribution may well map the (near part of the) Milky-Way disk.

Item (ii), the 'cosmological' redshifts of their afterglows, are often variable (Greiner, 2008), and do not correlate with distance

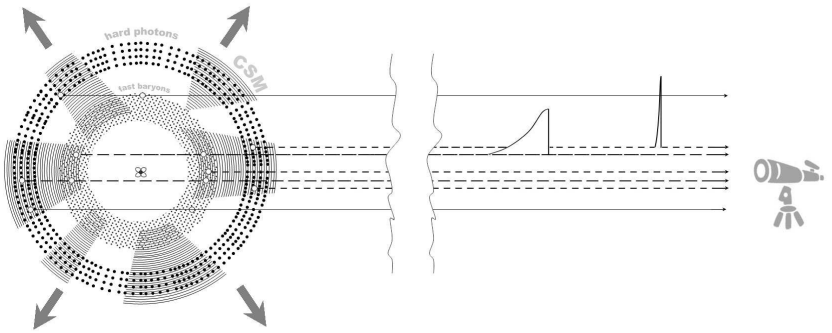

Fig. 2. Blown-up version of fig.1b, with a few blue- and red-shifted photon paths drawn in, both for emission and absorption lines.

(Song, 2008); in particular, the implied time-dilation of high-z bursts is absent in the data (Crawford, 2009). Instead, the observed redshifts can be understood as purely kinematic, reaching us from the far side of an expanding shell of baryonic ejecta, whilst their (bright) blueshifted analogues reach us only during short-lasting onsets of subbursts (FREDs), so far undetectably fast, cf. Figs.1b and 2. Observed redshifts of $z \lesssim 9$ correspond to Lorentz factors $\gamma \lesssim 5$, according to the 1-d Doppler formula

$$z + 1 = \gamma(1 + \beta) \ . \qquad (1)$$

We deal with transrelativistic ejecta of slowly spinning neutron stars – dying (or 'throttled') pulsars, often called 'magnetars' (Kundt, 2008a) – which impact onto their circumstellar medium (CSM) and cause it to flare, reminiscent of supernova (SN) ejecta, though less massive, and faster.

Item (iii), the often reported distant 'host galaxies', is plainly inconclusive. Originally, there was the 'no-host dilemma' of Brad Schaefer (1999) which demonstrated an anti-correlation between GRBs and large galaxies. None of the (massive) catalogued galaxies have ever served as a host for a GRB; the published hosts form a heterogeneous set of faint, low-mass, 'very peculiar' luminous objects (Savaglio et al, 2007). Some 50% of the proposed (50%) hosts of long GRBs ($\Delta t \gtrsim 2$s) may even be 'chance superpositions' (Cobb & Bailyn, 2007), so that only some 25% of all bursts have confirmed hosts. GRB 070125, a long burst, has been called a 'shot in the dark' by Robert Naye & Neil Gehrels, because no host could be found for it in a clear sky.

I like to think of the (well established) 'hosts' as light echoes, or transient reflection nebulae, to be considered below. The untenability of the host interpretation gets evident, in a large number of cases, via a simple energy balance: If a burst injected an (electromagnetic) energy of order $10^{54\pm1}$erg, or even $10^{55\pm1}$ erg (near TeV energies: Atkins et al, 2003), into a host galaxy of luminosity $\lesssim 10^{43}$erg/s (Savaglio et al, 2007), a significant percentage η of its injected power would be subsequently re-radiated by the burst's CSM, and be visible as a flaring (unresolved) afterglow point source of power $\lesssim 10^{48}\eta_{-2}t_6^{-1}$erg/s during the first few weeks and months t after the burst, with $t_6/\eta_{-2} \gtrsim 1$. This afterglow brightness would be strongly variable, controlled by the structure of the burst's CSM, and exceed the host's brightness (bolometrically) by some five times $\eta_{-2}t_6^{-1} \approx 5$ orders of magnitude! Nothing like this has ever been seen.

Item (iv), a coincidence with distant 'supernovae', has been reported for four or more bursts of long duration ($\Delta t \gtrsim 2$s) with lowest redshift z ($\lesssim 0.2$), cf. Bloom et al (1999). Their afterglows show a bump in the optical lightcurve looking like that of a SN, and even their optical spectra look SN-like, of (special)

type Ib or Ic. Instead of realizing a power-law decrease, their afterglows wane exponentially (for at least one month). Do we deal with coincidences between a SN and a GRB? Such a coincidence of explosions – of which we witness less than 5 per day in the whole Universe in the case of the GRBs, and less than 2 per week in the case of SNe – do not have a realistic a-priori chance of coinciding once per century in the sky unless they were causally connected. But a GRB lasts typically $\lesssim$ one minute whilst the first light from a SN comes from a sphere of radius several light-minutes – when its piston reaches the progenitor star's outer edge, and launches a UV flash – so that coincidences with GRBs are not at all expected; (a first recorded case was SN 2008D, Soderberg et al 2008). In my understanding, a SN creates neither a GRB, nor a jet (Granot 2007; Kundt 2008b). A coincidence with a GRB could therefore only happen by chance projection, whose probability is zero. On the other hand, in my understanding of GRBs, the impacted neutron star (by a clump of matter from its inner accretion disk) ejects a baryonic shell at transrelativistic speeds, centrifugally – the slower and the thicker the shell the longer are the burst and its early afterglow – and the smaller is its redshift z. Precisely this correlation has been found: Only long-duration bursts of small z have had SN-like afterglows. The physics of a GRB is not all that different from that of a (core-collapse) supernova: In both cases, a central explosion ejects a filamentary shell of processed baryonic material at high velocities. The GRBs form the low-mass, high-velocity tail in this distribution, and the slowest among them have SN-like afterglows. Again, Galactic neutron stars qualify as their sources; no SN is required. Note that two counter examples to SN-like afterglows of low-z, long GRBs have been discussed by McBreen et al (2008); see also Bisnovatyi-Kogan (2006).

Why can friends of mine be convinced, nevertheless, of the occasional supernova-GRB association? Let me expound on a recent best-case example, published by Sonbas et al (2009). By routinely interpreting the afterglow redshift z (= 0.0331) of GRB 060218 as measuring cosmic-recession speed – rather than the outburst velocity from a Galactic explosion – the authors feel urged to interpret its strong Balmer emission lines as due to an energetic (and focussed!) Hubble flow inside a "relic wind envelope around a core-collapse progenitor star" of a distant SN, of forbiddingly large energy, and of a forbiddingly long "shock-breakout time" of $\gtrsim 10$ h (rather than $\lesssim$ 1 h; cf. Colgate (1968), or rather Kundt (2005, 2008b). Spectra can allow for alternative interpretations.

The main reason that makes me mistrust the proposed cosmologically-far interpretations of the GRBs is their exotically large implied powers, from sources like neutron stars and/or BH candidates of which we have hundreds of well-studied representatives in our Milky Way. All the Galactic copies respect (approximately) the Eddington limit for a neutron star, $L_{Edd} = 10^{38.3}\mathrm{erg\ s^{-1}}(M/1.4M_\odot)$ – except for short-time outbursts which violate the isotropic-feeding assumption in the derivation of the Eddington constraint, and exceed L_{Edd} by factors of $\lesssim 10^3$ – whilst their distant brothers would have to transiently shine at $(d_2/d_1)^2 \approx 10^{16}$ times that much (for respective distances of $d_j \approx\{10^{10}, 10^2\}$pc). They would form a disjointly different class of sources, of which there is no single local representative. For a few years, the excess-energy factor 10^{16} has been lowered by model builders – by a factor of 10^{-4} to 10^{-6} – via a beaming hypothesis (for the prompt emission) which can no longer be maintained once a continuity has been established between 'prompt' and 'afterglow' emissions, cf. Chincarini et al (2006), Kann (2008) for GRB 080319B, Romano et al (2006) for GRB 060124, GRBs 990123, 060729, and Fig.3.

Before presenting the details of my 'throttled-pulsars' model, and indicating its viability, let me recall a number of distance estimates which support the local-Galactic interpretation. The first stringent distance estimate was published by Schmidt (1978), a year before the giant burst GRB 790305 (which projects onto N49 in the LMC, as the first soft γ-ray repeater (SGR)). Schmidt's estimate was soon followed by Aharonian & Ozernoy (1979), also by Zdziarsky ($\leq$1984),

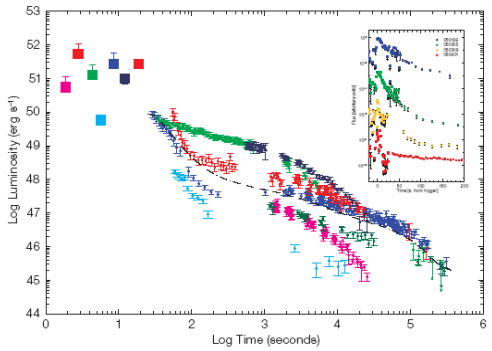

Fig. 3. Quasi-bolometric lightcurves (in colour) of seven GRBs and their afterglows, log L vs log t, with initial temporal gaps of $\gtrsim 30s$, copied from Chincarini et al (2006). The data suggest – as has meanwhile been multiply verified – that the (hard) prompt emission changes continuously into the (softer) afterglow emission, or rather: that intensity-wise, there is no well-defined decomposition into two disjoint emission modes.

and by Colgate & Petschek (1981). The estimate uses the condition that near the source (of restricted surface area), hard photons (above MeV) would pair-produce, and thus downscatter the spectrum towards softer energies. For the maximal source distance d, it can be written as:

$$d < \text{kpc} \;/\; \sqrt{S_{-4}} \qquad (2)$$

where S is the burst's maximal energy flux at $\gtrsim$ MeV energies (and $S_{-4} := S/10^{-4}$cgs units, as always). This estimate excludes a location of the burster in the LMC. Baring (1992) has stressed the assumption in this inequality that the hard photons should not be emitted in a perfectly aligned manner, where "perfect" would mean $\lesssim 10^{-3}$ for GRB 790305, and $\lesssim 10^{-8}$ for the non-SGR bursts. For a thermal emitter, such an assumption sounds overly conservative to me; it was repeatedly discussed by Zdziarsky. With this estimate, I strongly disagree with more recent authors like Lithwick & Sari (2001) who are happy to violate above inequality (2), and postulate a new type of jet formation, different from that of the well-observed ones (Kundt & Krishna 2004). Note that the estimate (2) differs from redshift-based estimates by a typical factor of 10^8.

A distance estimate similar to (2) was presented during the 80s, based on neutron-star energetics:

$$d < \text{kpc}\;\gamma\;\sqrt{L_{38}} \qquad (3)$$

in which γ is the (possible) bulk Lorentz factor of the emission, and L its power emitted by the source. Larger distances require more powerful engines.

Now comes an estimate which I have not yet seen in publications by others, even though it is at least as basic as the two preceding ones:

$$d < 0.3\ \text{kpc} \;/\; \sqrt{S_{-10}} \qquad (4)$$

in which this time, $S := \nu S_\nu$ denotes the early afterglow's energy flux density at frequency ν right after onset, which tends to be almost frequency-independent (at about a fortnight after the outburst), between mm wavelengths and X-ray energies. For this estimate, the assumption is made that the (early!) afterglow is emitted incoherently, hence governed by Planck's law. At visible frequencies ν, the estimate is obtained by comparison with the flux $S_\odot \approx 10^6 \text{erg cm}^{-2}\text{s}^{-1}$ which we receive from the Sun (at 1 AU distance), whose luminous area $\pi R_\odot^2$ can at best be available to the emitted flash for times $t > 2$s after onset, when the flash has reached a (radial) separation $R = ct \geq R_\odot$ from the burst center. For lower than visible frequencies, the Rayleigh-Jeans law $\nu L_\nu = 4\pi R^2 \sigma T^4 (\nu/\nu_{peak})^3$ (for emission at frequencies below the peak frequency ν_{peak}), when combined with the flux propagation law $L = 4\pi d^2 S$ at distance d, yield a similar distance estimate at slightly later times – depending on the detailed circum-burst medium – whereby the onset time t of the afterglow at wavelength λ should obey

$$t \geq 10^{4.8}\text{s}\;\lambda_{-1}^{3/2}\ . \qquad (5)$$

This onset time t ranges in minutes for IR wavelenths, and in days for mm wavelenths, in reasonable agreement with the (few) observations (e.g. of GRB 090423, Greiner 2009). The earlier the afterglow is caught, and the

lower the frequency ν at which it is caught (at fixed S), the tighter is the distance constraint. Note that the brightest ever optical burst, GRB 080319B, could have been seen with the naked eye, at 5.3 mag, simultaneously with its prompt γ-ray emission! For such a feat, the surface area of a neutron star at a cosmical distance is largely insufficient, even if glowing at hard X-ray temperatures. Future observations can still sharpen this estimate, down to distances of $\gtrsim$ 10 pc. But by this time it should have become clear that cosmic distances of the bursters would violate fundamental physical constraints.

The ($\gtrsim$8) SGRs tend to be judged at Galactic distances – with the possible exception of the 5 March 79 event (which projects onto N 49 in LMC, cf. distance estimate (2)) – even though their rare giant bursts are indistinguishable from ordinary GRBs. They are: SGR 0526-66, 1806-20, 1900+14, 1627-41 (Woods et al 1999), XTE J1810-197, SWIFT J1955+2614, GRB 070610 (Castro-Tirado et al 2008, Stefanescu et al 2008), and GRB 070201. Note that the last-two listed SGRs have also been viewed as GRBs of redshift $z = 0$. In my understanding, they are the nearest among all GRBs, from whom we even see the many softer, fainter repetitions, down in energy by a factor of order 10^{-3}; cf. Wachter et al (2007, 2008). For them follow three more distance estimates. The angular speed of SGR 1806-20, and expansion speed of its newly created radio bubble, during its giant outburst on 27 December 2004, were so large that

$$d \lesssim 30 \text{ pc } \beta_{-2.9} \qquad (6)$$

must hold for familiar Galactic proper-motion speeds $\beta := v/c \lesssim 10^{-3}$. This same estimate obtains when its maximal power (at outburst) is postulated to conform with the (five-thousandfold weakened) Eddington limit $L \lesssim 10^{42}$erg/s (for clumpy feeding):

$$d \lesssim 30 \text{ pc } \sqrt{L_{41.9}} \ . \qquad (7)$$

The ($\lesssim 10^{2.8}$ times) larger distance estimates favoured in the literature were all suggestive but not conclusive (Kundt 2009). Finally, the Cavallo-Fabian-Rees limit (on $\Delta L/\Delta t$) conforms with the latter estimate (Vietri et al 2007), as an independent fundamental constraint.

For completeness' sake, here are another twenty indications against the cosmological-distance interpretation of the GRBs, taken mostly from (Kundt, 2009):

• (j) The X-ray afterglow of GRB 031203 was resolved into $\gtrsim 2$ expanding (noisy) rings, of radii $\lesssim 3'$, during 10 successive 10^2min-observations, starting 6 hours after the burst, explained via (Galactic) foreground scattering (Vaughan et al 2004, also: Kundt 2009).

• (jj) There are frequent precursor events to GRBs, up to 10 minutes at least (Burlon et al 2008, Romano et al 2006), and postcursor events, of temporal offset $\lesssim$ 1 hour, both of (smaller but) comparable total energy; (cf. Wang & Mészáros 2007, who restrict their discussions to offsets by $\lesssim 10^2$s). Such temporal clusterings of supposedly quite rare, gigantic explosions pose problems to the cosmological interpretation.

• (jjj) GRB 060729 had an X-ray afterglow that hardly faded for 125 days (Grupe et al 2007). A similar case may have been GRB 070110 (Troja et al 2007).

• (jv) GRB 030329 showed (supposedly) two superluminal expansions, at (4 ± 1)c, and at 19 c, (Taylor et al 2004, 2005). Cf. the giant outburst of SGR 1806-20 on 27 Dec. 2003, whose radio bubble (supposedly) expanded transluminally.

• (v) Afterglow brightnesses are z-independent (Vreeswijk et al 2004).

• (vj) The X-ray-afterglow spectra do not reveal the expected increasing degree of ionization of their CSM into which their bursts should penetrate.

• (vjj) The lightcurves of the X-ray afterglows show strong flares ($\lesssim 10^2$), between minutes and days after outburst, as well as steep breakoffs (Chincarini et al 2007).

• (vjjj) GRBs show brightness excesses at the high-z end (Schaefer 2007). Their inferred luminosities, hardnesses, and variabilities grow like powers of z (Yonetoku et al, 2004, Graham et al, 2009).

• (jx) GRBs show hardness excesses at $\lesssim$ 10 TeV (Atkins et al 2003).

• (x) GRBs show occasional duration excesses, of (even) $\gtrsim$ hour (Fishman $ Meegan 1995, Fig.8).

• (xj) None of the bursts has ever shown a long-distance travel signature (Mitrofanov 1996).

• (xjj) No orphan afterglows have ever been detected, (i.e. afterglows whose generating bursts were beamed away from us) (Rau et al 2006).

• (xjjj) GRB 070201 has not been seen at gravity waves (by LIGO), against expectation (Svitil 2008).

• (xjv) The accreting Galactic dead-pulsar population should be detected, at a generally agreed integrated mass rate of 10^{-17}M$_\odot$/yr n* (Kundt & Chang 1993).

• (xv) The so-called host galaxies have (atypically low) luminosities: $L/L_\odot \ \epsilon \ (10^7,10^{10})$, (Savaglio et al 2007). See also Schaefer (2006) for host problems with the short GRBs.

• (xvj) Three-colour plots of optical afterglows do not show a large scatter, and signal a two-temperature (!) structure of their sources.

• (xvjj) Milgrom & Usov (1995) have presented (weak) evidence for a common origin of UHE CRs and GRBs, via their occasional (almost) coincident positions in the sky, and (weakly) correlated TOAs. (Note that UHE ions propagate almost like photons, except for slightly curved orbits in the Galaxy's magnetic fields, of curvature radius $R_B = \gamma m_0 c^2 \beta_\perp / ZeB = 2$ kpc $\gamma_{10}(m_0/m_p)/ZB_{-5.3}$). This suggestion agrees with mine, except that in my understanding, both source classes are local Galactic (Kundt 2005, 2009).

• (xvjjj) The column densities of the damped Lyman α systems (DLAs) in GRB spectra are either larger, or else smaller than in most quasar spectra (Vreeswijk et al 2004).

• (xjx) The (strong) Mg II absorbers in their spectra are 4-times overabundant w.r.t. quasars, and variable on the timescale of hours (Sudlovsky et al 2007).

• (xx) The $\log(N)$ vs $\log(S)$-distribution of the GRBs signals a thick-shell distribution in power, with $<d_{\max}, d_{\min} > \gtrsim 10$ (Fishman & Meegan 1995 Fig.13, Pendleton et al 1997); whereas $\log(N)$ vs $\log(L)$ ranges through many orders of magnitude, cf. (vjjj).

3. The sources of the GRBs

In this section I shall update my 1993 model (with Hsiang-Kuang Chang), in which the bursters are assumed to be (mostly) the dead-pulsar population: nearby Galactic neutron stars, whose wind-blown cavities have collapsed after some $10^{6.4}$years (of pulsar life), when their spin period had grown towards the 5 to 12 seconds interval (of the dying pulsars), and a low-mass accretion disk has formed around them which indents into their corotating magnetospheres, as sketched in Figs.3a,b of (Kundt 2009). Many of these 'throttled pulsars' are observed as soft X-ray sources, among them the anomalous X-ray pulsars (AXPs), soft gamma-ray repeaters (SGRs), recurrent radio transients (RRATs), or 'stammerers', or 'burpers', and the 'dim isolated neutron stars' (DINSs), with the following properties (Kundt 2008a):

The dying pulsars are isolated neutron stars, with spin periods P between 5s and 12s, and similar glitch behaviour to other neutron-star sources. They are soft X-ray sources, hotter than pulsars of the same spindown age by a factor of $\gtrsim 3$, mostly without pulsed coherent radio emission. Their spindown is rapid, $\tau = 10^{4\pm1}$yr, despite ongoing accretion. Their estimated number in the Galaxy is large, comparable to the number of pulsars, but due to their short spindown times, of order 10^4yr – compared with their age, of order $10^{6.4}$yr – their detectable number in the sky is reduced by a factor of $10^{-2.4 \pm 0.5}$ compared with ordinary pulsars. Most of their power is derived from accretion, whose implied (small) spinup is overcompensated by magnetospheric spindown. They are often (some 50%) found near the center of a pulsar nebula.

Throttled pulsars cannot only form from dying pulsars, as just explained, but also from newborn pulsars, via 'fallback matter', right after their birth inside a SN shell, when a small fraction of the ejected matter does not make its way to infinity. Such young pulsars can be seen embedded in an X-ray nebula, whose in-

nermost portion may well indent into the pulsar's corotating magnetosphere. Again we deal with a (mildly) throttled, magnetized, spinning neutron star.

This rather inconspicuous class of throttled pulsars can do two further things: It can emit cosmic rays, quasi-steadily, preferentially from the disk's inner edge to which the corotating magnetosphere is stick-slip coupled. And it can flare in the form of an impressive burst of gamma-rays through X-rays whenever a large chunk of (disk) matter gets sufficiently decelerated, via recoil on the (tangentially) ejected cosmic rays, and falls down onto the neutron star's surface, liberating its huge gravitational potential, and heating up to temperatures T of order

$$T \lesssim G\,M\,m\,/\,R\,k = 10^{12.2}\mathrm{K}\,(m/m_p)\ . \quad (8)$$

Such dumped matter will cool immediately, via neutrino and photon radiation, via energy-sharing with crustal matter, and via rebounce and adiabatic expansion, to heights exceeding the neutron star's radius $R = 10^6$cm. It will be forced magnetically into corotation with the neutron star, and part of it will be ejected centrifugally, across the speed-of-light-cylinder (SLC) distance, at transrelativistic speeds, corresponding to Lorentz factors γ of a few. Note that pulsars are thought to boost their electrons to Lorentz factors between 10^3 and 10^8 near the SLC, which would amount to comparable or larger kinetic energies than those of the ions expelled by a GRBer. Note also that a particle escaping (radially) from us with a Lorentz factor γ of 5 would be observed with a redshift of $z \lesssim 9$, according to equ.(1).

I therefore interpret the GRBs as the events when massive clumps ($\gtrsim 10^{15}$g) from an inner accretion disk fall onto the surface of a nearby neutron star, vaguely reminiscent of the accretion of comet Shoemaker-Levy 9 by Jupiter in May 1994. More precisely, the short GRBs – of duration $\lesssim$ 2s – are interpreted as the accretion events of one single chunk. Their fading and softening early X-ray afterglows have shown damped oscillations at the neutron star's spin period, between 5s and 12s, for $\lesssim 10^2$s, caused by periodic occultations of the impacted neutron-star hemisphere, as familiar from the giant outbursts of the SGRs (Gehrels et al 2006). Their lightcurve has the shape of a FRED (= fast rise, exponential decay), whereby the spectrum softens during the decay, to be understood as cooling. All the long bursts are superpositions of successive short bursts (FREDs), with washed-out oscillations, and higher integrated luminosities, cf. (Piran, 2004; Hjorth et al, 2006). Clearly, the long bursts eject more matter than the short bursts do, so that SN-like lightcurves are restricted to them. More massive chunks make wider FREDs than less massive ones.

Can this interpretation explain all the riddles (i) through (iv) listed at the beginning of the last section? The almost isotropy of arrivals (i) has already been explained as a (partial) compensation of column number densities by mild beaming (in the disk planes) in (Kundt & Chang 1993). Missing so far was a good explanation for the large observed redshifts in the afterglows. They can be understood by consultation of Figs.1b,2: When the impacted surface of the neutron star flares, a GRB is emitted, viz. a wide-angle flash of hard photons. Just ($\gtrsim \Omega^{-1} \approx$) one second later, centrifugally ejected hot baryonic matter follows the photonic flash, as a baryonic flash. Both flashes escape radially at high speeds, at $\{ =, \lesssim \}$the speed of light, impact on the circumstellar medium (CSM), and cause it to radiate. A distant observer sees at first blue-shifted radiation, from the near hemisphere of the CSM which is successively impacted by the two expanding shells, for seconds after onsets, and subsequently from fading, red-shifted radiation from the distant hemisphere, for hours and months to come. Further light reaches the distant observer from CSM located transverse to the line-of-sight, which dilutes the radiation from the front and back side of the outgoing flashes. Still, both redshifted absorption and redshifted emission (with the same z) are expected in general from the baryonic shell when it is crossed by the photonic burst's stimulated emission, and when it interacts directly with the CSM, with a Lorentz factor γ between 1 and 5. Which answers riddle (ii).

Riddle (iii) can be answered in a straightforward manner: A significant fraction of the two ejected shells' energies, photonic and baryonic, on collision with their CSM, is expected to be radiated by the burst's CSM, causing a strong light echo from the region which is impacted in $\gtrsim$ a light-crossing time, of radius $\lesssim$ one light day during the first day after the burst, and correspondingly for other times. This additional flaring, or reflection nebula, can be mistaken for a distant host galaxy, with the same redshift as the afterglow. In addition, occasional chance projections onto luminous background nebulae cannot easily be ruled out, when only one or two spectral lines are available for the identification.

And as concerns a similarity to a SN, riddle (iv), all we require is a dense enough shell of ejecta from an energetic (long-lasting) burst of comparatively small speed, $z \lesssim 0.2$, corresponding to $\beta \lesssim 0.17$, in which resonance scattering can store line photons for sufficiently long times to cause exponentially declining lightcurves (instead of power laws), (Kundt 2008b). We deal with a phenomenon not too different from that of a SN explosion.

Remains a discussion of the twenty problems (for the cosmological interpretation) listed at the end of the past section. Seventeen of them more or less invite a local-Galactic (re-) interpretation, with frequent repetitions (from additional impacts), and additional excitations (of the dying pulsar). The problems are: (j) a resolved X-ray afterglow, (jj) pre- and post-cursors to the bursts, (jjj) afterglows with long plateaus and abrupt declines, (jv) superluminal expansions (for the assumed excessive distances), (v) z-independence of the involved energetics, (vj) only mild distortions (ionizations) of their CSM, (vjj) recorded flares from the impacted (patchy) CSM, (vjjj) a non-cosmological energy dependence on z, (jx) spectral excursions to $\lesssim$ 10 TeV, (x) occasional long durations, (xj) no long-distance travel signatures, (xjj) no orphan afterglows (because of no beaming), (xjjj) no detectable gravitational waves (because of 10^{16}times lower energetics), (xjv) no missing signals from the (expected) dead-pulsar population, (xv) atypical hosts, (xvj) 2-temperature optical afterglows, and (xvjj) a relation to the UHE CR generators, whose distances cannot be cosmological, (because of the GZK cutoff).

The local-Galactic re-interpretation should likewise explain the remaining three problems, viz.: (xvjjj) the cosmological-mimicking intervening damped Lyman α (DLAs) and (xjx) metal-absorber systems, Mg II and C IV, apart from distinct deviations of their distributions (Vreeswijk et al, 2004; Sudilovsky et al , 2007): we may have to learn that the magnetars (or whatever) can have unusually high (absorbing) column densities in their CSM. And (xx) the famous 'thin-shell' distribution of the GRBs by BATSE, inferred from the log$N$-vs-log$S$ diagram – and thickened a bit by the Pioneer-Venus-Orbiter data – poses problems to both interpretations. In the local-Galactic interpretation, it asks for a certain fine-tuning between the inhomogeneous distribution of the Galaxy's nearby throttled pulsars and their somewhat anisotropic emissions, which has been shown not to be prohibitive, though, both analytically and numerically, by Kundt & Chang (1993). When fundamental physics clashes with circumstantial or statistical 'evidence', my confidence is in the former.

4. Conclusions

Mainstream interpretations of GRBs struggle with intensity factors of 10^{16} when compared with the one by Galactic neutron stars, because of a distance ratio of 10Gpc/10^2pc = 10^8; which shrinks (only) to 10^{10} when a (large!) beaming factor of 10^3 is assumed, based on several poorly understood mechanisms. The problem disappears when it is realized that redshifts need not mean distances. Note that the problem exists for all the emissions: not only for the prompt, hard emissions, but likewise for the (often similarly hard) afterglow emissions, from radio all the way up through (early!) optical to X-ray brightnesses, and even occasionally to TeV energies (with dominating power!).

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