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Those Daily Gamma-Ray Bursts: Where do they come from?

Wolfgang Kundt ⋆
Institut für Astrophysik der Universität, Auf dem Hügel 71, D-53121 Bonn, Germany

Abstract Following up on my 2003 report at this site, I offer new reasoning for my old conviction that all of the non-terrestrial GRBs are emitted by nearby Galactic neutron stars, at distances d within $10^{-2} \lesssim d$/kpc $\lesssim 0.5$. Their subset often interpreted as magnetars will be re-interpreted as throttled pulsars. The GRBers and the generators of the high-energy cosmic rays may well be identical.

Key words: gamma-ray bursts — afterglows — host galaxies — neutron stars: accretion — magnetars

1 REASONS FOR A COSMIC DISTANCE OF THE SOURCES, AND THEIR INCONCLUSIVENESS

During the 80s of the past century, a consensus had formed that all the detected γ-ray bursts came from nearby Galactic neutron stars (Mazets et al. 1981, Higdon & Lingenfelter 1990, Harding 1991, Lingenfelter & Higdon 1992, Kundt & Chang 1993, Ryan et al. 1994). This consensus has subsequently been undermined by the following four facts:

(i) A first blow to this conviction came by the mid-90s, with the improved statistics and angular resolution of the BATSE mission which detected an isotropic (and thin-shell) distribution of their arrivals, unlike expected from a Galactic-disk population. Note that this property (of isotropic arrival directions) is meanwhile shared by the highest-energy cosmic rays, above 10^{19} eV, whose curvature radii - enforced by the Galactic magnetic fields - are above 2 kpc, i.e. which propagate almost as straightly as photons do through our Galactic neighbourhood. In both cases, the scientific community considered source populations at large distances - Galactic Halo, Local Group, or cosmic - whereby the last alternative is not permitted for the cosmic rays, because of inverse-Compton losses on the intergalactic photon background. Instead, Chang & I (1993) maintained that isotropic, thin-shell distributions can result from a Galactic-disk population (of throttled neutron stars) in interaction with accretion disks whose planes are oriented more or less perpendicular to that of the Milky Way disk, (because assembled during oscillatory motions through its gravitational potential). Note that this latter interpretation deals (conservatively) with the energetics and timescales (of the bursts) familiar from all the other neutron-star sources, i.e. does not have to postulate new source classes of extreme power and at ultra-high frequencies.

(ii) An independent estimate of the source distances became possible with the detection of ‘afterglows’ by Beppo-SAX, at least for half of the long-duration bursts (of duration $\gtrsim 2$ s), via fast alarms and immediate X-ray positioning (of much higher angular resolution than is possible at γ-rays). These afterglows tend to show redshifted absorption lines corresponding to redshifts $z \lesssim 4.5$ which have been routinely interpreted as cosmic-distance indicators, even though the compact Galactic X-ray binary SS 433 has proved that relativistic redshifts and blueshifts can result kinematically in our Galaxy, i.e. need not imply large (cosmic) distances of the sources. Remarkably, afterglow intensities are independent of redshift (Vreeswijk et al. 2004a).

(iii) Cosmic distances of (long-duration) GRBs became even better ‘proven’ when a few ‘host galaxies’ were ‘identified’, by one or (at most) two emission lines - interpreted as [Ne III] and [O II] - redshifted by the same amount as the afterglow absorption lines. These host galaxies range among the faintest resolved luminous spots in the sky, fainter than any catalogued or well-studied optical source so far, and

⋆ E-mail: `wkundt@astro.uni-bonn.de`

may well have disappeared again by now; I interpret them as light echoes from the bursts, i.e. as transient reflection nebulae. Their identification as 'host galaxies' would be at variance, if correct, with the "no-host-galaxy dilemma" of Schaefer et al. (1997), also Schaefer (1999), who proved an anti-correlation between the strength of the bursts, and the luminosity of their hosts. They differ from well-known galaxies by being (1) subluminous, (2) blue, with (3) prominent emission lines, and with (4) much denser disks than the Milky Way, and often with (5) larger HI column densities, yet (6) low dust content, (7) no H_2 molecules, and (8) a large number of small anomalies in the identified, and unidentified absorption and emission lines (Ly α, C IV, Si II, Fe II), low dust/gas ratios, and high metallicities (Vreeswijk et al. 2004a, 2004b). (9) None of the identified absorption lines varied during repeated observations ($3\,\sigma$), against expectation, in view of the gigantic local optical/UV flash.

(iv) More recently, broad absorption lines have been detected in at least seven afterglow spectra, and 'identified' as damped Ly α (Vreeswijk et al. 2004b). If this identification was correct, their HI column densities would be (1) either higher, or lower than in typical QSO spectra, and (2) the corresponding metallicities would be low, yet (3) higher than in most ($\gtrsim 10^2$) QSO spectra. Again, the evidence is unsatisfactory.

If the sources of the GRBs were at cosmic distances, they would be in conflict with the following (further) facts: During the past 15 years, (1) their models have homed in on combinations of neutron stars and/or (stellar mass) black holes, perhaps in combination with supernovae (SNe), i.e. on sources of which our Galaxy has shown thousands, as (radio, or rather γ-ray) pulsars, as X-ray pulsars, X-ray bursters, flickerers, accretors and ejectors with or without jets, VHE sources, and central sources of SNe and SNRs. Their powers usually range below the Eddington limit of 1.4 $M_\odot$, except for very few sources during (explosive) flaring when excesses by factors of $\lesssim 10^3$ have been recorded. For cosmic distances (of similar sources), some 10^8-times farther, these powers would have to exceed this limit by some 10^{16} if unbeamed, and still by some 10^{12} if transiently beamed within a spherical angle of order 10^{-4}. I.e. they would have to be exotic, according to local standards. (2) Another exotic property of the (gigantic) bursts would be their frequent X-ray 'precursors', by minutes, or even by an hour (at comparable power!). (3) Embarrassing (for the cosmic interpretation) is the tenacious absence of long-distance travel signatures, which are expected in the form of correlations in hardness, duration, and intensity vs redshift (Mitrofanov 1996), as well as via some (bright) lensed events. (4) Even more impressive - as concerns net power - are the brightnesses of the afterglows, which (are z-independent and) can reach similar fluxes when caught early enough, with less or no beaming (Vestrand 2005). (5) Similar energetic problems are posed by the occasional super-long ($\gtrsim$ hour) and/or super-hard (GeV, $\gtrsim$TeV) bursts. (6) Finally, an increasing detector sensitivity has led to an increasing detected frequency, and hardness of the terrestrial γ-ray bursts, which appear to be emitted at the onset of ionospheric discharges, i.e. in a non-exotic way (Mende et al. 1997, Su et al. 2003).

Further worries of the cosmic interpretation have been expressed, and can be found in Bisnovatyi-Kogan (2003), Dar (2005), Fargion (2003, 2005), and Lamb (1999).

2 THE LOCAL GALACTIC ALTERNATIVE

My own interpretation of (the origin of) the γ-ray bursts has remained in the ballpark of what was thought during the 80s: local Galactic neutron stars, during spasmodic accretion. The Eddington power of $10^{38.5}$ erg s^{-1} of a neutron-star source asks for source distances $\lesssim \gamma$ kpc, (γ = Lorentz factor of beaming), temporal finestructure down to $\gtrsim 10^{-3.7}$ s asks for source sizes of $\lesssim$ tens of km, spectra ranging out to MeV energies ask for either transrelativistic potential wells, or transient electric voltages exceeding MV, the richness of different lightcurves is reminiscent of Jupiter's accretion of comet Shoemaker-Levy (in 1994) - torn into a string of clumps by tidal forces - and the on average observed four bursts per day hitting Earth carry the power expected from spasmodic interstellar accretion onto old Galactic neutron stars, some $10^{-17} M_\odot$ per year and neutron star (Kundt 2001, 2003b, 2004).

Why then do we observe an isotropic celestial distribution of arrival directions, instead of the stripe of the Milky Way? This crucial - if only statistical - property can be mimicked by anisotropic radiation patterns, like sparks from a grindstone, oriented w.r.t. the Milky-Way disk, brought about by interstellar accretion during a neutron star's oscillation through the Galactic potential (Kundt & Chang 1993, 1994). In this way, an increasing column density of sources with decreasing Galactic latitude is first-order compensated by a decreasing beaming probability near the plane of the (n*'s low-mass) accretion disk. Of course, once we trust such a Galactic conspiration for the GRBs' radiation patterns, we should not be forced to invent yet another explanation for the (isotropic appearance of the) cosmic-ray boosters. Indeed, there will be a strong overlap of the two source classes, as reasoned in the next section, under the term ‘magnetar’.

GRBs act like flashlights (that illuminate their surroundings), both via their relativistic ejecta, and via their hard radiation; in this way, they resemble supernovae (SNe). Each two bursts have different light curves, and probably also a different CSM. No wonder that also each two afterglows have different lightcurves, depending on the structure of their CSM, whereby some of them mimic SN lightcurves (Piro 2003; Schmidt 2005). In both cases - GRB and SN - we deal with relativistic pistons ejecting the ashes of some nuclear burning (Kundt 2003a). We see their environs flaring under the (transient) impact of the ejecta, photons and baryons. Still, SN lightcurves are piecewise exponential whilst afterglow lightcurves have (approximate) power-law shapes; the two phenomena must not be confounded. And unlike in SNe, the ejecta of GRBs tend to be relativistic, implying relativistic Doppler $\{$absorption, emission$\}$ redshifts for sufficiently $\{$small, large$\}$ inclination angles w.r.t. the line-of-sight. What has been interpreted as a ‘host galaxy’ may well have been a transient reflection nebula.

And why are there two kinds of (extraterrestrial) bursts, long and short ones? Are there really two kinds of them? Could the dip near duration 2 s be caused by the (poor) dynamic range of the detectors, which fail to record a strong, long-duration tail at lower intensity after, or before a bright spike (as Jochen Greiner once speculated in a Bonn seminar). If so, early afterglows are still expected to be more intense for the long bursts for which part of the - centrifugally ejected - n* surface matter has crossed the speed-of-light cylinder in time to be seen in absorption against the later part of a burst’s lightcurve.

3 THE MAGNETARS

The ‘magnetars’ were invented by Duncan & Thompson (1992), and pursued throughout Thompson & Duncan (1996) and beyond, as neutron stars with surface magnetic field strengths B of order 10^{15} G whose light curves are powered by magnetic-field decay. I doubt their existence: Fields of this strength, probably reaching 10^{17} G in the n*’s core, would be dynamically unstable (Flowers & Ruderman 1977); I also see no way how to form them. Independently, one proposed magnetar (1806–20) recently showed an upward jump in period derivative $\dot{P}$, corresponding to an upward (!) jump in (the gigantic) B; by what mechanism?

Duncan and Thompson have applied the magnetar model initially to GRBs, and later to apparently isolated neutron stars in rapid spindown - including the anomalous X-ray pulsars (AXP) and the soft γ-ray repeaters (SGR) - whose modes of spindown was unclear; no direct estimate of their B is known. Mereghetti et al. (2002) gave a careful characterization of the AXPs, within the class of X-ray pulsators, essentially equivalent with:

(a) An AXP is an isolated n* of spin period $5 \lesssim P_{\rm spin}/{\rm s} \lesssim 12$. (b) The spindown time τ of an AXP is short: $\tau := P/2\dot{P} \approx 10^{4\pm1}$ yr, (despite accretion!). (c) An AXP has a soft X-ray spectrum: kT $\lesssim 0.5$ keV, with rather steady luminosity L$_X \approx 10^{35\pm1}$ erg s^{-1}, and without pulsed radio output. (d) AXPs are brighter than permitted by their spindown; they are probably accretion powered. (e) Roughly half of all AXPs are seen at the center of a synchrotron nebula (Gotthelf et al. 2000); a pulsar nebula?

As already stated, I consider the above-defined magnetars as physically forbidden. Instead, I interpret the class of weak accretors characterized by properties (a) through (e) as ‘throttled pulsars’, whose magnetospheres are squeezed deeply inside their speed-of-light cylinders. This class of long-expected sources contains predominantly (in number) the class of dying pulsars: pulsars whose wind thrust falls short behind the pressure of a pulsar’s (heavy) CSM, attracted by its gravity, at a distance of $\gtrsim 10^{15}$ cm. Pulsar catalogues show that at a spindown-age τ between $10^{6.1}$ and $10^{6.4}$ yr, the observed linear rise of $N(\tau)$ drops abruptly to increasingly small numbers, corresponding to a statistical pulsar age of $\lesssim 10^{6.4}$ yr. At this age, their wind pressure drops below the minimum required for holding their CSM out; it avalanches down on them, sqeezes the magnetosphere, and throttles the radio pulses. The braking torque $T \approx r^3 \langle B_r B_\phi \rangle \approx (c/r\Omega)^3 T({\rm PSR})$ of a spinning dipole inside its speed-of-light cylinder increases as r^{-3} with decreasing confinement radius r, so that spindown times drop from some 10^6 yr to some 10^4 yr - cf. (b) above - and the detected number N(PSR$^+$) of dying pulsars (=fast-slowing AXPs) in this interval of life is shorter than the number of pulsars in this interval, some 10^3, divided by the ratio of spindown times, some 10^2: N(PSR$^+$) = ΔN(PSR) $\tau^+/\tau \approx 10$, as observed.

This re-interpretation of magnetars, evolved between my Heidelberg talk (040429) and now - as throttled pulsars - does not only close a gap in our understanding of pulsars, but at the same time gives a natural explanation of their properties (a) through (e) above, together with their expected number, of order ten, and their candidacy as sources of all the γ-ray bursts (including the SGRs), and of the high-energy cosmic rays. Some necessary quantitative estimates will soon follow; but I still have to explain how this interpretation can solve the isotropy problem, and also the energetics problem, and be complete.

No case is known of a pulsar being throttled; what will it look like? Clearly, during its radial fall from some 10^{15} cm down to some 10^7 cm, the CSM's (non-zero initial) angular momentum will be conserved, and a low-mass disk will form around the dying pulsar, cutting deeply into its corotating magnetosphere. The interaction of such a fast-rotating disk with the rapidly changing, strongly indented magnetosphere is highly Rayleigh-Taylor unstable, and should result in quasi-periodic stick-slip couplings with slingshot-like releases at the speed of light, a perfect scenario for the generation of cosmic rays of extreme energy. Most of the matter will fall through the magnetic field, after having strained it, in the form of heavy, diamagnetic clumps (blades), accrete onto the n*'s surface, and emit X-rays; whilst a tiny fraction will get boosted by the recombining field, and ejected from the system as cosmic rays. Such CR ejections will happen preferentially in the n*'s rotational equatorial plane, like sparks from a grindstone. Precisely this anisotropic ejection mechanism - oriented w.r.t. the Milky-Way disk - was assumed in Kundt & Chang (1993, 1994) to explain the isotropy of GRB arrivals, and should likewise explain the observed isotropy of the CRs at their highest energies.

This being understood, we still lack an important detail. Is there enough energy in the accretion of the dying pulsars? Why are the SGRs preferentially aligned with the Milky-Way disk? Why is there often a lack of a central source in SNRs? And is there a SGR at the center of Cas A, as indicated by Krause et al. (2005)? All these pending questions can be answered by noticing that not only old pulsars meet the problem of blowing a cavity into their CSM, but also the newborn ones do: all the (heavy) metter in their vicinity, $r \lesssim 10^{15}$ cm, will undoubtedly avalanch down, and throttle their magnetosphere, and delay their switchon as a radio pulsar. The class of sources commonly interpreted as 'magnetars' should be replaced by the (whole) class of 'throttled pulsars', both at birth, and dying. The pulsars at birth store a lot more spin energy than the dying ones do, hence are expected to lead in brightness (e.g., be SGRs), whereas the dying ones are expected to lead in number, by some 10^2, because they last some $10^{1.5}$ times longer (at almost comparable brightness), and involve the whole population of pulsars. The dying ones control the isotropic appearance. All throttled pulsars are expected to continually generate cosmic rays, and all of them are expected to emit occasional bursts of γ-rays, as a consequence of unsteady, clumped accretion.

Once the scenario is set, I still owe the reader a few quantitative estimates. To be solved are the hydrodynamic equations for a pulsar cavity's surroundings:

$$\nabla p \;=\; \rho_{\rm csm}\, g \;, \tag{1}$$

where the cavity pressure $p_{\rm psr}$ equals the PSR wind's ram pressure $L/4\pi r^2 c$, $L = (2/3c^3)\mu_\perp^2 \Omega^4$, $\rho = pm/kT$, and $g = Gm/r^2$. This ordinary differential equation for the radial CSM pressure dependence $p(r)$ beyond the cavity radius $r_{\rm cav}$ is solved by the (exponential) atmospheric height formula

$$p(r)\;/\;p(\infty) \;=\; \exp(u) \quad with \quad u \;:=\; GMm/rkT\;. \tag{2}$$

The minimal cavity radius is found by solving the inequality $p_{\rm psr} \geq p(u)$ at its lower end in r, yielding $u_{\rm max} = 2$, and

$$r_{\rm cav} \;\geq\; G\,M\,m\;/\;2\,k\,T \;= 10^{14.9}{\rm cm}/T_3 \tag{3}$$

for an n* mass M of $10^{33.5}$ g, and for a CSM assumed to consist of 'cool' hydrogen, at $T = 10^3$ K. In reality, the CSM may well be inhomogeneous, consisting of cold hydrogen ($T = 10^2$ K) embedded in (relativistically) hot pair plasma, with $T = 10^3$ K as a typical temperature of the mixture, and the (stable) cavity radius $r_{\rm cav}$ will hardly fall below 10^{15} cm. For an old pulsar, this minimal cavity radius is reached when its spin period $P = 2\pi/\Omega$ has grown to

$$P_{\rm max} \;=\; 2\pi(2/3\pi e^2)^{1/4}(\mu_\perp kT/GMmc^2\sqrt{p})^{1/2} \;=\; 8{\rm s}\,(\mu_{31}T_3/\sqrt{p_{-12.3}})^{1/2}\;. \tag{4}$$

This last equation shows that for a typical CSM composition, a pulsar dies abruptly when its spin period P has grown to several seconds, in conformity with property (a); the required confining CSM pressure scales as the period's fourth power. The dying PSR then behaves essentially like a magnetar has been thought to behave, except for its additional generation of cosmic rays.

4 THE SGRS, AS THE NEAR EDGE OF THE BURSTER DISTRIBUTION

In my alternative interpretation of GRB afterglows, as Galactic light echos, I have assumed that the SGRs are representative of the whole class, being the nearest - and hence brightest - among them, at distances of $\lesssim 50$ pc, (for which we do not only see their 'ordinary' bursts but also their much more frequent, softer, and much dimmer repetitions, at a 10^3-times lower power). For SGR 0525–66, 1907+09 (or 1900+14), 1806–20, and 1627–41, we know their spin periods, P/s = 8.0, 5.17, 7.56, and 6.4, yielding expected afterglow delay times of $P/2\pi$ s = 1.3, 0.82, 1.2, and 1.0 respectively, in agreement with the onset duration for afterglow visibility. The first three of them flared as GRBs 790305, 980827, and 041227.

With this interpretation, I have assumed that the first and most famous SGR, GRB790305, only projects onto SNR N49 in the LMC but, in reality, lies at the inner edge of the GRB source distribution (in the Galaxy), at a distance of some 50 pc, as has been convincingly argued by Zdiarski (1984); also Bisnovatyi-Kogan & Chechetkin (1981). Projection is a suggestive argument, but physical reasoning based on spectral properties counts higher in my ranking. Similarly, none of the other SGRs has a well-determined distance: Their embedding synchrotron nebulae are likely pulsar nebulae, not SNRs, whose intrinsic luminosities are much fainter than assumed in the distance estimates (Kundt & Chang 1994).

Similarly famous has become SGR 1806–20, with its brightest ever flare, right after Christmas: GRB 041227 (Hurley et al. 2005, Lazzati 2005, Israel et al. 2005). Its distance has been judged (15.1 $+1.8 - 1.3$) kpc by Corbel & Eikenberry (2004), between 6.4 kpc and 9.8 kpc by Cameron et al. (2005), and $\lesssim 50$ pc by Kundt & Chang (1994), with an implied luminosity range spanning five orders of magnitude. For the first (largest) distance estimate, the likely companion star of the burster would outshine the brightest stars in our Galaxy, called 'rare' by the authors, and we should see comparable outbursts of this calibre throughout a significant fraction of the Universe, whereas the smallest estimate would deal with familiar energetics, though with a comparatively large intrinsic X-ray absorption column of the source. The radial velocity of the companion is zero within the errors, (10 $\pm$ 20) km s^{-1}, consistent with our nearest Galactic neighbours. Again, an uncertain distance estimate can mislead all our inferences.

As a last case that has made headlines recently, let us consider GRB 041219a, even though it is not (known to be) a SGR. Like GRB 990123, this burst showed a simultaneous broadband afterglow, and was mapped at optical and near-IR frequencies (Vestrand et al. 2005, Blake et al. 2005). Its afterglow had an optical luminosity $L_{\rm V}$ of $L_{\rm V}/L_\odot = (d/0.6\text{kpc})^2$, requiring a luminous emission area of solar size for incoherent radiation at distance 0.6 kpc. For a similar brightness at K band, two octaves redder, this size of the emitter must even be 4^4 times larger. The (optical) afterglow was seen within less than three minutes after the onset of the burst, when the burst's (relativistic) shock wave had not possibly travelled farther than some 10^{13} cm. This large, early afterglow brightness restricts the distance of the burster to less than 6 kpc, orders of magnitude nearer than commonly believed.

5 CONCLUSIONS

New evidence is coming in, with every well-sampled burst and/or afterglow, that the cosmological interpretation of the GRBs is untenable, with its excess factor of 10^{16} in burst power over local sources. It would never have boomed, had the coming generation been brought up to discriminate between proposed alternatives rather than to strengthen a growing consensus. Nearby Galactic neutron stars satisfy all the constraints, whereby magnetars will have to be replaced by throttled pulsars. The latter also qualify as boosters of the CRs.

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References

Bisnovatyi-Kogan, G.S., 2003, Physical Limits of Different Models of Cosmic GRBs, Chin. J. Astron. Astrophys., Vol. 3 Suppl., 489-500
Bisnovatyi-Kogan, G.S., Chechetkin, V.M., 1981, Sovj. Astron., 25, 320
Blake, C.H., et al. (28 authors), 2005, Nature, 435, 181
Corbel, S., Eikenberry, S.S., 2004, Astron. Astrophys., 419, 191
Dar, A., 2005, these and earlier proceedings of Vulcano workshops

Duncan, R.C., Thompson, C., 1992, Ap J, 392, L9-13
Fargion, D., 2003, GRBs-SN and SGR-X-Pulsar as blazing Jets, Chin. J. Astron. Astrophys., Vol. 3 Suppl., 472-482
Flowers, E., Ruderman, M.A., 1977, ApJ, 215, 302
Gotthelf, E.V., Vasisht, G., Gaensler, B., Torii, K., 2000, in: Pulsar Astronomy - 2000 and beyond, IAU Coll. 177, eds. M. Kramer, N. Wex, R. Wielebinski, ASP Conf. Ser. 202, 707-708
Harding, A.K., 1991, Phys. Reports, 206, 327
Higdon, J.C., Lingenfelter, R.E., 1990, Ann. Rev. Astron. Astrophys., 28, 401-436
Hurley, K., et al. (20 authors), Nature, 434, 1098; also: Gaensler et al. (19 authors), p. 1104, Palmer et al. (28 authors), p. 1107, Terasawa et al. (17 authors), p. 1110, Cameron et al. (14 authors), p. 1112
Israel, G.L., Belloni, T., Stella, L., Rephaeli, Y., Gruber, D.E., Casella, P., Dall'Osso, S., Rea, N., Persic, M., Rothschild, R.E., 2005, ApJL, accepted; also: astro-ph/0505255
Krause, O., Rieke, G.H., Birkmann, S.M.,Le Flog'h, E., Gordon, K.D., Egami, E., Bieging, J., Hughes, J.P., Young, E.T., Hinz, J.L., Quanz, S.P., Hines, D.C., 2005, Science, June 10; also: astro-ph/0506186
Kundt, W., 1998, Fundamentals of Cosmic Physics, 20, 1-119
Kundt, W., 2001, In: F. Giovannelli and G. Mannochi, eds., Italian Physical Society Conf. Proceedings, 73, Frontier Objects in Astrophysics and Particle Physics, Bologna, 301-312
Kundt, W., 2003a, in: From Twilight to Highlight, ESO Astrophysics Symposia, eds. W. Hillebrandt and B. Leibundgut, Springer, 75-80
Kundt, W., 2003b, Chin. J. Astron. Astrophys., Vol. 3 Suppl., 501-506
Kundt, W., 2004, Astrophysics, A New Approach, Springer
Kundt, W., Chang, H.-K., 1993, Ap&SS, 200, 151-162
Kundt, W., Chang, H.-K., 1994, In: G.J. Fishman, J.J. Brainerd, and K. Hurley, eds., AIP Conference Proceedings Vol. 307, American Inst. of Physics, Gamma-Ray Bursts, p.596-599
Lamb, D., 1999, A&AS, 138, 607-615
Lazzati, D., 2005, Nature, 434, 1075
Lingenfelter, R.E., Higdon, J.C., 1992, Nature, 356, 132
Mazets, E.P., Golenetskii, S.V., Aptekar, R.L.,Gur'yan, Yu.A., Il'inskii, V.N., 1981, Nature, 290, 378
Mende, S.B., Sentman, D.D., Wescott,, E.M., 1997, Scient. American, 277, August, 36
Mereghetti, S., Chiarlone, L., Israel, G.L., Stella, L., 2002, in: MPE-Report, 278, 29-43
Mitrofanov, I.G., 1996, MemSAIt, 67, 417
Piro, L., 2003, Nature, 426, 397-380
Ryan, J., Bennett, K., et al. (22 authors), 1994, ApJL, 422, L67
Schaefer, B.E., 1999, ApJ, 511, L79-L83
Schaefer, B.E., Cline, T.L., Hurley, K.C., Laros, J.G., 1997, ApJ, 489, 693-697
Schmidt, B., 2005, Science, 308, 1265
Su, H.T., Hsu, R.R., Chen, A.B., Wang, Y.C., Hsiao, W.S., Lai, W.C., Lee, L.C., Sato, M., Fukunishi, H., 2003, Nature, 423, 974
Thompson, C., Duncan, R.C., 1996, ApJ, 473, 322-342
Vestrand, W.T., et al. (23 authors), 2005, Nature, 435, 178
Vreeswijk, P., et al. (32 authors), 2004a, A&A, 419, 927-940
Vreeswijk, P., Moller, P., Ledoux,, C., Ellison, S., Masetti, N., Fynbo, J., Jakobsson, P., Hjorth, J. 2004b, The Messenger, 118, 35-39
Zdziarski, A.A., 1984, A&A, 134, 301-305

DISCUSSION

D. FARGION How can nearby neutron stars produce relativistic redshifts (of the GRBs and their afterglows)?

W. KUNDT Transrelativistic redshifts tend to be interpreted as cosmological distances even though SS 433 teaches us that (Galactic) neutron stars can likewise do it; cf. p.115 of my 2004 book.