The New Paradigm for Gamma Ray Bursts: a Case of Unethical Behaviour?

A. De Rújula

Theory Division, CERN, CH-1211 Geneva 23, Switzerland

Abstract

One might have hoped that the immediacy and completeness of scientific information provided through the internet would have made the wrongful appropriation of someone else’s ideas —now so easy to detect and document— a sin of the past. Not so. Here I present evidence, which the reader should judge, of such an apparent misconduct by Sir Martin Rees, the British Astronomer Royal, and others. Unethical behaviour is not unknown in science. My sole intention is to call attention to the problem by way of example, in an attempt to contribute to a more ethical atmosphere, which would in my opinion be beneficial to the field.

Our lives begin to end the day we become silent about things that matter. Martin Luther King, Jr.

1 Motivation

It is often said that ‘battles between scientists are so fierce... because there is so little at stake’. This is probably true of most scientific disputes, perhaps even of the matter I shall discuss. However, this note is less concerned with scientific issues than with questions of academic integrity: the proper procedure by which novel ideas may be adopted from the works of others, the appropriate attribution of priorities, and the example to be set by those in high office — in this instance, Sir Martin Rees, the British Astronomer Royal and Master designate of Trinity College, Cambridge.

The issue at hand is the understanding of Gamma Ray Bursts (GRBs), intense but transient showers of high-energy photons (gamma rays) impinging upon the upper atmosphere several times per day. GRBs were discovered in the late 60’s by the American Vela satellites and were later shown to be cosmological,
in the sense that the mighty engines making them are distributed roughly uniformly throughout the visible universe.

What can these engines be and what is the mechanism by which the gamma rays are produced? These two puzzles, often considered as among the greatest mysteries of astrophysics, have challenged scientists for decades. Several different interpretations of GRBs—often vague and mutually incompatible models that were provisionally accepted by most workers in the field—have succeeded one another to address these questions. Until recently, none of these schemes adequately explained the data. However, I believe that recent observations of GRBs and their theoretical interpretation are now sufficient to provide a definitive paradigm. The once-mysterious engines responsible for GRBs are nothing more than supernova explosions, and the mechanism producing the bursts is inverse Compton scattering (ICS), the process by which high-energy electrons strike low-energy photons, thereby uplifting their energy to that of gamma rays, seen as GRBs.

The currently best-studied theories of GRBs are the Fireball models and the Cannonball model. The first set of models is often considered to be the standard model of GRBs. The second, of which I am a coauthor, is generally viewed as heretical (to borrow a term used by one of our anonymous referees). In spite of their similarly-sounding names, these two models are completely different in their basic hypothesis, in their description of the data, and in their predictions.

What I shall discuss here is not the validity of any particular model, but the ways by which some scientists rewrite history by de-emphasizing the contributions of others relative to their own, or by imposing their own modes of thought upon the community. I shall also pose the question of whether the main concepts underlying what is very likely to become the new GRB paradigm will be attributed to their creators. Today, because scientific articles are virtually instantaneously ‘posted on the web’ in freely accessible and inviolate electronic Archives, one might naively suppose an affirmative answer. But science is a profoundly human endeavour and what may appear obvious is not always so.

Whether or not a note such as this should be posted in the Archives is a debatable question, alternatives to which I have discussed with many colleagues. But a “higher court” of science does not exist. Moreover, the Archives now have a much greater impact than journals: it is mostly the original version

---

1 To be precise, these answers apply most convincingly to the best studied GRBs, those of long duration (seconds or minutes, as opposed to fractions of a second).
2 Most articles cited here can be found in the Astrophysics or (in one case) the High-Energy-Physics-Phenomenology section of http://www.arxiv.org/ Their numbers (year, month, serial arrival number) are quoted in the reference list. New versions of an article can be added to the Archives, but the older versions cannot be erased, even if the paper is ‘withdrawn’.
of posted papers that people read, without checking the journal versions for changes, even when the journal version is the one they quote. In my opinion, what is freely posted in the Archives ought to be discussed in the Archives, since it is the sole responsibility of its authors.

In this note I shall focus on the mechanism producing GRBs (for which I have no responsibility) rather than the engine generating them (for which development I do claim a shared responsibility). This gives me the benefit of a somewhat wider perspective.

2 Facts

By facts I mean the statements itemized below, in which all of the quotations are copied from the Archives on the web.

- In an article posted on the web on 14 July, 1994, Nir Shaviv and Arnon Dar [1] argued persuasively that ICS is the mechanism underlying GRB generation. I quote from their abstract: “Striking similarities exist between high energy gamma ray emission from active galactic nuclei and GRBs. They suggest that GRBs are generated by inverse Compton scattering from highly relativistic electrons in transient jets. Such jets may be produced along the axis of an accretion disk formed around stellar black holes (BH) or neutron stars (NS) in BH-NS and NS-NS mergers and in accretion-induced collapse of magnetized white dwarfs or NSs in close binary systems.” The emphasis is mine. In this article Shaviv & Dar predicted what would be a tell-tale signature of the ICS mechanism: a very large polarization of the gamma-rays of a GRB.

- It is difficult to measure the degree of polarization of the gamma-rays of a GRB. Very recently, however, the RHESSI satellite (whose primary purpose is to study the Sun) succeeded in measuring the polarization of a GRB [5]. The result is Π = 80 ± 20%. That is, the gamma ray polarization is virtually complete, as predicted by Shaviv & Dar.

- From the 90’s and until most recently, the generally-accepted paradigm [8–11] for the mechanism generating GRBs was synchrotron radiation: light

---

3 The quoted production mechanisms are those thought to give rise to “Type Ia” supernovae. Our current contention is that these supernovae are responsible for short-duration GRBs [2].

4 Shaviv & Dar state that ICS was first discussed as a mechanism for GRB production by Shemi [3], but in the context of (spherical) fireballs, in which there is no expected polarization. Actually, ICS was discussed earlier by Zdziarski et al. [4].

5 The data analysis has been criticised [6] and defended [7].
emitted by electrons moving in a magnetic field\textsuperscript{6}. Nonetheless, at the time (1994), Shaviv & Dar discussed, both in person and by mail, their then novel idea —\textit{ICS by narrow jets ejected in stellar processes}— with Martin Rees, who kindly pointed to them a typographical error in a calculation they had originally quoted and used.

\begin{itemize}
\item In an article posted on the web on August 14th, 2003 [2], Dar and I incorporated in detail the idea of ICS into the Cannonball model of GRBs [15], which we have developed in collaboration with Shlomo Dado [16,17]. The large polarization it entails is but one of the many successes of the model. Not surprisingly, in that paper [2] we provide ample reference to the original idea of Shaviv & Dar. On the GRB-generating mechanism, we say in the introduction: “The gamma-rays of a GRB may not be produced by synchrotron radiation and their polarization may not necessarily imply a strong, large-scale, ordered magnetic field in their source. In fact, Shaviv and Dar (1995) suggested that highly relativistic, narrowly collimated jets ... may produce cosmological GRBs by inverse Compton scattering (ICS) of stellar light”.

\item In an article posted on the web on September 1st, 2003 [18], Rees and his junior collaborators state: “In this paper we show that the detection of a high level of linear polarization does not necessarily imply that the gamma-ray photons are produced by synchrotron... Compton (Thomson) scattering of photons can, under the appropriate observing geometry, produce highly polarized radiation”. These statements are very similar to those of the previous item.

\item Even clearer is the attribution by Rees and collaborators, in the same article [18], of the idea that Compton scattering is the GRB-generating mechanism. They write: “The possibility that the gamma-ray photons in the prompt phase of GRBs are due to the bulk Compton up-scatter of UV field photons was first discussed by Lazzati et al. (2000; see also Ghisellini et al. 2000)”\textsuperscript{4}. The emphasis is mine and the quoted papers [19,20] are also by Rees and collaborators. The basic idea was not “first discussed” by them, but was thoroughly studied nine years earlier by Shaviv & Dar. This fact cannot have escaped their attention, for they cite our recent paper [2], though in a disparaging manner: “For $\Gamma \gtrsim 10$ the curves are indistinguishable and can be approximated with Eq. 1 with an accuracy of 2\% for $\Gamma = 10$ and 0.1\% for $\Gamma \geq 100$ (see also Dar & De Rujula 2003, who consider only this limiting case)”\textsuperscript{7}. Rees and collaborators neglect to inform the reader that $\Gamma \geq 100$ is the only relevant case, even for
\end{itemize}

\textsuperscript{6} Synchrotron radiation can produce a large polarization, but only under the most unrealistic circumstances. In my opinion, this is what recent articles on the subject show [12–14], although it is not what they say.

\textsuperscript{7} The electrons’ Lorentz factor is $\Gamma \equiv 1/\sqrt{1-v^2/c^2}$. In ICS, the energy of the struck photon is uplifted by a factor that can reach a maximum of $2\Gamma^2$. The Eq. 1 of [18] is Eq. 28 of Shaviv & Dar, written in its more precise form. It also appears in this form as Eq. 19 in [2], and in many standard books on quantum electrodynamics.
In their paper of the year 2000 [19], Rees and collaborators state: *The Compton drag effect has already been invoked for GRBs by Zdziarski et al. (1991) [4] and Shemi (1994) [3]... none of these scenarios was able to account for all the main properties of GRBs. They do not quote the work of Shaviv & Dar (1995), which they would have no good reason to dismiss. By September 2003, as we have seen, Rees and collaborators refer to the Compton mechanism as something that they ‘first discussed’. One of the very many reasons [2] making this mechanism so compelling in comparison to any others is the observation of a high polarization, a result announced on the web in May 2003 [5].

• Is the behavioural pattern described above unusual in the field? No. In the concluding section of Dar & De Rújula [2], after itemizing many similar grievances, we dare to state: “The Cannonball model [ours] may of course be wrong, but it is successful. It is not at all inconceivable that the Fireball models [theirs] continue to incorporate and “standardize” other aspects of the Cannonball model”. In Section 19.1 we referred more specifically to the earlier work of Rees et al. [19] in which they ‘first discuss’ the ICS mechanism: “The authors noticed that, for a large $\Gamma$, the characteristic GRB energies could be explained (Shaviv & Dar 1995); but —perhaps because at the time fireball ejecta were still considered to be broad and to point at the observer— they overlooked the crucial prediction of Shaviv and Dar: a large polarization”. This time Rees and collaborators [18] no longer missed that crucial prediction [1].

3 Later and earlier developments

On September 3rd, 2003, Dar sent an e-mail to Rees, the senior author of the above appropriation of ideas, expressing his surprise and stating: “With due respect, Sir Martin Rees, I think that your position as the Royal Astronomer of Britain requires setting an example of proper scientific conduct and more responsibility. I expect you to withdraw your paper and I expect an apology.” Rees answered promptly, saying that “when we revise our paper we will add a reference to your 1995 paper and change the wording of our comment on your 2003 preprint”.

8 The deviations from the approximate result are of order $1/\Gamma^2$: it is not necessary to draw curves to convince oneself that, even for $\Gamma = 10$, the precision of the approximation is more than sufficient. Moreover, for low $\Gamma$, other uncertainties are crucial, e.g. the directional distribution of target photons. Thus, in my opinion, these calculations in [18] are not only unnecessary, but also misleading.
The response of Rees is inadequate. There is a clear difference between inadvertently forgetting a relevant reference and knowingly attributing someone else’s ideas to oneself, while paraphrasing the original authors’ principal hypothesis, conclusions and results. No one, least of all the Astronomer Royal, should feel licensed to write a paper [18] in which (at least in the original version posted in the web) the ideas of others are simply appropriated. Even if this incorrect attribution of authorship were a momentary lapse, any responsible researcher, having written such a paper, should be apologetic and glad to withdraw it or—at the very least—to correct its posted version immediately. The response of Rees to Dar is not the solution but a further symptom of the problem. Thus, on September 4th, 2003, I sent Rees a strongly-worded e-mail asking him for an apology (which Dar did not obtain) and again requesting that the article be withdrawn. A copy of the message was sent to Rees by registered mail a few days later. I have had no response. As I wrote to Rees, I am left with no choice but to make this issue public.

Fearing a serious clash between astronomers (Rees) and particle physicists (me), a common friend of ours wrote to Rees expressing his concerns. Rees, in his very kind answer (which I was explicitly allowed by Rees to see), writes: “It’s very likely that the paper will need revising on the basis of referee’s comments. Indeed it may of course be rejected – and undoubtedly will be if Dar and de Rujula’s assessment is well-based”. I disagree with this transfer of responsibility to an anonymous referee. It is the duty of the authors and of the editor, who in this case had been informed of the issue. By October 2nd the paper [18] had been accepted, with the proviso that proper references be given. That will not affect the subsequent attribution of the original ideas by other workers in the field, particularly since, to date, the original version of [18] is still the only one posted on the web.

Let me give three other pertinent instances of inadequate citation. When the gamma-ray signal of a GRB is over, the event is not. The GRB is followed by an afterglow (AG). That is, the source continues to shine photons of lower energy, and remains observable for a very long time. GRB afterglows have been observed at many frequencies, from X-rays to visible light, to radio. As far as I know, the first prediction of AGs is due to Jonathan Katz [21–23], who wrote: “The debris’ energy degrades. Its radiation shifts to lower frequencies and increases in duration, and may be observable at frequencies from X-rays down to radio.” The predicted AGs were discovered in 1997 [25] and have played a crucial role in the understanding of GRBs. However, the prediction of AGs is systematically attributed to Mészáros and Rees [26], who, some four years after Katz, wrote: “We find that the resulting cosmological GRB remnants ... produce significant fluxes of softer radiation, mostly X-rays and

---

Paczynski & Rhoads [24] independently predicted a radio AG, analogous to that of SN remnants.
optical, but in some cases radio as well”. These authors do cite Katz [21,23], not for the prediction of AGs (which is what Mészáros and Rees allege to make), but in a collective reference unrelated to AGs. In this case, peer review did not ensure that the earlier work of Katz was properly acknowledged.

The self-attribution by Rees and collaborators of ICS as the GRB-generating mechanism and of the subsequent polarization has born fruit, for they are already quoted in the literature for both items. For instance, Sikora et al. [27], state: “Proposed scenarios include... and Compton scattering... (Lazzati et al. 2000 [19] and references therein). If the polarization measured by the RHESSI satellite is real... the Compton mechanism can still work (... Lazzati et al. 2003 [18]), provided that the jet has an opening angle < 1/Γ.”

Incidentally, the last-cited condition is a complete novelty in Fireball models, while it is satisfied by construction in the [uncited] Cannonball model, in which the only relevant angle is the observer’s viewing angle. To accommodate the data, the original spherical “Fireball” models had to evolve into “Firecone” models [28,29]. Firecones were to emit gamma rays as idealized torches, that is, within a cone with a given “jet” opening angle. For years, these models were anthropoaxial: the observer was placed exactly on the axis of the cone. In Dado et al. 2002 [16], we criticized this improbable hypothesis. Subsequently, in a handful of papers, one of them by Rees and collaborators [30], the relevance of the viewing angle was at last recognized by the GRB community. We were not cited in any of those papers for this trivial but crucial point.

4 In lieu of a conclusion

I have felt obliged to describe several instances of what appears to me to be unethical behaviour on the part of Rees and others. Whether or not this behaviour is plagiarism may be a matter of opinion. Alas, this kind of behaviour is not exceptional in the field, as we have already documented in Dar & De Rújula [2], particularly in the conclusions and in an appendix on the history of the contention that supernovae are the engines of GRBs.

---

10 One of these papers was coauthored by the (not anonymous) referee of our papers [16,17], who had ample time to paraphrase and publish our simple geometrical considerations while delaying our publications for more than a year.
Aftermath

The first version (v1) of this paper was posted on October 27th. Rees and collaborators posted version v2 of their paper in October 29th, with the comment “this manuscript is posted following the comments and allegations of Dr. De Rujula.” In this v2, full reference is given to Shaviv & Dar [1] and the comments that I considered inappropriate have been erased. In this sense, I consider their v2 satisfactory.

The authors of [18] now refer to [1] and [2] as “the point-source limit.” Cannonballs [15,2] are supposed to initially contain a dense enclosed radiation field that drives their expansion during the GRB phase at a radial velocity (in their rest system) comparable to (or somewhat smaller than) the speed of sound in a relativistic plasma \(c/\sqrt{3}\). Since they travel at \(v \approx c\), their “jet opening angle”, as viewed from the SN’s center (in the SN rest system) is \(\theta_j \sim 1/(\sqrt{3} \Gamma)\), or smaller: CBs are “small”, but not pointlike. True enough, we have made the (good) approximation of neglecting the opening angle relative to the viewing angle, but cannonballs are not point sources.

A more significant question of nomenclature—or tactics—is the use of the generic trademark “fireball” to describe contradictory models. The opening angle of the “fireballs” that Rees et al. choose to study varies from \(\theta_j = 0.2/\Gamma\) to \(5/\Gamma\) [18]. While the larger of these “fireballs” are not what we would call cannonballs, they subtend extremely narrow angles. These “fireballs” are very much more similar to cannonballs than to the original fireballs: concentrical spherical shells spanning a full \(4\pi\) solid angle, or a good fraction thereof, see [8–11] and references therein. In this sense, v2 of Rees et al. is still a good example of a possibility contemplated in [2]: “that the Fireball models continue to incorporate and “standardize” other aspects of the Cannonball model”. If the opening angle is further restricted to \(\theta_j < 1/\Gamma\), as in the statement by Sikora et al. [27] quoted in section 3, this good example becomes a perfect example, and we may have been right in having said: “fireballs may turn out to have always been cannonballs” [2].

References

[1] Shaviv, N. J. & Dar, A. 1995, ApJ, 447, 863; astro-ph/9407039
[2] Dar, A. & De Rújula, A. 2003; astro-ph/0308248, submitted to MNRAS
[3] Shemi, A. 1994, MNRAS, 269, 1112; astro-ph/9404047
[4] Zdziarski, A. A., Svensson, R. & Paczynski, B., 1991, ApJ, 366, 343
[5] Coburn, W. & Boggs, S. E., 2003, Nature 423, 415; astro-ph/0305377
[6] Rutledge, R. E. & Fox, D. B., 2003; astro-ph/0310385
[7] Boggs, S. E. & Coburn, W., 2003; astro-ph/0310515
[8] Mészáros, P. 2002, ARA&A, 40, 137; astro-ph/0111170
[9] Piran, T. 1999, Phys. Rep., 314, 575; astro-ph/9907392
[10] Piran, T. 2000, Phys. Rep., 333, 529; astro-ph/9907392
[11] Waxman, E. 2003, In Supernovae and Gamma Ray Bursters, ed. K. W. Weiler, Lecture Notes in Physics, Springer-Verlag (in press); astro-ph/0303517
[12] Eichler, E., & Levinson, A., to appear in ApJL; astro-ph/0306360
[13] Waxman, E. 2003, Nature 423, 388; astro-ph/0305414
[14] Nakar, E., Piran, T. & Waxman, E. 2003; astro-ph/0307290
[15] Dar, A. & De Rújula, A., 2000, rejected for publication in A&A; astro-ph/0008474
[16] Dado, S., Dar, A. & De Rújula, A. 2002, A&A, 388, 1079; astro-ph/0107367
[17] Dado, S., Dar, A. & De Rújula, A. 2003, A&A, 401, 243; astro-ph/0204474
[18] Lazzati, D., Rossi, E., Ghisellini, G. & Rees, M.; astro-ph/0309038, accepted for publication in MNRAS
[19] Lazzati, D., Ghisellini, G., Celotti, A. & Rees, M. 2000, ApJ, 529, L17; astro-ph/9910191
[20] Ghisellini, G., Lazzati, D., Celotti, A. & Rees, M. 2000, MNRAS, 316, L45; astro-ph/0002094
[21] Katz, J. I., 1994; ApJ, 422, 248; astro-ph/9212006
[22] Katz, J. I.; astro-ph/9311015
[23] Katz, J. I., 1994, ApJ, 432, L107; astro-ph/9312034
[24] Paczynski, B. & Rhoads, J. E., 1993, ApJ, 418, L5; astro-ph/9307024
[25] Costa E., et al., 1997, Nature, 387, 783; astro-ph/9706065
[26] Mészáros, P. & Rees, M. J., 1997, ApJ, 472, 232; astro-ph/9606043
[27] Sikora, M. et al.; astro-ph/0309504
[28] Rhoads, J. E. 1999, ApJ, 525, 737; astro-ph/9903399
[29] Frail, D. A., et al. 2001, ApJ, 562, L55; astro-ph/0102282
[30] Rossi, E., Lazzati, D. & Rees, M. J. 2002, MNRAS, 332, 945; astro-ph/0112083