GAMMA-RAY BURSTS AND THE SOCIOLOGY OF SCIENCE

ALVARO DE RÚJULA

CERN

1211 Geneva 23, Switzerland

E-mail: alvaro.derujula@cern.ch

ABSTRACT

I discuss what we have learned about Gamma-Ray Bursts (GRBs) by studying their afterglows, and how these are interpreted in the generally-accepted fireball model of GRBs, as well as in the generally-unaccepted cannonball model of the same phenomena. The interpretation of GRBs is a good example around which to frame a discussion of the different approaches to science found in various fields, such as high-energy physics (HEP), high-energy astrophysics, or even the deciphering of ancient languages. I use this example to draw conclusions on post-academic science, and on the current status of European HEP.

1. Motivation

Why would one give a talk on the sociology of science at a meeting on Un altro modo di guardare il cielo, or more generally on neutrino physics, the meeting definitely not being centred on sociology? My excuse is that, when talking about GRBs, I have always detected a very considerable interest on their sociology: an extremely negative reaction to my views on the subject in meetings on GRBs, and an extremely surprised and curiosity-driven interest from HEP or general audiences.

A talk or article such as this one may seem rather unusual, but it is not. A precedent with quite similar content and conclusions has been written by Charles Dermer.[1]

2. Introduction

Some three times a day, on average, gamma-ray bursts (GRBs) reach the upper atmosphere from isotropically distributed sky locations. Much of their energy is in photons of a few hundred keV, with a total fluence of \(10^{-6}\) erg s\(^{-1}\), give or take a couple of orders of magnitude. GRB durations range from tens of milliseconds to hundreds of seconds, with varied time structures generally consisting of fast rising and declining, isolated or partially-superimposed pulses. The distribution of GRB durations is bimodal, with a trough at \(\sim 2\) s, separating “short” from “long” GRBs.

The example of the \(\gamma\)-ray counting rate of GRB 030329 is given in Fig. 1. This burst, originating at \(z = 0.1685\), is the second-closest GRB of known distance. It is “long” and it has a relatively simple structure, with just two similar “pulses”.

It has become a custom to refer to Gamma-Ray Bursts as the biggest explosions since the big bang. I contend that this is bad propaganda: the big bang was not an
explosion in any conventional sense, and GRBs are a highly-beamed but relatively-small fraction of the energetic budget of a supernova (SN) explosion. For not-very updated reviews of these views, and to trace the many references I cannot include, see Dar\(^2\) and De Rújula\(^3\) and... references therein.

We call our unconventional theory of GRBs “the CannonBall (CB)” model. The conventional models are collectively dubbed the “fireball” model\(^a\). In the available space, I cannot give justice to either model, so I will describe them rather superficially and compare them in detail only in one particular but not unusual case, concerning the analysis of the “radio afterglow” of GRB 991208.

3. Science

3.1. GRB afterglows

Our information about the once totally mysterious gamma-ray bursts increased spectacularly in the past few years. The rapid directional localization of GRBs by the satellites BeppoSAX, Rossi and by the Inter-Planetary Network of spacecrafts led to a flurry of progress. The crucial discovery\(^1\) was the existence of “afterglows” (AGs)

\(^{a}\)These models are “standard” in that the analysis of observations is invariably phrased in their language. They are not “standard” in the same sense as the standard model of particle physics.
of long-duration GRBs: not surprisingly, a GRB “event” does not end as the γ-ray flux becomes undetectably small. The source continues to emit light at all smaller observable frequencies, ranging from X-rays to radio waves, and to be observable for months, or even years. The fact that these remaining emissions can be very well localized in the sky has led to the discovery of the GRBs’ host galaxies; the measurement of their redshifts that verified their cosmological origin; the identification of their birthplaces —mainly star formation regions in normal galaxies— and the first evidence for a possible association (in time and location) between GRBs and supernova explosions: that of GRB 980425 and the supernova SN1998bw.

Two examples of optical “R-band” AGs and their CB-model fits are given in Fig. 2, showing the time evolution of their fluence (measured energy per unit time, surface and frequency interval). In the case of GRB 991208, three contributions to the observations are shown and added: the unresolved host galaxy, the “true” GRBs AG, and a supernova identical to SN1998bw, but “transported” to the redshift of this particular GRB. In the case of GRB 021211, the fitted host galaxy’s contribution is subtracted, and the SN contribution to the AG is also observable.

3.2. The afterglows of fireballs and firecones

In the fireball model, reviewed, for instance, by Piran and Meszaros, both the γ-rays and the AG of a GRB are made by synchrotron radiation in backward-
and forward-moving shocks, which are produced as relativistically expanding shells collide with each other and with the interstellar medium (ISM). These shells are made of $e^+e^-$ pairs, with a small admixture of protons (a “baryon-load”) fine-tuned not to quench the observed radiation.

The possibility that the fire-“ball” ejecta may not be spherically distributed has been repeatedly studied in the literature. In the fireball model this was not done in detail prior to the influential papers by Rhoads,[12], who predicted abrupt breaks in the power-law temporal behaviour of the AG light curves. So did fireballs evolve into “collimated fireballs”, “firecones” or “conical fireball jets”, while maintaining the “fire” lineage.

As in the cases of Fig. 2, abrupt breaks are not observed. Yet, observers fit AG light curves to extract a break time $t_b$ from “phenomenological” formulae, such as:

$$F_\nu = \frac{2 F_\nu^b}{[(t/t_b)^{\alpha_1} \cdot (t/t_b)^{\alpha_2}]}^{\frac{1}{s}};$$

which interpolate between two power laws with a tunable “abruptness” $s$, often set to $s = 1$. The values of $t_b$ extracted from such arbitrary expressions have no clear meaning. Even when applied to the same GRB’s AG, a fit of the above form may be problematic. In the case of GRB 020813, for instance, Covino et al. extract $t_b = 0.59 \pm 0.03$ days from data in the interval between 3 hours and 4 days,[13], while Li et al. find $t_b = 0.13 \pm 0.03$ days, for data in the 1.7 hours to 1.2 day period.[14]

Various groups[15,16,17,18] have modelled the light emitted by firecones without some of the approximations originally introduced by Rhoads. The evolution of the ejecta, for instance, is treated continuously, not as a process with a break-time. Not having an abrupt break put in by hand, no abrupt break is predicted. The fair conclusion[19] is that the AG light curves, even in firecone models, are too smooth to allow for a determination of a hypothetical break time $t_b$. There is no reason to fit them with underived expressions such as Eq. (1), nor to extract any conclusions from such fits.

To me, the most surprising aspect of all detailed theoretical analyses of GRB AG data published so far is that the firecone advocates place the observer precisely on the jet’s axis, for no stated reason. It is obvious that the viewing angle is a relevant parameter that cannot be unceremoniously dismissed, if only because $d \cos \theta = \sin \theta \, d\theta$: the probability of being away from the axis increases with $\theta$. Moreover, a distribution of viewing angles would completely erase a possible meaning of the distribution of specific $t_b$ values extracted from expressions such as Eq. (1). To say the least, the anthropo-axial view that the ejecta of the observed AGs always point to the observer has not been shown to be a fair approximation. To air this kind of critique at GRB conferences is not without danger, as made evident by Fig. 3.
3.3. The AG of GRB 991208 in fireball language

The summary of this detailed section is: the SM—in its many variations and with lots of parameters—fails in its fits and predictions and, to face this fact, only unsupported excuses are given.

Early radio measurements of the AG of this GRB, from day $\sim$3 to day $\sim$14 after burst, were reported by Galama et al.\cite{G1} (hereafter G1), who discussed them, along with the optical data, in the “standard” fireball model (hereafter SM). Follow-up radio measurements up to day 293 after burst and a SM reanalysis of the broad-band AG of GRB 991208 were reported by Galama et al.\cite{G2} (hereafter G2).

In G1 the authors use the radio and optical AG of this GRB to extract the power-law index of the synchrotron-radiating electron distribution $p$, and the values at three different times of the SM quantities needed to describe the AG: the self-absorption and peak frequencies $\nu_a$ and $\nu_m$, and the peak flux density $F_m$. With $p = 2.52$ fixed and power-law fits to the temporal evolution of the other quantities, they fit the AG of GRB 991208. They find that various spherical models (“ISM” with a constant-density medium, and “WIND” with a circumburst ISM density decreasing as $1/r^2$) and a conical (“JET”) model are all inadequate. In conclusion, they advocate a model with a transition from a quasi-spherical to a jet evolution, but they do not offer any
analysis in its support: the conclusion is what the French would call _paroles verbales_.

The predictions of G1 are that $\nu \propto t^{-14/13}$ at $t > 10$ days and $F_\nu \propto t^{-(2.2 \text{ to } 2.5)}$ for $\nu = 8.46$ GHz at $t > 12$ days, as well as for $\nu = 4.86$ GHz at $t > 17$ days. These predictions are in stark contrast with the findings of G2.

In G2 the authors introduce an extra cooling frequency $\nu_c$, and a “FREE” fit with 9 parameters ($p$ and 2 parameters for $F_m$ and each transition frequency, all assumed to behave as $Ct^{-b}$). The more constrained ISM and WIND models turn out to be inadequate, as in G1. The JET model is an improvement over that of G1, but it fails to reconcile the late-time decay $F_\nu \sim t^{-1.1}$ at 8.46 GHz with the much steeper optical decay $F_\nu \propto t^{-2.2 \pm 0.1}$, which should be similar. The FREE model provides a satisfactory fit to the data, but it implies that the combination $\gamma B^3$ of the bulk Lorentz factor of the flow and the post-shock magnetic field ought to be roughly constant, while both are expected to decline with time. In G2, the predictions of a model with two electron energy distributions are also found to fail.

Faced with so much unsuccess, the authors of G2 conclude “the simplest explanation which is consistent with the data and requires no significant modifications is that the blast wave of GRB 991208 entered a non-relativistic expansion phase several months after the burst”. As in G1, no support is given to this verbal conclusion.

### 3.4. A refreshing interlude: Jets in Astrophysics

A look at the sky, or a more modest one at the web, results in the realization that jets are emitted by very many astrophysical systems (stars, quasars, microquasars,...). One of the most impressive cases is that of the quasar Pictor A, shown in Fig. 4. Somehow, the active galactic nucleus of this object is spitting something that does not appear to expand sideways before it stops and blows up, having by then travelled for a distance of several times the visible radius of a galaxy such as ours. A closer look at another such object is provided in Fig. 5: the central region of M87, wherein what appears to be a succession of blobs of matter has been jetted. Many such systems have been observed. They are very relativistic: the Lorentz factors $\gamma \equiv E/(mc^2)$ of their ejecta are typically of $O(10)$, and there is one case with a claimed $\gamma \sim 10^3$. The mechanisms responsible for these mighty ejections —suspected to be due to episodes of violent accretion into a very massive black hole— is not understood.

In our galaxy there are “micro-quasars”, in which the central black hole is only a few times more massive than the Sun. The best studied example is the $\gamma$-ray source GRS 1915+105. In a non-periodic manner, about once a month, this object emits two oppositely directed cannonballs, travelling at $v \sim 0.92c$. As the emission takes place, and as illustrated in Fig. 6, the X-ray emission —attributed to an unstable accretion disk— temporarily decreases. How part of the accreting material ends up ejected along the system’s axis is not understood. The process reminds one of the blobs emitted upwards as the water closes into the “hole” made by a stone dropped onto its
Figure 4: A Chandra X-Ray image of Pictor A.

Figure 5: A Chandra X-Ray image of the M87 jet.
surface. It is only the relativistic, general-relativistic magneto-hydro-dynamic details that remain to be filled in! Atomic lines from many elements have been observed in the CBs of $\mu$-quasar SS 433. Thus, at least in this case, the ejecta are made of ordinary matter, and not of some fancier substance such as $e^+e^-$ pairs. In the analysis of quasar and microquasar ejecta, the relevant parameters are the Lorentz factor and the angle between the jet direction and the observer (and not, as in the firecone models, the opening angle of the jetted material).

3.5. The Cannonball model

The CB model is not based on hypothetical fireballs, firecones or hypernovae, but on close analogies with the observed astrophysical jets. The *long-duration* GRBs and their AGs are produced in ordinary *core-collapse* supernovae by jets of CBs, made of *ordinary atomic matter*, and travelling with high Lorentz factors, $\gamma \sim 10^3$. A CB is emitted, as observed in $\mu$-quasars, when part of an accretion disk falls abruptly onto the newly-born compact object. As it crosses the circumburst material (the shell of the SN and the “wind” of the parent star) the surface of a CB is collisionally heated to keV temperatures and the quasi-thermal radiation it emits as it reaches the transparent outskirts of the circumburst matter —boosted and collimated by the
CB’s motion— is a single $\gamma$-ray pulse in a GRB. A competing mechanism\cite{29,30} for the $\gamma$-ray production is inverse Compton scattering of the SN light by the electrons in the emerging CBs\cite{c}. For both mechanisms, the timing sequence of emission of the successive individual pulses (or CBs) in a GRB reflects the chaotic accretion process; its properties are not predictable, but those of the single pulses are.

After a few observer minutes, the CBs’ emissivity –the afterglow– is dominated by synchrotron emission from the electrons that impinge and penetrate in them from the ISM\cite{31}. These electrons are Fermi-accelerated in the CB’s magnetic maze to a broken power-law energy distribution with a “bend” energy $E_b = \gamma(t) m_e c^2$, with $\gamma(t)$ diminishing as the CBs decelerate. Let $\theta$ be the angle between the CBs’ viewing and travelling directions, $\delta(t) \approx 2 \gamma/(1 + \gamma^2 \theta^2)$ be the emitted radiation’s Doppler energy-boost factor, and $n_e \approx n_p$ the electron and proton ISM number densities. The observer sees an energy flux:

$$F_\nu \equiv \nu \frac{d n_e}{d \nu} \propto n_e [\gamma(t)]^{3\alpha-1} [\delta(t)]^{3+\alpha} \nu^{-\alpha},$$

with $\alpha$ steepening from $\approx 0.5$ to $\approx p/2 \approx 1.1$ at the “injection bend” frequency\cite{32} corresponding to $E_b$:

$$\nu_b \approx 1.87 \times 10^3 [\gamma(t)]^3 \delta(t) \left[ \frac{n_p}{10^{-3} \text{cm}^{-3}} \right]^{1/2} \text{Hz}. \quad (3)$$

We assume the SNe associated with GRBs to occur mainly in super-bubbles of approximately constant $n_p$, except in the immediate vicinity of the progenitor. For a constant-density ISM, $\gamma(t)$ is the real root of the cubic:

$$\frac{1}{\gamma^3} - \frac{1}{\gamma_0^3} + 3 \theta^2 \left[ \frac{1}{\gamma} - \frac{1}{\gamma_0} \right] = \frac{6 c t}{(1 + z) x_\infty}, \quad (4)$$

where $\gamma_0 = \gamma(0)$, and $x_\infty$ characterizes the CB’s slow-down (it takes a distance $x_\infty/\gamma_0$ for a CB to decelerate to half its original Lorentz factor).

In the CB-model fits\cite{31} we fix the electron index to its theoretical value $p \approx 2.2$. The optical AGs then depend on 4 parameters: overall normalization, $\gamma_0$, $x_\infty$ and $\theta$. In the radio domain, where self-absorption is important, only one extra parameter is needed. The dominant absorption mechanism is free–free attenuation (inverse bremsstrahlung $e p \gamma \rightarrow e p$), characterized by a parameter $\nu_a$ in the opacity, which behaves as $\tau_\nu = (\nu_a/\nu)^2 (\gamma(t)/\gamma_0)^2$. Self-absorption produces a turn-around of the spectra from $F_\nu \sim \nu^{1.5}$ to $F_\nu \sim \nu^{-0.5}$ as $\nu$ increases.

To date, the CB model provides a very good, simple and unified description of

\*This process produces a highly polarized beam of $\gamma$-rays, except right at the jet’s axis.
the light curves and spectra of the AGs of all GRBs of known redshift.

3.6. GRB 991208 in the CB model

This section is to the CB model what section 3.3 is to the standard model. Its summary is: the CB model —simple and parameter-thrifty as it is— succeeds in its fits and predictions.

The AG of GRB 991208 has been analysed thrice in the realm of the CB model. In Dado et al. (hereafter DDD1) we fitted the available R-band data on all the then-measured GRBs of known redshift, including this one, which is shown in the left panel of Fig. 2. In DDD2 these results were extended to wide-band fits of all the available optical and radio data, which included at the time the early radio data of G1. Finally, in DDD3, we compared our predictions in DDD2 with the observations in G2 of the later-time radio data.

In the CB model, the AG of a GRB has three contributions: the CB, the host galaxy and a “standard candle” supernova akin to SN1998bw, transported to the GRB’s redshift. In Fig. 2 the presence of the SN is shown in two cases, one of which is GRB 991208. In a CB-model analysis, in all instances wherein such a SN could be seen, it was seen. This is so for all AGs with $z < 1.2$ (DDD1), including the cases where the presence of a 1998bw-like SN was a prediction, based on the optical data preceding the observable SN contribution.

Results for multifrequency fits to GRB AGs cannot be shown in a limited space. In comparing the SM results of G1 and G2 with the CB-model results of DDD2 and DDD3, I concentrate on the radio data at 8.46 GHz, for which the measurements of G1 and G2 are particularly abundant and precise. Shown in Fig. 7 are, on the left, the G1 early data and its SM extrapolated prediction for later times, quoted in section 3.3. Shown on the right are the CB model fit of DDD2 and its predicted extrapolation in time.

Referring once again to an observed 8.46 GHz frequency, I show in Fig. 8 on the left, the comparison of the late G2 radio data with the SM prediction in G1. The later data are labelled by asterisks. In the same figure, on its right, two CB-model fits are shown. One of these wide-band fits is the DDD2 fit shown in Fig. 7; the other is a new fit, along identical lines, including the new radio data of G2. The figure shows that the predictions of DDD2 were very satisfactory: the a-priori and a-posteriori fits are very similar and they both provide a good description of the observations, their difference not being larger than the scintillating ups and downs of the data.

In Table 1 I report the parameters for the R-band fit of DDD1, the broad-band fit of DDD2 and the DDD3 fit to all data. They are quite stable. Even the DDD1 fit to only the R-band data determines $\gamma_0$, $\theta$ and $x_\infty$ to within a few per-cent of the results.

\[4\text{In the CB model, GRB 980425 —associated to SN1998bw— is in no way exceptional.}^{30,31,32}\]

Unlike in the SM, it makes sense to use this SN as a putative standard candle.
Figure 7: The radio fluence of GRB 991208 at 8.46 GHz (G1). The ups and downs of the data are due to scintillations. The best fits shown are the subensemble of the wide-band fits by G1 (left) and DDD2 (right) that refer to this particular radio-frequency. The (red) thick lines in the left panel bracket the predictions of G1.

Figure 8: Comparisons of the predictions of G1 (left) and DDD2 (right) with the later measurements in G2, labelled by asterisks. The red-point line on the right is the CB-model prediction of DDD2 and Fig. 7. The black-point line is a fit including the G2 data.
of the DDD2 fit (117 data points in total), even though the former fit is based on the mere dozen of early data points that are not dominated by the SN, see Fig. 2. For fits that are so similar, their single parameters describing the overall normalization are also necessarily similar: they are not reported in Table 1.

Table 1: Parameters of the successive CB-model fits to the AG of GRB 991208. DDD1 is a fit to only R-band optical frequencies. DDD2 is a wide-band fit with only the early radio-data of G1. DDD2 is the fit to all data, including the G2 late radio data.

| Parameter | DDD1 | DDD2 | DDD3 |
|-----------|------|------|------|
| $\theta$ [mrad] | 0.100 | 0.111 | 0.103 |
| $\gamma_0$ | 1034 | 1034 | 1089 |
| $x_\infty$ [Mpc] | 1.357 | 1.014 | 1.382 |
| $\nu_a$ [MHz] | **** | 103 | 98 |

Table 1 shows how robust and predictive the CB model is. Its parameters are few, and consistently determined as new data are added to successive fits. This, as we have seen, is in stark contrast with the situation in the SM, with its many more parameters, its predictive failures, and the verbal excuses for its successive inadequacies. In my opinion Occam would have no trouble choosing between these models; he may not even need his proverbial sharp razor, a dull spoon would suffice. Notice that, the way I put it, the defenders of the standard model would also agree!

4. Sociology

In what follows, I try to place the avatars of the CB model in a more general context.

4.1. Things that happen to us

So far, the CB model has encountered no problems in its confrontation with data. It is in its confrontation with humans that the model fares the worst. Just as an example, let me comment on the result of having sent for publication in the
Astrophysical Journal Letters our paper DDD3, entitled “Fireballs and Cannonballs confront GRB 991208”, where we compare the SM analysis by G1 and G2 to our CB-model analysis of the same data, as I did here.

The first referee asserts: “There is nothing new in this manuscript”. Then, commenting on the fact that Galama et al. do not refer to our successful predictions of their G2 data, he continues, somewhat contradicting himself: “If Dado et al. are right, then surely the referee of Galama et al. will catch this gross oversight and have it fixed in the revised submission”. This is pulling our legs under the cover of anonymity.

We ask for a second referee, who reports: “The claim that the CB model works better than the standard fireball models is not made in a way that would convince any objective reader”. He does not bother to say why. To me this sounds as being impermeable to facts. Finally, we complain to the editor, who responds: “I have no claim to infallibility”.

My colleagues and I have written some 18 papers on GRBs in the CB model, the first four of which were rejected on grounds very similar to the above. That is, not once on the basis of scientific critique. This is very discouraging. One is tempted to entitle all of one’s papers on the subject “Mission Impossible”.

4.2. Things that happen

Scientists generally adhere to the Popperian view that every genuine test of a theory is an attempt to falsify it. Reading the current astrophysical literature, one very often sees this opinion challenged. As we have seen, and to quote Popper again: Some genuinely testable theories, when found to be false, are still upheld by their admirers —for example by introducing ad hoc some auxiliary assumption, or by reinterpreting the theory ad hoc in such a way that it escapes refutation. Such a procedure is always possible, but it rescues the theory from refutation only at the price of destroying, or at least lowering, its scientific status. But it can be even worse, as I shall illustrate with a few examples.

GRBs occur in star-formation regions and are no doubt associated with processes in aged very large stars. One expects the matter density around the progenitor to be characteristic of the environment of such stars, which shed matter for a few thousand years at the end of their lives, at a roughly constant mass-loss rate. This results in a circumstellar density profile $\rho \sim 1/r^2$. In an article on GRB 011121, its authors state: “Unfortunately, until now there has been no clear evidence for a wind-fed circumburst medium... in the afterglow of any cosmologically located GRB”. At the time there were a score of such AGs, meaning that unfortunately the SM expectation was not corroborated for these many cases. The article continues: “We undertake afterglow modeling of this important event and to our delight have found a good case for a wind-fed circumburst medium”. This kind of misfortune and delight may be

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*I am not being sexist in my language, I am sure that no woman would have said such things.*
what Popper refers to when saying: *It is easy to obtain confirmations, or verifications, for nearly every theory —if we look for confirmations.* Fortunately, this attitude is the opposite to that of most researchers in most areas of science, who are motivated by challenging their respective “standard models”.

Placing belief in prejudices ahead of facts that contradict them is not as unusual in science as one may hope. Cosmic-ray physics is another area in which the corresponding “standard model” is in dire straights. Cosmic rays are supposed to be accelerated in the shocks produced by the collisions of the moving shells resulting from SN explosions with the ambient matter. Synchrotron radiation from accelerated electrons in such sites has been observed, but the limits on \( \gamma \) rays from \( \pi^0 \) decay are well below the expectation from collisions of the assumed accelerated protons and nuclei. I looked for a recent review on the subject and, in the first one I found[^39], it says: “Frustratingly, the accelerated “cosmic-ray” ions, which should produce \( \gamma \) rays by nuclear interactions with the ambient gas, have evaded detection so far. So, we are still unable to prove the origin of cosmic rays nearly a century after their discovery!”. The emphasis is mine, the style, by now, is familiar.

More often than not, astrophysical phenomena involve very complex physics. Deciphering them is not unlike deciphering the script of an ancient language. It may not be surprising that there are similarities between the sociologies of these two fields.

The jesuit priest Athanasius Kircher pretended to have deciphered the ancient-Egyptian hieroglyphic language. His “translations” of the writings in the Egyptian obelisks in Rome were entirely forged. But Kircher’s influence was so enormous that he managed to stall progress in the field for a full century. Alas, even in the XXth century, similar things did happen. Sir John Eric Sidney Thompson had an entirely incorrect view of Mayan scriptures, which he thought were “anagogical” (having a mystical meaning beyond the text) and ideographic, as opposed to phonetic. Given his great stature in the field, his views delayed the deciphering of the Mayan language by some 30 years. Perhaps he was knighted for that feat.

Nothing of what I have reported is that surprising for, after all, science is a human endeavour, not a divine activity. Yet, by now, if I am being effective, my audience or my hypothetical readers ought to be indignant. _Nothing of this sort could happen in my university or my lab!... should they be screaming to themselves_. I cannot fully scream in the same way for, in my lab (though it is the “best and biggest” of its kind) one can also find all sorts of humans. Which brings me to my next subject.

### 4.3. High Energy Physics

Two things that high-energy physicists cannot be accused of are excessive belief in their standard model (in spite of its brutal and continued success) and lack of receptiveness to new ideas. A result lying three or even fewer standard deviations away from the standard expectation is enough to send a good fraction of the community
bananas. Theories that have very little contact with current experiments are widely venerated. Models that would require an extraordinary piece of luck to be relevant in the near future (such as extra dimensions at accessible high energies or short distances) create a flurry of activity. None of this is particularly unhealthy, for science is exploration by the open-minded.

Yet, the fact that HEP experimental research now requires very large groups and a complex organization inevitably brings into the fore considerations that are not as “pure” as “pure science” ought to be, according to “the book”. Thus, we announce with great to-do “discoveries” that are not all that convincing. We embark in programs that are patently useless. When giving the talks on which this article is based to HEP audiences, I did not say explicitly to what discoveries or programs I was referring to. And yet... everybody knew. Exactly.

In my opinion, the most worrisome current aspect of HEP in not that we are moving so fast from science to management, or from science to “post-academic” science. What really bothers me is how little we are doing to revitalize our field by fighting for more diversified scientific programs, for larger long-term investments in R&D, and for new resources, even though the field is as challenging as it ever was!

5. Conclusions

It goes without saying that my critique of the standard model of GRBs does not imply that I am convinced that the cannonball model is entirely “right”. It is an extreme simplification of a very complicated phenomenon; it will either require refinements or even turn out to be completely wrong. The latter is improbable for, unlike the SM, the CB model explains well and in an extremely simple fashion practically all aspects of the data on long-duration GRBs. There seems to be something right about it. But the assumptions and predictions of the CB model, or any other, should be tested against observations, or challenged for consistency. In other realms of science the existence of a sensible model challenging the standard lore would be very welcome, as opposed to olympically ignored.

Relative to my more general “sociological” considerations, I have nothing to add.

6. Acknowledgements

Viki Weisskopf used to say “Physics is best done in a hostile environment”. Surely my coauthors and I are, in this sense, obliged to quite a few ominous and anonymous colleagues. But we would not have been able to survive the environment for long, had we not held prior tenured positions.

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