6

Doubts About Big Bang Cosmology

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1. Introduction

Only beasts could remain indifferent to questions about the origin, structure and fate of the cosmos in which they live. Only saints could resign themselves to never knowing the answers. The upshot has been that every civilization known to anthropology has put together such meagre observations as it possesses, has interpreted them in the light of currently fashionable ideas, and then manufactured as plausible a cosmological story as it can to tell its students and its children. The trouble is that none of those cosmologies have stood the test of time. Have we any reason to be more confident in the Big Bang Cosmology (BBC) which is fashionable today?

There are many good reasons to be sceptical of cosmology *as a subject*. For instance:

(A) There is only one universe! At a stroke this removes from our armoury as scientists all the statistical tools that have proved indispensable for understanding most of astronomy.

(B) The universe has been opaque to electromagnetic radiation for all but 4 of the 60 decades of time which stretch from the Planck era (dex -43 sec) to today (dex +17 sec.) Since as much interesting physics could have occurred in each logarithmic decade, it seems foolish to hope the we will ever know much about the origin of the cosmos, which is lost too far back in the logarithmic mists of Time. Even the Large Hadron Collider will probe the microscopic physics back only as far as dex (-10) secs [1].

(C) Cosmology requires us to extrapolate what physics we know over huge ranges in space and time, where such extrapolations have rarely, if ever, worked in physics before. Take gravitation for instance. When we extrapolate the Inverse Square Law (dress it up how you will as G.R.) from the Solar System where it was established, out to galaxies and clusters of galaxies, it simply never works. We cover up this scandal by professing to believe in "Dark Matter" – for which independent evidence is lacking.

(D) The human and historical time frame is so short compared to the cosmic one that we have in effect only a few still shots of a dynamical universe, with no proper (oblique) motions. It's as if we had to deduce not only the final score, but the rules of a football match from a few still photos.

(E) By cosmical (i.e. intergalactic) standards our local background is very bright. For instance the extra-galactic universe contributes less than one percent of the optical photons even at a dark mountain site on a moonless night. Much of the universe must therefore, and at many wavelengths, still lie hidden below the sky, even from space, because of the problem of *contrast*. And according to Tolman [2] distant extended objects like galaxies will be dimmed by (1+z) to the fourth power, an enormous factor at the kind of redshifts (z~10) where galaxies are supposed to form. Many galaxies, even nearby, will be sunk below the sky.

Even so cosmology is such a fascinating subject that I for one would like to believe that progress can and is being made. But how could one tell? Just because large teams are dedicated to working out the details of BBC doesn't mean that the underlying paradigm is secure. Although Hubble is widely and incorrectly credited with the discovery of expansion back near 1930, in fact he died in 1956 still sceptical, as were many of his contemporaries, of the dramatic notion that redshift implies expansion. Today the opposite attitude prevails where expansion, and all that it implies, goes virtually unquestioned. To be sure there is more evidence, but not all that evidence points in the same direction. Scientific history is littered with theories which once fitted many facts – Newtonian gravitation for instance. In the end though it is the discrepancies which signify more, even where they are relatively minor (e.g. the perihelion of Mercury). And as a galaxy astronomer I can see many worrying discrepancies between BBC as it stands now and the galaxies we can observe so minutely in our neighbourhood. We do BBC no favours by accepting it without question. We only blind ourselves to other truths or modifications that might be staring us in the face.

Here I discuss BBC mainly from an epistemic point of view and in particular try to answer two questions:

(1) Do we have enough evidence to be confident that BBC is broadly right?

(2) Where the evidence is contradictory, as it certainly is in the case of BBC, can one nevertheless come to a rational verdict on its soundness, taking into account the whole surrounding network of interlocking clues?

As to the first question I will suggest that the answer is ' Probably No' because BBC appears to have more Free Parameters than relevant observations. As to the second there is a Bayesian way to summarize contradictory evidence, but one's final verdict necessarily depends on the rather arbitrary weights (Likelihoods) one must attach to some of the contradictory clues. There is a great deal of room for debate here but I contend that it is a debate that needs to be held, and discussed openly.

2. BBC's lack of evidential significance

We question the significance of BBC by looking at the difference between the number of measurements with cosmological relevance that have been made, and the number of Free Parameters (FPs) introduced by BB theory to fit those same measurements. Where that difference is comfortably positive, one might regard cosmological theory as "significant" in the sense that the fit may be better, perhaps much better than one could have expected by chance. But where it is zero or negative there is no such balance of probabilities to recommend it.

Precisely which, and how many FPs are regarded as 'Cosmological', as distinct from more widely 'Astrophysical', is to some extent a question of taste, but it does not matter much so long as we treat them consistently, i.e. if included for fitting they also be included for measurement.

We proceed by means of an historical table (Table 1) where each line introduces either new FPs (column 3) widely touted then as being of cosmological significance or the first (seldom the best) claimed measurement of them (column 4), with the concurrent difference in number between the two i.e. the concurrent "Significance", in column 5. This is purely a counting exercise with no real need to understand what the parameters are, or how they have been measured. Readers interested in such details can however follow them up in Ratra and Vogeley's excellent recent review 'The Beginning and Evolution of the Universe' [7]. I deliberately halted the survey after the first account of WMAP's findings in 2003 in order to let the dust settle but have used the same ensemble of parameters as they did. No doubt more recent, and probably more controversial additions (or subtractions) could be made, according to taste.

	(1)	(2)	(3)	(4)	(5)
	DATE	NEW STEP	NEW FREE PARAMS	NEW MEASUREMENTS	CURRENT SIGNIFICANCE.
1	1917	Einstein's model	H_0 , k_0 , Ω_0	One equation between them.	-2
2	1921	Cosmological constant	Ω_Λ		-3
3	1929	Galaxy Redshifts		H_0	-2
4	1965	Cosmic Background Radiation(CBR)	η	η	-2
5	1970's	Big Bang Nucleosynthesis	Ω_b	Ω_b	-2
6	1974	Cosmochronology		$(\sim 1/ H_0)$	-2
7	1978	Dark Matter	Ω_M		-3
8	1970,s	Initial Seeds	A,n_s		-5
9	1978	Gravitational Waves	r		-6
10	1981	Inflation	N		-7
11	1980's	Large Scale Structure	b, σ_8 , ξ		-10
12	1990	COBE		A	-9
13	1998	Supernovae	w	Ω_Λ	-9
14	1998	Clustering		σ_8	-8
15	2000	Galaxy Infall		ξ	-7
16	2000	BOOMERANG		n_s, Ω_M , Ω_0 (k_0 inferred from equation in row 1)	-4
17	2003	WMAP	d n_s /dlogk, τ , τ_0	τ ,d n_s /dlogk, b	-4

Table 1. Cosmological parameters

The main conclusion to note is the large number of Free Parameters that have, over the years, been widely and variously allowed into the discussion of cosmology. Many have been measured (column 4) with varying degrees of reliability. But at no stage, so far as I can see, has there been an excess of independent measurements over FPs. Nor is the trend a healthy one (col. 5). The Significance there, which is what matters in the end, is no better now than it was back in 1917. Of course we've got more measurements, far more, but so have we got a far more elaborate theory, one covered all over with sticking plasters such as Inflation, Dark Matter, and Dark Energy designed to stick poor Humpty Dumpty together again. Even the three successful predictions (of apparently flat space, by Inflation; of the Light Element abundances, by nuclear theory (retrodicted); of the maximum ages of the oldest star-clusters, by Expansion) are overbalanced by at least half a dozen unpredicted surprises (redshifts, CBR, Dark Matter, Inflation, Dark Energy and no CBR quadrupole).

Of course there are many caveats, some pro-cosmology, some anti. On the pro-side, the counting of *independent* measurements is not trivial. Modern instruments make measurements not in a single channel but in a spectrum of channels within a given dimension (e.g. wavelength). This could increase the information returned by as much as the logarithm of the number of such channels i.e. by several. On the anti- side note that we have been counting only the FPs *explicitly admitted* within the theory. But BBC is not a single theory any more but 5 separate sub-theories constructed on top of one another. The ground floor is a theory, historically but not fundamentally grounded in General Relativity, to explain the redshifts – this is Expansion, which happily also accounts for the Cosmic Background Radiation. The second floor is Inflation – needed to solve the horizon and 'flatness' problems of the Big Bang. The third floor is the Dark Matter hypothesis required to explain the existence of contemporary visible structures, such as galaxies and clusters, which otherwise would never condense within the expanding fireball. The fourth floor is some kind of description for the 'seeds' from which such structure is to grow. And the fifth and topmost floor is the mysterious Dark Energy idea needed to allow for the recent acceleration of the Expansion, apparently detected in supernova observations. Each new super incumbent theory was selected out of an essentially infinite set of alternatives, to fit the observations as they were known at the time. By rejecting the alternatives one is, in effect, fitting several extra *implicit* FPs in each case. These extra "conceptual" FPs should arguably be added to the totals in Table 1, perhaps 2 or 3 for each sub-theory, reducing the total Significance by 10 or more. This is why such a counting exercise can never be precise.

These caveats are however arguments at the margin. A healthy theory, with a large positive Significance, could afford to ignore them. BBC, with its formally negative Significance, must remain for now a bloody tilting ground for its protagonists and sceptics.

3. Contradictory evidence

Some aspects of the BBC scenario are better supported than others. The existence of Cosmic Background Radiation (CBR) with a Black Body spectrum speaks strongly in favour of an early dense hot phase, the essential feature of a Big Bang cosmology, and that state offers a plausible womb for gestating the light elements that cannot be manufactured in stars. However if redshift is truly evidence of Expansion it should dim distant galaxies out of sight in a most dramatic way (The Tolman Effect]. But we can see redshift 7 galaxies all too easily – an inconvenience which can only be explained by assuming an equally dramatic rate of galaxy evolution which fortuitously cancels Tolman.

On the other hand the universe seems to be highly isotropic – not what one expects of a monotonically expanding cosmos in which new, causally disconnected material, continuously appears over the horizon. This stumbling block of isotropy was solved by 'Inflation', a vague concept in which it is assumed that once-upon-a-time the universe was small enough and static enough for causal contacts to propagate, after which it 'inflated' exponentially to its present configuration. Apart from being ad-hoc it is extremely ugly in that it precludes us from ever deciding whether the cosmos is spatially finite or infinite. Thus it throws out most of the cosmological baby with the bath water.

In a hot high-pressure cosmos, structure will only form late – after radiation and matter have decoupled, and then only slowly, so it is difficult to explain the rich world of clustered galaxies we observe today. The structure problem was neatly solved by hypothesizing the existence of overwhelming amounts of Cold Dark Matter (CDM), that is to say dark matter with a low velocity dispersion which doesn't interact with radiation.[e.g.4] Thus it would condense through much of the radiation era and then act as a focus for the lower amounts of ordinary (baryonic) matter to coagulate around. And it wasn't *ad hoc* because there already existed strong observational evidence that galaxies were dominated dynamically by unseen matter 10 to 100 times more massive than the ordinary baryons which make up their stars and gas.

The CDM provides a natural scenario, called Hierarchical Galaxy Formation [HGF], for forming galaxies by the merger of smaller objects into larger. Unfortunately the observations reveal that galaxies don't form in this manner. They appear to evolve in the reverse order, big ones first ('downsizing') and to be far too regular to have formed by random mergers in this hierarchical manner (later).

So the evidence is contradictory, as it often is in a developing and perhaps primitive science. In a recent open minded review of BBC Peebles and Nusser [5], while pointing to some serious cracks in the edifice, particularly with regard to structure- formation, nevertheless concluded; "We do not anticipate that this debate will lead to a substantial departure from the standard picture of cosmic evolution from a hot Big Bang, because the picture passes a tight network of tests…."

Fair enough, but surely a convincing discussion demands a quantitative measure of the combined strength of such a network, of the jigsaw of interlocking bonds between the hypothesis and its surrounding evidential support – both bonds which fit and bonds which don't. That we try to supply next.

4. Evaluating a network of evidence

We here assemble a tool for evaluating a jigsaw of contradictory evidence then apply it to the BBC, less in the hope of immediately convincing the reader than in demonstrating how simply and powerfully the tool can work. The conclusions it will lead to will necessarily rely on the Likelihoods (weights) that any user must attach to the various pieces of evidence, either for or against, that go to make his jigsaw. In the case of BBC it is hard to see how many of those weights can be other than rough and ready. Thus so must be one's final conclusion.

The only permit we know of for Induction is Bayes' Theorem [e.g.6]:

$$P(H \mid E_1) = P(E_1 \mid H) \times P(H) / P(E_1)$$

which gives the Probability of Hypothesis H, given Evidence E_1. Rewriting in terms of $\bar{H}$ ('not-H')

$$P(\bar{H} \mid E_1) = P(E_1 \mid \bar{H}) \times P(\bar{H}) / P(E_1)$$

and dividing through

$$O(H \mid E_1) \equiv \frac{P(H \mid E_1)}{P(\bar{H} \mid E_1)} = \frac{P(E_1 \mid H)}{P(E_1 \mid \bar{H})} \times \frac{P(H)}{P(\bar{H})} \equiv L(E_1 \mid H) \times O(H) \tag{1}$$

which yields the Odds-*on* H, given E_1, in terms of O(H) – the Odds-on H *prior* to considering E_1, and $L(E_1 | H)$ the 'Likelihood-Odds', [Sometimes called the 'Bayes' Factor'] the Probability of E_1 *if* H is true, divided by the Probability if it is *not*. Written thus (1) is no more than self-evident common sense.
Next consider a second clue E_2; by an identical argument:

$$O(H | E_2) = L(E_2 | H) \times O(H | E_1) = L(E_2 | H) \times L(E_1 | H) \times O(H)$$

and so on, so that finally, considering all n clues:

$$O(H | E_1, E_2, ...E_n) = L(E_1 | H) \times L(E_2 | H) .... \times L(E_n | H) \times O(H) \quad (2)$$

which we henceforth label 'The Detective's Equation' because it formalizes the procedure a rational detective would use to combine all the clues, and the Likelihoods she attaches to them, to reach some final measure of her conviction in Hypothesis H. [The Equation is presumably well known but we could find no reference to it in the literature]
The Detective's Equation does exactly what we want. Each Likelihood-Odds $L(E_i | H)$ is a measure of the strength we assign to the fit between one piece of evidence E_i in the jigsaw and the hypothesis H we are trying to fit. The combined strength is multiplicative so that several weaker fits may nevertheless combine to equal the strength of a single strong bond. This suggests that all the evidence must be included, even where it is rather weak, or hard to weigh. A bad fit is characterised by its odds *against* H, so that its Likelihood – Odds L(E|H) is fractional, thus detracting from the strength of the final result. Equivocal evidence obviously has a Likelihood of 1 and could be ignored. [Lacking any precise theory of the errors involved in quantitative data then if a Normal distribution is adopted, as least contentious, an error of 0.1 sigma corresponds to odds of 12 to 1 *on*; of 2 sigma 44 to 1 *against*, and so on.]
Now let us apply it to BBC, piece of evidence by piece, assembling the running results as we go along in Table 2. If the BBC is true:
(A) Nothing should be older than the expansion age τ_E essentially distance divided by recession velocity. This appears to be obeyed because, where ages can be determined, for instance for star-clusters, for white-dwarf stars and for certain radio-active elements, they all appear younger than the expansion-age of about 14 billion years [7]. By definition the Likelihood – Odds of this evidence is

$$L(E_A | H) = \frac{P(E_A | H)}{P(E_A | \bar{H})}$$

$P(E_A | H)$ is obviously 1 but $P(E_A | \bar{H})$ is certainly not zero. Indeed galaxies, the building blocks of the cosmos, are notoriously difficult to age and some could well be much older than τ_E. Thus $L(E_A | H)$ presumably increases the odds on H, but by how much? There is no obvious or objective answer. It would be unwise to either ignore the evidence altogether, or to give it too much weight. A reasonable compromise *might* be to assign the Likelihood a value of 5 say, i.e. assume that the observed ages increase the odds-on H by 5.
(B) Firmer support comes from evidence that the expanding Universe should have emerged from an earlier dense and hot state. Thus the discovery of the Cosmic Background Radiation

(CBR) and its Black Body Spectrum provide, in the absence of any alternative explanation (i.e. $P(E_B|\bar{H})$) strong evidence in favour of H with a Likelihood of $L(E_B|H)$ = 50 say. (I am reluctant to use Likelihoods more than 50, or less than 1/50, in a subject which has so often proved wrong.)
Combining (A) and (B) using the Detectives Equation (2)

$$O(H|E_A, E_B) = 5 \times 50 \times O(H)$$

i.e. between them they have increased the odds on BBC by no less than 250.
(C) The cosmos on its largest scale ought to look highly anisotropic – whereas the very reverse is observed; the CBR temperatures at the antipodes being identical to a few parts per million. This is serious evidence against BBC and might reduce the Likelihood in its favour by as much as the CBR argued for it; i.e. one might justifiably assume that $L(E_C|H)$ = 1/50 (but see Inflation later).
Thus one might proceed through the list of clues (Table 2) assigning Likelihoods in each case as follows: (D) Because of gravity between its parts the cosmic expansion ought to be decelerating – but it is not. (E) If redshift is truly evidence of Expansion it should dim distant galaxies in a dramatic way [8]. But we can see high redshift galaxies all too easily – an inconvenience which can only be explained by assuming a rate of galaxy evolution which fortuitously cancels [8]. (F) As mentioned, light elements like Helium and Deuterium whose abundances cannot be otherwise explained could have been synthesized in approximately the right amounts in the Big Bang. (G) There are minute but measurable irregularities in the CBR with a scale naturally explained in terms of expansion. (H) Expansion naturally suppresses condensation into structures such as the galaxies which surround us on all sides. The problem is that radiation pressure in the early universe would have smoothed out any irregularities in baryonic matter so that by the time the two decoupled there would have been no 'seeds' from which such irregularities could naturally grow by self-gravitation.
Taken together, and with the crude Likelihoods I have assigned them in Table 2:

$$O(H|E....) = 5 \times 50 \times 1/50 \times 1/2 \times 1/10 \times 10 \times 20 \times 1/50 = 1 \times O(H)$$

In other words, by chance, all the 8 clues used so far have cancelled out so that they neither favour nor disfavour BBC.
Next add some modern refinements and observations:
(I) The structure problem was neatly solved by hypothesizing the existence of overwhelming amounts of Cold Dark Matter (CDM), that is to say dark matter with a low velocity dispersion which doesn't interact with radiation. Thus it would condense through much of the radiation era and then act as a focus for the lower amounts of ordinary (baryonic) matter to coagulate around. And it wasn't *ad hoc* because there already existed strong observational evidence that galaxies were dominated dynamically by unseen matter 10 to 100 times more massive than the ordinary baryons which make up their stars and gas [9].
(J) CDM provides a natural scenario, called Hierarchical Galaxy Formation, for forming galaxies by the merger of smaller objects into larger . Unfortunately it doesn't seem any longer to be the mode by which observed galaxies formed. Big galaxies evolved first, small ones later [10].
(K) The stumbling block of isotropy was solved by 'Inflation', a vague concept in which it is assumed that once-upon-a-time the universe was small enough and static enough for causal contacts to propagate, after which it 'inflated' exponentially to its present configuration [11, 12

(L) Most surprisingly, recent attempts to measure deceleration using exploding stars lead to the unpredicted discovery that the universal expansion appears to have accelerated recently [13, 14]. Sometimes called 'Dark Energy' this phenomenon has not been plausibly explained.

Table 2 shows the above clues, their associated Likelihoods, and in the last column the Running Odds as one multiplies those Likelihoods together row after row, not counting any prior O(H).

CLUE		Likelihood $L(C_i \mid H)$	Running Odds
A) Nothing older than expansion age	Yes	5	5
B) Earlier dense state	Yes	50:1=50	250
C) Universe should be anisotropic	No	1:50=1/50	5
D) Universe should decelerate	No	1:2=1/2	5/2
E) Galaxies should dim with redshift	No	1/10	1/4
F) Could produce light element abundances	Yes	20	5
G) Predicts CBR structure (First Peak)	Yes	10	50
H) Can't produce observed matter structure		1/50	1
I) But CDM can produce such structure		25	1/2
J) But real gals very unlike CDM models		1/10	5/2
K) Inflation may explain isotropy		2	5
L) Recent acceleration unexplained		1/20	1/4

Table 2. Big bang cosmology likelihoods

The end result, seen at the bottom of the last column, appears, to say the least of it, thoroughly unconvincing. The combined odds of all the above evidence yields odds of 4 to 1 *against* BBC. However that result relies on a number of Likelihoods whose evaluation is bound to be contentious, but which no honest thinker can evade if they are to come to a defensible conclusion.

My conclusion is as tentative as the Likelihoods I have declared. At 4 to 1 against at least it agrees with my uneasy feeling that BBC, once rather beautiful and economic, has grown uglier and more ad hoc in recent years.

My point is not to persuade readers of my own particular viewpoint but to persuade them to subject their own convictions on this matter to the same Bayesian analysis. If nothing else it should encourage tolerance of dissent, badly needed in this field, or so it seems to me.

5. Science or folk tale?

If cosmology is to be a science then the arguments of the last two sections, in so far as they are right, suggest that BBC may be in a sickly state. There is much anecdotal evidence to support this suspicion. For instance, after publishing a previous sceptical article on this topic [15], I received hundreds of e-mails from professional astronomers saying 'Thank God somebody is saying these things at last – but don't quote me'. Then again many younger astronomers will privately admit that they don't believe a word of Lambda-CDM, 'But if I don't acknowledge it in my grant and observing proposals then I don't succeed.'

Anecdotes aside let us look at some symptoms of BBC's malaise.

(A) When the supernova results came out, cosmology should have stopped in its stride. BBC had utterly failed to predict such a thing. But what happened instead? BBC jumped on its horse and galloped off in chase of yet another free parameter, Lambda, based on zero physics but with the catchy title 'Dark Energy'.

(B) 'Multiverses', much discussed by certain cosmologists, are not science. What can never be detected is not physics, but metaphysics [26].

(C) Computer simulations have much to answer for. So they produce 'filaments'? So what. Look at star-formation simulations on a sub-parsec scale: they produce beautiful filaments too [27]. It has nothing to do with cosmology. As Zeldovich explained long ago filaments are the natural outcome when gravity overwhelms internal pressure. In any case computer simulations, and the Scientific Method, have yet to take the full measure of one another. Until they do, arguments based on simulations should be given a low weight. Computer simulations have a very mixed record in Astrophysics.

(D) So much is made to hang from the WMAP data. But it is just another still, and a very messy picture, of a single moment in time. Maybe it's an earlier moment, but not so much earlier in the relevant logarithmic sense. And most of the non-Galactic structure lies in the First Peak – which has only an oblique bearing on cosmology – and whose position can be derived from dimensional considerations alone.

(E) Most unhealthy is the present comedy surrounding CDM. Galaxies, near or far, simply do not conform to the dictates of this once attractive theory. Bigger galaxies seem to evolve before small ones – 'down-sizing' [10]. There aren't hundreds of dwarfs for every giant [17]. Galaxies don't have cuspy cores [18]. Mergers are rare and cannot lead to the thin discs we see on every side [19]. There is little or no correlation between the properties of exponential galaxies and their environments [20, 21]. Finally galaxies exhibit a drastic and puzzling degree of self-organisation (forming a 1-parameter set) that is totally at odds with Hierarchical Galaxy Formation, the child of CDM [22, 23]. And of course we haven't found the DM, cold or otherwise. So CDM is in tatters – but somehow, like the Emperors New Clothes, lives on. Why? Presumably because without it BBC has lost a vital prop – a means for forming structure. What is so bizarre is the asymmetry between galaxy astronomy, which is rich with Information, and cosmology, which is not. And yet the cart is pushing the horse here. [24, 25].

Some opine that one shouldn't criticise an hypothesis without offering an alternative. I do not agree. Publishing its weaknesses ought to encourage alternatives, even where the critic cannot find one himself. However it is interesting to note that all the dynamical discrepancies that call for Dark Matter could as well point elsewhere. Wherever large lumps of matter are accelerated by gravitation (e.g. in clusters) the acceleration is always too large; it's as if each accelerated lump is dragged along by its neighbours. That is Mach's Principle. And if there is something to it extragalactic astronomers would be the first to know.

Given its rickety state one wonders at the hushed respect in which BBC is still widely held ('*Cosmology Deference*'). Had the subject matter been less momentous one feels that parts of it at least would have been discarded some time ago. But there lies its singularity, its difference from the rest of science. Mankind seems to need a cosmology, and just now BBC is the only one he's got. But for this observer at least, something even more mysterious and interesting appears to be going on out there. The last thing we should be doing is trying to force it into an old-fashioned corset that doesn't seem to fit. Scepticism is the portal to progress. Science risks discredit if it isn't willing to apply to cosmology the same sceptical attitude that it does to all other supplicants for its approval. Is BBC really a science, or is it a just-so folk tale heavily disguised as a science? One cosmologist [28] said: *"Cosmology is the dot com of the sciences. Boom or bust. It is about nothing less than the origin* *and evolution of the Universe, the all of everything. It is the boldest of enterprises and not for the fainthearted. Cosmologists are the flyboys of astrophysics, and they often live up to all that image conjures up".* That sounds to me like special pleading.. If so then science should certainly turn it down.

The highest compliment we can pay BBC is to treat it as a scientific hypothesis, like any other, and weigh up its pros and cons.

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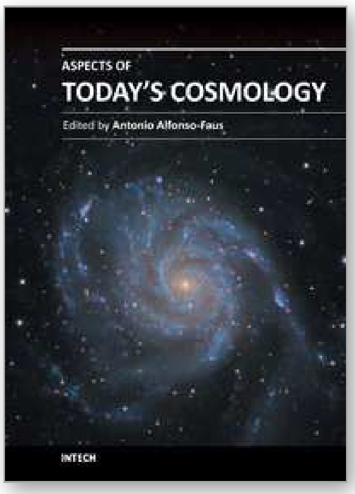

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This book presents some aspects of the cosmological scientific odyssey that started last century. The chapters vary with different particular works, giving a versatile picture. It is the result of the work of many scientists in the field of cosmology, in accordance with their expertise and particular interests. Is a collection of different research papers produced by important scientists in the field of cosmology. A sample of the great deal of efforts made by the scientific community, trying to understand our universe. And it has many challenging subjects, like the possible doomsday to be confirmed by the next decade of experimentation. May be we are now half way in the life of the universe. Many more challenging subjects are not present here: they will be the result of further future work. Among them, we have the possibility of cyclic universes, and the evidence for the existence of a previous universe.