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# The Case Against Cosmology

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It is argued that some of the recent claims for cosmology are grossly overblown. Cosmology rests on a very small database: it suffers from many fundamental difficulties as a science (if it is a science at all) whilst observations of distant phenomena are difficult to make and harder to interpret. It is suggested that cosmological inferences should be tentatively made and sceptically received.

KEY WORDS : Cosmology ; observations ; science

## 1. INTRODUCTION

Given statements emanating from some cosmologists today one could be forgiven for assuming that the solution to some of the great problems of the subject, even "the origin of the Universe" lie just around the corner. As an example of this triumphalist approach consider the following conclusion from Hu et al. [1] to a preview of the results they expect from spacecraft such as MAP and PLANCK designed to map the Cosmic Background Radiations: "...we will establish the cosmological model as securely as the Standard Model of elementary particles. We will then know as much, or even more, about the early Universe and its contents as we do about the fundamental constituents of matter".

We believe the most charitable thing that can be said of such statements is that they are naive in the extreme and betray a complete lack of understanding of history, of the huge difference between an observational

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and an experimental science, and of the peculiar limitations of cosmology as a scientific discipline. By building up expectations that cannot be realised, such statements do a disservice not only to astronomy and to particle physics but they could ultimately do harm to the wider respect in which the whole scientific approach is held. As such, they must not go unchallenged.

It is very questionable whether the study of any phenomenon that is not repeatable can call itself a science at all. It would be sad however to abandon the whole fascinating area to the priesthood. But if we are going to lend this unique subject any kind of scientific respectability we have to look at all its claims with a great circumspection and listen to its proponents with even greater scepticism than is usually necessary. This is particularly true when the gulf between observers and theoreticians is as wide as it usually is here. Either side may be more inclined to accept the claims of the other than they should. As an extra-galactic observer addressing a mostly theoretical audience I want to emphasise the very many caveats that should always be attached to the observational side of this field. I do so as a friend and admirer of George Ellis who has one of the few minds capable of bridging the gulf.

## 2. THE OBSERVATIONS WHICH BEAR ON COSMOLOGY

The observations which bear on cosmology are, for such a grandiose subject, extremely sparse. I count only about a dozen which probably bear — most of them stumbled upon by accident (see Table I). And they are *observations* not controlled experiments which therefore means that they cannot compare with the thousands of particle physics experiments upon which the Standard Model is based.

**Table I. All the observations which bear on cosmology**

1. The dark sky background.*
2. Isotropy of galaxy counts.
3. Magnitude-redshift diagram for galaxies.*
4. Approx equivalence between $1/H_0$ and $\tau_{\text{stars}}$, $\tau_{\text{elements}}$.*
5. Existence of CBR.*
6. Isotropy of CBR.*
7. BB spectrum of CBR.
8. Measured fluctuations in CBR?
9. Abundance of Helium.*
10. Abundance of Deuterium.*
11. Magnitude-redshift diagram for supernovae.

12. Existence of walls and voids in LSS.*
13. Radio source-counts.*?

*Serendipitous. ? = of questionable relevance.

## 3. THE SPECIFIC DIFFICULTIES OF COSMOLOGY

Table II lists some of the special difficulties which cosmology has to face as a science. They are mostly obvious but it is worth emphasising one or two:

**Table II. Particular difficulties for cosmology as a science**

1. Only one Universe.
2. Universe opaque for 56/60 decades since Planck era.
3. Need to extrapolate physics over huge distances.
4. Need to work with what we can currently detect. [But...]
5. Local background very bright.
6. Distances very hard to determine (standard candles).
7. Observational selection insidious.
8. Distant galaxies hard to measure and interpret unambiguously.
9. Luminosity functions unreliable.
10. Geometry, astrophysics and evolution often entangled.
11. Physics of early Universe unknown (and unknowable?)
12. Human time-frame so short compared to cosmic.
13. Origin of inertia.
14. The singularity.

(A) There is only one Universe! At a stroke this removes from our armoury 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 between the Planck era ($10^{-43}$ sec) and today ($10^{17}$ sec). Since as much interesting physics could have occurred in each logarithmic decade, it seems foolhardy to claim that 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 microphysics back only as far as $10^{-10}$ secs (Ref. 2, p.109).

(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

GR) 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 as much independent evidence exists as for the Emperor's New Clothes.

(D) Objects at cosmologically interesting distance are exceedingly faint, small and heavily affected by factors such as redshift-dimming and $k$-corrections, so it will obviously be very difficult, if not impossible, to extract clear information about geometry, or evolution, or astrophysics — all of which are tangled up together.

(E) Observational astronomy is all about the *contrast* between an object and its background (Ref. 3, p.19) — both the background of the local Universe and the background noise in our instruments, which are never perfect. Almost all the galaxies we know of are just marginally brighter than the terrestrial sky — either extraordinary good fortune, or more likely a signal that far more are hidden beneath it [4–6]. In other words we are in this, as in all other facets of observational astronomy, hapless victims of "Observational Selection" — an area in which George Ellis has done some brilliant work (Ref. 7, p.43). The sky isn't dark. Even at the darkest site of Earth the unaided eye can pick up 50,000 photons a second coming from an area of "dark sky" no larger than the full moon. Bigger telescopes are all very well — but they pick up more unwanted foreground light, as well as background signal. When you think that the galaxies at a redshift $z$ of 2 should be dimmer by $(1+z)^4 \sim 100$, and by another large but uncertain factor for the $k$-correction [i.e. band-pass shifting], it is more than a wonder to me that we can see anything of them at all. Ordinary galaxies at that redshift should be hundreds of times dimmer per unit area than our sky! It is also sobering to realise that only one per cent of the light in the night sky comes from beyond our Galaxy.

(F) The tragedy of astronomy is that most information lies in spectra, and yet you need to collect between 100 and 1000 times more radiation to get a spectrum than to see an image. Thus most of the faint galaxies which may have cosmological stories to tell must remain, in spectroscopic terms, tantalisingly out of earshot. If history is anything to go by little good will come of the thousands of nights of big-telescope time now being lavished on the intriguing objects first seen with the Space Telescope, and made famous through the Hubble Deep Field. We will probably learn more cosmology from studying the surprising and diverse histories of star-formation that Hubble is finding among galaxies in the Local Group [8].

In summary we have very few observations, most of them were accidentally made, and all are subject to observational selection. It is therefore outrageous to claim a comparison with all the carefully controlled experiments made by particle physicists. And even if we do get a perfect map of the Cosmic Background Radiation it will only be a map of a moment in time. Celestial mechanics is very precise — but it doesn't tell us how the solar system was formed.

## 4. THEORY AND OBSERVATIONS

Martin Harwit (Ref. 9, p.231) has argued that we cannot have made more than ten per cent of the crucial discoveries in Astronomy. He uses what John Barrow aptly calls 'the proof-readers argument'. If two independent readers look at a manuscript then it is possible to estimate, by comparing their different results, how many errors there must be in total, including those not identified. In an analogous way two independent astronomical channels (say optical and X-ray) can be used to examine the Universe and a comparison of their separate key discoveries will yield an estimate of the numbers still to be found.

In any case with so little data to work on it shouldn't be too difficult to devise a plausible theory to account for them. It is, however, sobering to compare the cosmological situation with the history of other sciences.

Take geology. Men were living on the earth for millions of years, and quarrying rock, digging mines and canals and puzzling over its fossils for thousands of years, before unexpected palaeomagnetic patterns revealed for certain the key idea of Continental Drift.

In stellar physics two thousand years elapsed between Hipparcos's speculations and Bessel's first measurement of a stellar distance. Seventy years later the statistical patterns in the H-R diagram led to our understanding of stellar structure.

However the closest comparison comes from my own field of galaxy astronomy which is, as an observational science, almost exactly contemporary with cosmology. Although we now have good spectra and images of thousands of galaxies the list of fundamental things we don't know about them (Table III) is far more striking that the list of things we do.

**Table III. What we don't know about galaxies**

1. How our knowledge is warped by Selection Effects.
2. What they are mostly made of. (Dark Matter?)
3. How they formed — and when.
4. How much internal extinction they suffer from.
5. What controls their global star-formation rates.
6. What parts their nuclei and halos play.

7. If there are genuine correlations among their global properties.
8. How they keep their gas/star balances.

Of course these are only arguments by analogy. The optimistic cosmologist can always counter argue [I don't know how] that the Universe in the large is a great deal simpler than its constituent parts.

## 5. THE COSMOLOGIST'S CREDO

The cosmologist, who would also be a scientist, must surely subscribe to at least the following assumptions:

(A) "Speculations are not made which cannot, at least in principle, be compared with observational or experimental data, for tests" [the NON-THEOLOGICAL assumption].
(B) "The portion of the Universe susceptible to observation is representative of the cosmos as a whole". [The 'GOOD LUCK' assumption].
(C) "The Universe was constructed using a significantly lower number of free parameters than the number of clean and independent observations we can make of it". [The 'SIMPLICITY' assumption].
(D) "The Laws of Physics which have significantly controlled the Universe since the beginning are, or can be, known to us from considerations *outside cosmology itself* i.e. we can somehow know the laws which operated during the 56/60 electromagnetically opaque decades". [The 'NON-CIRCULARITY' assumption].

Finally the really wishful cosmologist who believes the final answers are just around the corner must confess to the following extra creed:

(E) "We live in the first human epoch which possesses the technical means to tease out the crucial observations" (as opposed to Hipparcos and parallax, Helmholtz and the age of the Earth, Wegener and palaeomagnetic drift). [The 'FORTUNATE EPOCH' assumption.]

I can see very little evidence to support any of the last 4 assumptions while it is dismaying to find that some cosmologists, who would like to think of themselves as scientific, are quite willing to abrogate the first.

## 6. THE PATHOLOGIES OF COSMOLOGY

(A) Cosmology must be the slowest moving branch of science. The number of practitioners per relevant observation is ridiculous. Consequently the same old things have to be said by the same old people (and by new ones) over and over and over again. For instance "Cold Dark Matter" now sounds to me like a religious liturgy which its adherents chant like a mantra in the mindless hope that it will spring into existence. Much of cosmology is unhealthily self-referencing and it seems to an outsider like myself that cosmological fashions and reputations are made more by acclamation than by genuine scientific debate.

(B) There is a serious problem with the cost of astronomical spacecraft. An instrument capable of cosmologically interesting observations may cost half a billion dollars or more. There is therefore an insidious temptation to overclaim what they will see [1]. This, however, is a dangerous game which can blow up in your face, as proponents of the Supercollider were to find out.

(C) There is something beguiling and yet fallacious about working on "the faintest objects ever observed" even though, by definition, they contain "the least information ever detected". During my working life a major fraction of the prime time on all large telescopes has been devoted to the study of objects right at the horizon, with, or so it seems to me, very little result. To be rude about it, statistical studies of faint objects can keep a career going for ages without the need for a single original thought — or indeed a genuinely clear result. The jam is always just around the next corner.

(D) As particle physics has become paralyzed by its escalating cost many particle theorists have 'moved over' into cosmology, wishfully thinking of the Universe as 'The great Accelerator in the Sky'. Alas they are mostly not equipped with the astronomical background to appreciate how 'soft' an observational, as opposed to an experimental science, has to be. But they have only to look at the history of astronomy and at some of the howlers we have made (Table IV) to find out.

**Table IV. Some historical mistakes in cosmology**

1. 'Early' cosmologies —- e.g. Genesis, Hindu,...
2. Many unsound explanations for dark sky (up to 1960).
3. Assumption of a static Universe.
4. Original expansion claim based on unsound statistics (Hubble).
5. $H_0$ wrong by factor $\sim 10$ for 25 years.
6. Universe measured to be younger than stars.
7. CBR not recognised for 25 years [McKellar 1942, Gamow...]
8. Radio-source counts misinterpreted due to use of fallacious statistics.
9. Mass of neutrinos forgotten/ignored for 40 years.
10. Sandage's "search for 2 numbers" forgot evolution.
11. Horizon/flatness problems virtually ignored before a possible solution appeared.

(E) Despite our intuitions very many Inverse Problems (and astronomy is very largely an Inverse Problem) are not well posed [10]. For example when the HST was found to be spherically aberrated half the astronomical community claimed that the images could be restored by mathematical 'deconvolution'. But they could not be — because the problem is ill posed; the highest resolution information will be swamped by the highest frequency noise during the inversion — it is a fundamental property of numerical differentiation. Only very high signal-to-noise data (a luxury astronomers rarely enjoy) can be deconvolved successfully. Likewise, I suspect that the multiparticle simulations beloved of certain numerical cosmologists are extremely ill-posed. They start off with a whole lot of CDM 'dots', the dots apparently form filaments under the force of gravity — as they are bound to do according to Zeldovich's simple back-of-the-envelope analysis — and we are supposed to admire the result. What result? That to me is the question. Presumably we are supposed to compare the dots with real structures and infer some properties of the physical Universe. In my opinion it is nothing more than a seductive but futile computer game. What about the gas-dynamics, the initial conditions, the star-formation physics, evolution, dust, biasing, a proper correlation statistic, the feedback between radiation and matter...? Without a good stab at all these effects 'dotty cosmology' is no more relevant to real cosmology than the computer game 'Life' is to evolutionary biology.

(F) However, the most unhealthy aspect of cosmology is its unspoken parallel with religion. Both deal with big but probably unanswerable questions. The rapt audience, the media exposure, the big book-sale, tempt priests and rogues, as well as the gullible, like no other subject in science. For that reason alone other scientists simply must treat the pretensions of cosmology, and of professional cosmologists, with heightened scepticism, as I am attempting to do here.

## 7. COSMOLOGY IN PERSPECTIVE

Of course we would all love to know of the fate of the Universe, just as we'd love to know if God exists. If we expect science to provide the answers though, we may have to be very patient — and literally wait for eternity. Alas professional cosmologists cannot afford to wait that long. For that reason the word 'cosmologist' should be expunged from the scientific dictionary and returned to the priesthood where it properly belongs.

I'm not suggesting that cosmology itself should be abandoned. Mostly by accident it has made some fascinating, if faltering progress over the centuries. And if we are patient and build our instruments to explore the Universe in all the crevices of parameter space, new clues will surely come to hand, as they have in the past, largely by accident. But we should not spend too many of our astronomical resources in trying to answer grandiose questions which may, in all probability, be unanswerable. For instance we must not build the Next Generation Space Telescope as if it was solely a cosmological machine. We should only do that if we are confident of converging on "the truth". If we build it to look through many windows we may yet find the surprising clues which lead us off on a new path along the way.

Above all we must not overclaim for this fascinating subject which, it can be argued, is not a proper science at all. Rutherford for instance said "Don't let me hear anyone use the word 'Universe' in my department". Shouldn't we scientists be saying something like this to the general public:

*"It is not likely that we primates gazing through bits of glass for a century or two will discern the architecture and history of infinity. But if we don't try we won't get anywhere. Therefore we professionals do the best we can to fit the odd clues we have into some kind of plausible story. That is how science works, and that is the spirit in which our cosmological speculations should be treated. Don't be impressed by our complex machines or our arcane mathematics. They have been used to build plausible cosmic stories before — which we had to discard afterwards in the face of improving evidence. The likelihood must be that such revisions will have to occur again and again and again."*

I apologise for such a highly opinionated attack, but it does appear to me that the pendulum has swung much too far the other way. Surely the 'burden of proof' ought to rest squarely on the proponents of what will always be a fascinating but suspect subject.

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