Foolproof

On All and On Nothing

(Alberto Bolognesi)

1.

There is an ancient dispute that divides supporters of the objectivity of science and proponents of the relative, limited and partial nature of everything that we know.

Gödel's famous theorem, suggesting that mathematics is partly based on inherently unprovable propositions, hangs like a sword of Damocles above contemporary science. Karl Popper challenged the validity of constructing, scientific truth by the mere accumulation of congruent facts, claiming that the discovery of a single piece of contrary evidence could be equated to falsification of the whole. The fragile fields of cosmology and even of remote astronomy would thus be permanently exposed to the risk of total annihilation, given the impossibility of making, direct checks or measurements. Only the philosopher Thomas Kuhn offers some kind of consolation for universe builders, outlining a path of reason marked by phases of normal science and moments of revolutionary breakthroughs1.

Despite this, the Big Bang has become the be-all and end-all of the whole world of physics. There are those who predict that it will swallow not only up the Devil himself, but also astronomy, chemistry, biology, logic, philosophy and religion. Stephen Hawking, to mention just one, is convinced that it will be possible to reach a Unified Theory before 2000, one that could explain the totality of reality for us in a very clear way, while John Schwarz of Caltech and Michael Green of Imperial College London claim that they are capable of redefining, the fabric of matter and the cosmic eco itself using, Indivisible ring-shaped entities of about 10-33 cm in size. These rings, called "superstrings", are neither bodies nor energy, and neither are they geometry, but manage to be all three at the same time.

Superstrings are rapidly winning favor among researchers into the "Theory of Everything", although their illustrious critics include Nobel prizewinner Sheldon Glashow, who advocates their immediate withdrawal from the cosmology scene. To start with, observes Glashow, something must start them vibrating in the first place, and then we need to hypothesize a space-time with ten or more dimensions and a significant quantity of new particles. This in itself would be no daunting prospect for Glashow, as he claims that theorists in general, himself included, are capable of inventing "all sorts of rubbish" with which to fill the universe2. Nevertheless, he feels that superstrings are quite beyond the bounds of science, and that their inventors are sailing in purely speculative waters. It was Glashow, together with his fellow Nobel prizewinners Weinberg and Salam, who demonstrated the existence of a fundamental link between electromagnetism and simple nuclear force. He is also credited with shedding valuable light on the first ten billionth of a second of the universe, but modestly prefers to refrain from talking about cosmology.

Even more critical is another Nobel prizewinner, Philip Anderson, who works on condensed matter and fails to believe that a Unified Theory can ever succeed in explaining the world satisfactorily. The dominant validity of physical laws comes up against insuperable contradictions when we move from one cosmic scale to another, and a totally different set of concepts, parameters and languages is needed. Anderson claims that reality has a hierarchical structure, and that every level of scale has its particular characteristics, independent and sometimes in blatant contrast with the others. It is very tempting but equally mistaken to believe that a general principle valid at one level could be accepted as valid for all the others3.

Harsher still is IBM information scientist Rolf Landauer, who bluntly declares that the Philosopher's Stone simply does not exist, and rank upon rank of scientists and observational astronomers side with him, anxious to win back the universe after their reckless flirt with microphysics.

There are many more people, however, who feel that this flirtation has led to an indissoluble marriage. As the Kitt Peak astronomer Dave Crawford humorously puts it, when there's a sacrament involved, there's no way of backing out. You have no choice but to go on together, moving back through time to when the galaxies were so close together that they formed a single chunk of primordial matter, stepping even further without fear inside the cosmic egg itself, the dimensionless point that exploded into the universe.
For the moment, at least, a majority of persons seem to have already made their choice, and uncreated matter is no longer of interest. What is far more stimulating is the subject of creation. By now what counts is not whether a story is true or false-what counts is to narrate it well.
Alexandr Vilenkin is an important name in cosmology. After emigrating from Russia and stopping off briefly in Italy, he moved to America and found a job from a newspaper advert. He studied Zeldovic and made his mark with "nothing", "bubbles" and "foam".
What is "nothing"? "Nothing", he could calmly reply. Neither time nor space, neither energy or geometry. Is it the opposite of superstrings? Again, "nothing" would be the answer, followed by his specifying that he has only worked with Turok's strings4.
Because there are strings and there are superstrings, and in the same way that there's a Theory of Everything, there's also a Theory of Nothing. Here, strings are not "super", and they are consequences, not causes. They could be described as a web of cracks in space-time, thin labyrinths smaller than a particle where the energy conditions of the Big Bang still survive. But Vilenkin goes way beyond strings, and much further back. His viewpoint is that the universe is a vacuum fluctuation, the same viewpoint that earned fame for an American physics student when he brought down the house in laughter at a convention5.
In his *Creation of Universes from Nothing* (Physics Letters, 1982), Vilenkin lucidly examined the possibility that the universe, or even multiple universes, could emerge from nothing without violating any law of conservation, quite simply as a "bubble" or a crinkle emerging from the vacuum of eternity, from the perfect homogeneity, from the "supersymmetry". An accidental bubble or bubbles, but totally real in the midst of a mass of virtual or impossible foam that constantly collapses back into the oceanic vacuum. A bubble or bubbles that must nevertheless obey pre-existing physical laws once they have emerged. Are physical constants what they are because this "bubble" is what it is? Vilenkin doubts this. lf it had been a little different, perhaps this universe would not have come through. Nothing has an imprint, but no matter.

2. Matter and Life

The particle physicist Heinz Pagels is someone else who wants to know where physical constants come from. "Who is it that tells the nothing that it can give birth to a possible universe on certain conditions?" he asks. On the other hand, he also challenges the Anthropic Principle, claiming that this fable has never provided even a single factual proof or number to demonstrate its validity. In his oft-quoted book *Perfect Symmetry,* Pagels proposes that life is not a selective principle that is predominant over matter, but is a consequence.
The basic idea is that if life is a property of matter, even Aladdin must have come out of his lamp. Perhaps plain and simple rules exist capable of combining to generate the complex systems that we call "life". The complexologist Christopher Langton claims that if a programmer were to create a world of synthetic molecules able to follow these rules, they would organize themselves spontaneously, feeding, reproducing and evolving. They would be alive, even though only inside a computer.
The age-old dispute between vitalists and mechanists has thus been transferred from philosophy to science, and thence to computers, in the hope that some final explanation might be found. The debate continues, in milder tones and on paradoxically inverted fronts, with algorithms and notions of

cosmology, molecular biology and genetic engineering, generating new monsters and resuscitating ancient divisions.

Harvard evolutionist Stephen Jay Gould came close to Pagel's position when he argued that life is not shaped by deterministic laws but by unpredictable circumstances. Gould is a biologist, and his reference was more specifically addressed to the phenomenon of organic life that to the entirety of the universe, but even here we can sense an adhesion to casual causationism that has a distinct flavor of quantum mechanics and the supersymmetrical Big Bang.

Retaliation was simmering. Philip Anderson appeared again to protest that biology is not simply applied chemistry, while the great French biologist Jacques Monod warned that life is highly and even demonstrably improbable.

Stuart Kauffman, the expert in artificial life, fires broadsides of vitalist mechanism almost without realizing it. Kauffman is convinced that Nature knows perfect1y well what she has to do, following a code, or even better, a fully-fledged universal trend, an anti-chaos, a new fundamental force that competes with disorder and the second principle of thermodynamics!

In his book *At Home in the Universe* (1995), Kauffman even takes his distance from Monod and the improbability of life. He claims instead that biological genesis and its evolution are in a certain sense inevitable, a much more voluntary process than simple natural selection.

The Anthropic Principle is an old idea that keeps coming back. The doctors of Montpellier proclaimed it at the end of the eighteenth century, including it in the celebrated *Encyclopédie*6. They imagined the vital essence to be an unconscious force, a kind of spontaneous organizing principle that acts at molecular level. This is not unlike the "new fundamental force" now advocated by Kauffman, the same that not so long ago, with infinite facets, inspired Bergson, Driesch, Reinke and countless others. It is worth remembering, however, that this principle has faced an uphill struggle ever since it was first enunciated, as only a few years later, in 1828, urea was synthesized from purely inorganic ingredients.

But Kauffman sticks staunchly to his guns, attempting to prove by means of sophisticated computer simulations that when a group of substances attains a certain level of complexity or interconnection, it undergoes a spontaneous transition that represents a veritable shift in phase. The molecules start to combine into larger molecules of increasing complexity, just as if they were following a plan. It is this autocatalytic capacity, argues Kauffman, and not the accidental formation of a molecule capable of reproduction, that leads to the creation of life.

Murray Gell-Mann tries to obtain consensus on the language to be used. In his book *The Quark and The Jaguar,* he claims that the probabilistic nature of quantum mechanics allows the universe to unwind in an infinite number of ways, in some of which there may be conditions favorable to the appearance of complex phenomena, such as life in galaxies, and then right on down to us, on our tiny planet. But we have still not managed to square our circle. It seems far too easy for Gell-Mann to say that there is no need for "a new force" to explain complex phenomena like life, and that the second principle of thermodynamics in itself permits the temporaneous growth of order and complexity in relatively isolated systems. We come inevitably back to Pagel's dilemma, which is none other than that once posed by Aristotle: Who decides physical constants? Just who is it that dictates the laws of thermodynamics, who determines electron mass or the varieties of quarks? And who inspires Murray Gell-Mann?

We could think of God, perhaps, to the joy of Allan Sandage, or of the *Aliens* series for sci-fi fans, when the heroine poses her sinister question: "Who lays the eggs?".

3. Foolproof

Marco is thirteen, and has inherited his eyes and his shiny black hair from his Philippine mother. He wants to be an astronomer when he grows up, or a computer programmer, and he's an enthusiastic follower of gravitational lenses.

"Perhaps God doesn't exist", he says, in his typically loud voice, "because if He did we'd have seen Him already behind the universe".
"You don't expect to see an old man with a white beard or a square eye, do you?" I hasten. to reply.
"But what's strangest of all", he continues, ignoring my interruption, "is that if every sight-line in the sky ends up in the Big Bang, the light of creation should be amplified and we ought to be able to see it still".
Maybe Marco is a genius, or maybe he doesn't play outside enough. Maybe in a few years his passion for astronomy will dry up, and maybe his math talent will be put to far more profitable use (in monetary terms) doing the books for a restaurant with paper lampshades that serves bamboo shoots and fried squid. But if in the meantime the most sophisticated observation instruments should happen to detect some kind of luminous radiation like the one postulated by Marco, then 1 solemnly swear that I will forever call it by his name and none other.
There are already too many contenders on our waiting list for a fossil background of X and gamma rays. "Marco's light", instead, would do justice to them all, without the mumbles and grumbles that unfortunately accompanied 3° K radiation. Perhaps no-one will ever see the fireball, the *lux biblica* of Lemaitre, Gamov or Marco, but pessimism is certainly out of order here. Anyone concerned with physics knows that if you look stubbornly enough for something, you always end up finding something, even though this something might be something completely different. My twenty-five readers are doubtless aware that in remote astronomy, direct verifications of any kind are absolutely impossible. If we were to pose the provocative hypothesis that 3° K radiation is not fossil but local, linked to our own galaxy, or to the cluster or supercluster of which we are a part, we would need thousands, millions or billions of years respectively to confirm this, because of the limits imposed on us by the speed of fight.
It is truly disheartening to calculate the time that would be needed for a space probe using present-day technology to leave our galaxy, cluster or supercluster, complete its observations of the background and send its data back to us. To give some idea of this for those who rarely think about the problem, the effect can be compared to discovering that Santa Claus does not exist, that Martians live a long, long way away and that very often, to keep our spirits up, we are forced to do our own present-giving to ourselves. No cosmologist will ever willingly tell you that in remote astronomy, our measurements, convictions and errors are all doomed by eternity.
Fortunately, this does not mean that we are prevented from finding at least a few answers, and neither does it mean that anything goes. What it means is that we will never have all the answers. More than a human condition, this seems to be a condition of physics.
Naturally, no-one at Caltech, Harvard, MIT or Fermilab will become more, cautious because there's a skeptical amateur at the AAU7 Who writes things like this. On the contrary, many scientists are convinced that they can relegate even Kant to their archives, and are looking forward to a chance of booting the noumenon round some even bigger accelerator, discovering the secret of the universe and perhaps even selling it to the Japanese!
In the meantime, the model of the universe has been officially acquired into the world of science-there was an explosion starting from a single point, a point without dimensions that now surrounds us in all directions.
What is considered to be one of the most influential articles in the immense panorama of Big Bang literature appeared in the August 1991 number of *Nature.* Entitled *The Case for the Relativistic Hot Big Bang Cosmology,* it was penned by Jim Peebles, David Schramm, Edwin Turner and Richard Kron (PSTK). Peebles and Schramm need no presentation-they are so famous that some people call them "The Bio Bane, Bombers". Turner is an astronomer specializing in gravitational lenses. Kron has made a great reputation with his surveys on red shifts carried out on small sections of deep space.

Right from their introduction, these authors attribute three fundamental requisites to the Bio Bang:
1) It explains and forecasts observations in an excellent way.
2) No other satisfactory alternative cosmological models are known.
3) Although there are a few unsolved puzzles, nothing contradicts the Big Bang.
So we could stop here if we wanted, and continue reading, the article only if we have a particular weakness for questions of details, anecdotes and "puzzles"
In another article in the Italian edition of *Scientific American*8, PSTK conclude their nth discussion of the topic by declaring that any new cosmological theory must inevitably incorporate the idea of the Big Bang. Whatever may happen in. the future, cosmology has by now been transformed from a branch of philosophy into a physical science, in which hypotheses must pass the test of observations and experiments.
Foolproof. The Big Bang is proclaimed to be a physical phenomenon and cosmologists nominate themselves the depositaries of scientific truth. Extrapolations and not observations and experiments (not even future ones!) will guide us on the path of wisdom. An empirical finding, when it contradicts the assumed hypothesis, will be discarded as an error of selection.
Apart from the usual predictable people, no-one seems to have raised any objection to PSTK'*s* syllogism-cosmology is science; the only plausible cosmology is the Big Bang; therefore the Big Bang is the only science.
Halton Arp and T. Van Flandern immediately fired off their *Case Against the Big Bang8 in* the direction of the exultant *Case for the Relativistic Hot Big Bang Cosmology,* listing a great quantity of data and observations that seem to be incompatible with PSTK'*s* model. But how many people read it? And who wants a to risk a shoot-out with our Fermilab colleagues or to stir up trouble at CERN?
Thus it was that Italy's Nobel prizewinner, Carlo Rubbia, safe and sheltered beneath the umbrella of "whatever may happen in the future", told a television audience that the universe is "15 billion years old", and that quite soon we should be able to emulate God by reproducing in a cellar somewhere the ultra-heavy particles of the Creation, technically known as the Hot Bio Bang.
At the moment of writing, following more precise measurements made with the Hubble Space Telescope, the age of the universe is quite literally crumbling. The expansion constant Ho, generally thought to be below 50 km per second per megaparsec, has now been calculated as being no less than 80 and more probably nearer 90 km per second per megaparsec. And this to the understandable embarrassment of cosmologists, admits Duccio Macchetto, the director of the HST Institute, who are now called on to put together galaxies that can be no older than seven or eight billion years with star clusters that are at least twenty billion years old9.
If we prefer not to phone Chicago or Baltimore so as not to disturb, we can always try Professor Rubbia at CERN, perhaps posing some question like: "Why did you declare that the universe is 15 rnillion years old?" I actually tried ringing him, on all the numbers 1 could find, but after 1 stated my reason for calling 1 was never put through.
So it is to PSTK that we must ask our question, loud and clear. As concems "whatever may happen in the future", just what *might* happen if Ho, is 80 km per second per megaparsec? Do we have to retrieve the term "Δ " from field equations, the notorious "cosmological constant" that helped Einstein hold his static universe in equilibrium? Or will we have to rewrite the entire story of stellar evolution (naturally, as an accelerated evolution)?
Both of these seem likely. A touch of acceleration here, slow down that piece over there, a bit of computer-dressing, and our Big Bang will be safe again. Halton Arp will write another article of fiery dissent that no-one will read, and a deranged star-gazer will set phones ringing in vain in the cosmology departments of half the world.

Notes

1 Thomas Kuhn, *La struttura delle Rivoluzioni*, Scientifiche, 1962.
2 Sheldon Glashow, *Desperately Seeking Superstrings*, *Psysics Today*. The remark was reiterated in full at the Cambridge convention on dark matter.
3 Philip Anderson, *More is Different*, Science, 1972.
4 Neil Turok, English physicist and one of the main proponents of cosmic strings.
5 Ed Tryon, now a Professor at Hunter College, New York, and author of "Is the Universe a Vacuum Fluctuation?", *Nature* 246.
6 Paul Barthez (1734-1806), state physician and member of the Académie des Sciences.
7 AA.VV. Associazione Astronomia Umbra.
8 PSTK, L' *evoluzione dell' universo*, Scientific American, special edition 1994, no. 316, Italian edition.
9 The most recent measurements of variable cepheids belonging to galaxy clusters in Virgo and Leo, obtained with the Keck Telescope and the HST, give these results:
Ho = 87 ± 7 km. sec. Mpc (NGC 4571, M. Pierce et al, 1994).
Ho = 80 ± 17 km. sec. Mpc (M 100, W. Freedman et al, 1994)
Ho = 69 ± 8 km. sec. Mpc (M. 96, N. Tanvir et al, 1995).

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