Non-standard Models and the Sociology of Cosmology[1]

Martín López-Corredoira

Instituto de Astrofísica de Canarias, E-38200, La Laguna, Tenerife, Spain
Departamento de Astrofísica, Univ. La Laguna, E-38206 La Laguna, Tenerife, Spain

Abstract

I review some theoretical ideas in cosmology different from the standard "Big Bang": the quasi-steady state model, the plasma cosmology model, non-cosmological redshifts, alternatives to non-baryonic dark matter and/or dark energy, and others. Cosmologists do not usually work within the framework of alternative cosmologies because they feel that these are not at present as competitive as the standard model. Certainly, they are not so developed, and they are not so developed because cosmologists do not work on them. It is a vicious circle. The fact that most cosmologists do not pay them any attention and only dedicate their research time to the standard model is to a great extent due to a sociological phenomenon (the "snowball effect" or "groupthink"). We might well wonder whether cosmology, our knowledge of the Universe as a whole, is a science like other fields of physics or a predominant ideology.

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1. Introduction

The present-day standard model of cosmology (the "Big Bang") gives us a representation of a cosmos whose dynamics is dominated by gravity (from

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general relativity), with a finite lifetime, large scales homogeneity, expansion and a hot initial state, together with other elements necessary to avoid certain inconsistencies with the observations (inflation, non-baryonic dark matter, dark energy, etc.). Although the Big Bang is the most commonly accepted theory, it is not the only possible representation of the Cosmos. In the last ∼90 years —such is the brief history of the branch of science called cosmology— there have been plenty of other proposals. I describe them in §2 of this paper.

Cosmologists do not usually work within the framework of alternative cosmologies because they feel these are not at present as competitive as the standard model. Certainly, they are not so developed, and they are not so developed because cosmologists do not work on them. It is a vicious circle. The fact that most cosmologists do not pay them any attention and only dedicate their research time to the standard model is to a great extent due to a sociological phenomenon. In a second part of the paper, §3 and §4, I will discuss the sociological aspects related to cosmology and the debate on the different theories.

2. Alternative models

Although the standard model ("Big Bang") is the most well known and commonly accepted theory of cosmology, it is not the only possible representation of the Cosmos, and it is not clear that it is the right one, not even in an approximate way (for a discussion of some of its problems see López-Corredoira, 2003, and see also below in §2.5). There were and there are many other alternative approaches to our understanding of the Universe as a whole. Among them, because of its historical importance and impact, the quasi-steady state model and plasma cosmology are significant examples. There are many other examples too. I will give a brief description of them in this section. I will not give a complete list of models, but this sample is large enough to give an idea of what theoretical approaches are being discussed in cosmology from heterodox standpoints: either from dissidence with respect to the standard model, or dissidence with respect to the dominant dissident theories.

2.1. Quasi-Steady State Cosmology

The theory (better call it a hypothesis) which is called nowadays the "quasi-steady state cosmology" (QSSC) was indeed first called the "steady state theory". Hoyle (1948), and independently Bondi & Gold (1948), proposed the hypothesis of the steady state in which, contrary to the Big Bang approach, there was no beginning of the Universe. The Universe is expanding, it is eternal and the homogeneous distribution of matter is being created at a rate of 10^{-24} baryon/cm^3/s, instead of the unique moment of creation in the Big Bang. The perfect cosmological principle of a Universe which is observed to be the same from anywhere and at any time is followed in this model, whereas the standard model only gives a cosmological principle in space but not in time. There is no evolution. The Universe remains always the same. Newly created matter forms new galaxies which substitute those that are swept away by the expansion.

Fred Hoyle (1915–2001) inadvertently baptised the rival theory: he dubbed the primaeval atom theory of Gamow and coworkers[2] the "Big Bang" in order to ridicule it. However, the name caught on. During the '50s, both theories held their ground. While there were attempts to explain the abundances of the chemical elements with Gamow et al.'s theory, the Steady State Theory also provided plausible explanations. E. M. Burbidge et al. (1957) explained the abundances of the light elements (helium, lithium, deuterium [an isotope of hydrogen] and others) in terms of stellar nucleosynthesis and collision with cosmic rays in the remote past of the Universe. The heaviest elements could also be explained in terms of stellar rather than primordial nucleosynthesis, and the defenders of Big Bang in the end also had to adopt the stellar nucleosynthesis of Burbidge et al. for the heavy elements.

Nonetheless, the steady state theory would lose competitiveness by the mid-sixties, because it could not explain certain observational facts. It could not explain why the galaxies were younger at higher redshift. It could not explain the excess of radio sources at large distances (Ryle & Clarke, 1961), nor the distribution of quasars. Most importantly, it did not explain the cosmic microwave background radiation (CMBR), discovered in 1965 by Penzias and Wilson.[3] This strongly favoured the Big Bang theory.

[2]George Gamow (1904–1968) and one of his students, Ralph Alpher, published a paper in 1948. Gamow, who had certain sense of humour, decided to put the reputed physicist Hans Bethe as second author, even though he had not participated in the development of the paper. Bethe was amused, so the result was a paper by Alpher, Bethe and Gamow (to rhyme with "alpha, beta and gamma"). Later, R. C. Herman joined the research team, but—according to Gamow—he refused stubbornly to change his name to "Delter".

[3]Indeed, the radiation had been discovered previously, but Penzias and Wilson, adviced

In 1993–94, Hoyle, Burbidge, & Narlikar (1993, 1994)[4] published a modification of the model that was called the "quasi-steady state" theory. The main modification consisted in positing an oscillatory expansion apart from the exponential term:

$$a(t) \propto e^{t/P}[1 + \eta \cos(2\pi\theta(t)/Q)].$$

$P \sim 10^{12}$ years, $\theta(t) \sim t$. The exponential factor had already been introduced in the first version of the Steady State model to keep $\frac{\dot{a}}{a}$ =constant and consequently maintain a constant density of matter by invoking the continuous creation of matter. The new term here is the sinusoidal oscillation. The creation of matter is confined to epochs with minimum $a(t)$ rather than being continuous. The parameter Q and η would be determined from Hubble's constant, the age of globular clusters and the maximum observed redshift in the galaxies. With this model, some of the problems that affected the original theory of 1948 were solved. This explained why there are younger galaxies at higher redshift, the problem of the radio sources, the distribution of quasars (with lower density for $z \gtrsim 2.5$), the formation of large-scale structure (Nayeri et al., 1999).

The CMBR and its blackbody spectrum would be explained as the effect of the thermalization of the radiation emitted by the stars of the last cycle $P/3$ due to absorption and re-emision that produce needle-shaped particles ("whiskers") in the intergalactic medium. Due to the long distance travelled by the photons in the maxima of the oscillation and due to the thermalization that occurs at each minimum, there is no accumulation of anisotropies from one cycle to another. Only the fluctuations of the last minimum survive, which gives fluctuations of temperature comparable to the observed $\Delta T/T \sim 5 \times 10^{-6}$. First, the carbono needles thermalize the visible light from the stars giving rise to far infrared photons at $z \sim 5$, keeping the isotropy of the radiation. Afterwards, iron needles dominated, degrading the infrared

by R. H. Dicke et al., interpreted it in cosmological terms (Dicke et al., 1965). In the old Soviet Union, Shmaonov (1957) had made measurements at a frequency of 9 GHz of a background radiation that was isotropic and had an antenna temperature of 4 ± 3 K. There were also previous measurements by japanese teams, and indirect measurements of the existence of radiation of ~ 2.3 K by MacKellar in 1941 with the spectral analyses showing excitation of rotational transition of cyan molecules (Novikov, 2001).

[4]See also Hoyle, Burbidge, & Narlikar (2000) or Narlikar et al. (2007) for a complete development of the theory and comparison with observational data.

radiation to produce the observed microwave radiation (Wickramasinghe, 2006). The anisotropies of this radiation would be explained in terms of clusters of galaxies and other elements (Narlikar et al., 2003, 2007).

Concerning the origin of the redshift in the galaxies, the proposers of this model admit a component due to the expansion $a(t)$, like in the Big Bang, but furthermore they posit the existence of intrinsic redshifts. This allows the solution of problems such as the periodicity of redshift in quasars, and the possible existence of cases with anomalous redshifts (López-Corredoira, 2010). The total redshift would be the product of both factors, expansion and intrinsic:

$$(1+z) = (1+z_{\rm exp.})(1+z_{\rm int.})$$

The intrinsic redshift is explained by means of the variable mass hypothesis. Hoyle & Narlikar (1964) derived this hypothesis from a new gravitation theory based on Mach's principle with the solution that the Minkowski metric and the particle mass depend on time as $m \propto t^2$. This variable mass hypothesis is used by the authors of QSSC to explain cases of anomalous redshifts, but it is not part of the main body of the hypothesis QSSC, that is, it is optional; QSSC can be conceived without the variable mass hypothesis. The intrinsic redshift would be due to variation of the energy of the emitted photon when the masses of protons and electrons vary:

$$(1+z_{\rm int.}) = \frac{m_{\rm observer}}{m_{\rm source}} = \frac{t_0^2}{(t_0 - r/c)^2}.$$

In the case of quasars, anomalies in the redshift would be observed because the mass of their constituent particles grows proportionally to $(t - t_{quasar})^2$ instead of t^2 (Narlikar, 1977; Narlikar & Arp, 1993).

Summing up, they proposed a model which aimed to compete with the standard "Big Bang" theory but with a very different description of the Universe. According to the authors, QSSC is able to explain the existing cosmological observations, at least in an approximate way, and it can even explain some facts that the Big Bang model does not explain (such as the anomalies in the redshifts of quasars). It also contains predictions different from the standard model, though these are difficult to test. The predictions include (Narlikar, 2006): existence of faint galaxies ($m > 27$) with small blueshifts ($\Delta z < 0.1$), the existence of stars and galaxies older than 14 gigayears, an abundance of baryonic matter in ratios above those predicted by the Big Bang, and gravitational radiation derived from the creation of matter.

2.2. Plasma Cosmology

Plasma Cosmology assumes that most of the mass in the Universe is plasma controlled mainly by electromagnetic forces (and also gravity, of course), rather than gravity alone, as in the standard model. The Universe has always existed, it is always evolving, and it will continue to exist forever. Some of its proposers are the Physics Nobel Prize laureate Hannes Alfvén (1908-1995), O. Klein, A. L. Peratt, E. Lerner, A. Brynjolfsson (Alfvén & Klein, 1962; Alfvén, 1981, ch. 6; Alfvén, 1983, 1988; Lerner, 1991).

The plasma, through electric currents and magnetic fields, creates filaments similar to those observed in the large-scale filamentary structure of the Universe. The plasma cosmology model predicts the observer morphological hierarchy: distances among stars, galaxies, cluster of galaxies, and filaments of huge sizes in the large-scale structure. The observed velocities of the streams of galaxies in regions close to the largest superclusters are coincident with those predicted by the model, without the need for dark matter (Lerner, 1991). The formation of galaxies and their dynamics would also be governed by forces and interactions of electromagnetic fields (Peratt, 1983, 1984; Lerner, 1991, chs. 1, 6).

Hubble expansion is admitted in the first version of plasma cosmology and was explained by means of the repulsion between matter and antimatter. Alfvén proposed his "fireworks" model in which a supercluster is repelled by other superclusters; and within a supercluster each cluster is repelled by other clusters; and within a given cluster each galaxy is repelled by the other galaxies, and so on, obeying a distribution of matter and antimatter. In each local volume, a small explosion would impose its own local Hubble relationship, and this would explain the variations in the velocities of Hubble's law, i.e. the different values of the Hubble constant measured in the 70s and 80s, when Alfvén posited his hypothesis, in different ranges of distances or looking in different directions, all without invoking dark matter. The energy derived from the annihilation of protons and electrons would produce a background radiation of X- and γ-rays. In more recent times, some proposers of plasma cosmology (e.g., Brynjolfsson, 2004; Lerner, 2006) have stated that there is no expansion, the Universe is static, and that the redshift of the galaxies would be explained by some kind of tired light effect of the interaction of photons with electrons in the plasma.

With regard to the CMBR, Lerner (1988, 1995) explains it in terms of absorption and re-emission of the radiation produced by stars. It is similar to the mechanism proposed by QSSC, but here the thermalization is due to interaction with electrons. The interaction of photons and electrons produces a loss of direction in the path of the light, giving rise to an isotropic radiation.

2.3. Static Models

There exist plenty of models which are characterized by lacking an origin of time (an eternal Universe), such as those described in the two previous subsections; such models moreover posit that there is no expansion, in some cases the space even being infinite and Euclidean. The redshift of the galaxies given by Hubble's law would be due to some mechanism different from the expansion or Doppler effect, mainly a "tired light" effect (see reviews by López-Corredoira, 2003, §2.1; López-Corredoira, 2006). Among the many cases, I will mention just a few of them:

- The eternal Universe by Hawkins (1960, 1962a, 1962b, 1962c): Based on the existence of a negative pressure in a cosmic fluid derived from general relativity (not very different from the role the cosmological constant has acquired nowadays). The main point which differenciates this model from the standard theory is the proposal that the Universe is static, infinite, without an instant of creation and without expansion. The redshift of the galaxies is explained as a gravitational effect combined with a slight amount of intergalactic extinction[5] (10^{-7} times the local interstellar absorption per unit distance). Hawkins (1993) argues that his model is not unstable, with no tendency to collapse or expand, and that the CMBR is due to the emission of Galactic and intergalactic dust grains. Olbers' paradox (which says that integrating over infinite distance we should get infinite flux) is solved by means of absorption in clouds of dust, but energy does not disappear, so this dust should be heated and re-emit; this problem has no easy solution.

- Chronometric cosmology (Segal, 1976; Segal & Zhou, 1995): This model assumes that global space structure is a 3D-hypersurface in a Universe of four dimensions. Events in the Universe are ordered globally according to a temporal order. The redshift of the galaxies obeys a quadratic law with distance (nowadays, it is known this cannot be correct; Sandage & Tammann, 1995). There is no explanation for the CMBR.

[5]Extinction produced by some particles which are placed in the space surrounding galaxies.

- Curvature cosmology (Crawford, 2011; developed since the '80s and '90s): A new gravitational theory based on a combination of general relativity and quantum mechanics. The curvature pressure stems from the motion of charged particles in non-geodesic paths. In the case of the photons that travel across the matter, this produces a "tired light" effect as a product of the gravitational interaction between wave packets and curved space-time, giving rise to the observed redshift of galaxies. The result of the interaction of the photon are three new photons: one with almost identical energy and momentum to that of the original photon and two extremely low energy secondary photons. Anomalous redshift cases might be produced by the extra redshift due to the photons' passage through the cloud around the anomalous object (Crawford, 2011). The CMBR comes from the curvature-redshift process acting on the high-energy electrons and ions in the cosmic plasma. The energy loss which gives rise to the spectrum of photons of the CMBR occurs when an electron that has been excited by the passage through curved spacetime interacts with a photon or charged particle and loses its excitation energy.

- Wave system cosmology (Andrews, 1999): The Universe is a pure system of waves with mass density and tension parameter proportional to the local intensity of the modes of the waves. The peaks of the constructive interferences are the elementary particles. The redshift is produced by a "tired light" mechanism.

- Subquantum kinetics (LaViolette, 2012) is a unified field theory with the foundations for a new wave theory of matter. Its non-dispersing, periodic structures resolve the wave-particle dualism and produce de Broglie wave diffraction effects. Subquantum kinetics model proposes an open, order-generating universe, continuously creating matter and energy. It predicts that gravity potential should have a finite range. It uses "tired-light" redshift in a static Universe, without radiating a secondary photon, no angular deflection, no strong wavelength dependence. It works as if intergalactic space on the average were endowed with a negative gravitational mass density.

2.4. Variations on the Standard Model

There are also models which are closer to the main characteristics of the standard model, but they are different in some minor aspects. Many of these models are investigated by some main stream cosmologists. They are alternative models which stem from the variations of the standard model. Here are some examples:

- Newtonian cosmology: In the early development of Big Bang cosmology there appeared a proposal (Milne, 1933, 1934) to keep an infinite euclidean space, with Newtonian gravity and expansion as a pure Doppler effect in the recession of the galaxies. Many facts that were explained by the standard model with general relativity could also be explained with Newtonian cosmology. There remained some problems (stability, Olbers' paradox), but there are also proposals to solve them without general relativity (see the review by Baryshev & Teerikorpi, 2012, §7.1.3)

- The fractal Universe (e.g., Baryshev et al., 1994; Gabrielli et al., 2005): The density distribution of the Universe is not homogeneous on very large scales, but obeys a fractal distribution. That is, the density within a sphere of radius R is not proportional to R^3 for large enough R (in the regime in which there should be homogeneity) but proportional to R^D with a fractal dimension $D < 3$.

- The cold Big Bang (Layzer, 1990; developed since the '60s): Rather than a very high temperature at the beginning of the Universe with a later progressive cooling, the Universe starts with $T = 0$ K. Alternative explanations are offered for the origin of the elements (Aguirre, 1999), the CMBR (Aguirre, 2000) and other phenomena explained by the standard hot Big Bang.

- Variations or oscillations of physical constants (c, G, h, etc.) with time or distance.

- Modifications of aspects of the gravity law. For instance, modified Newtonian dynamics [MOND, reviewed by Sanders & McGaugh, 2002], which posits that Newton's law of gravitation is not followed for very low accelerations. Another such theory is modified gravity (MOG), and there are many other cases.

- Multiple variations on the type of dark matter, dark energy/quintessence, or even a Universe without these elements of the present-day standard model. For instance, some authors claim that non-baryonic (cold) dark matter in haloes is not necessary to explain the rotation curves of the galaxies: with the above-mentioned MOND scenario, for example, dark matter is explained in terms of massive photons (Bartlett & Cumalat, 2011), protons and alpha particles moving at relativistic speeds (so they interact very little; Drexler, 2005), magnetic fields (Battaner & Florido, 2000), some distribution of mass in the outer discs (Nicholson, 2003; Feng & Gallo, 2011), etc. Other examples are alternative proposals to explain the Hubble diagram of supernova data in terms other than the standard dark energy interpretation: an inhomogeneous Universe (Romano, 2007), evolution of SNIa luminosity (Domínguez et al., 2000) or the absorption of their light by grey dust (Bogomazov & Tutukov, 2011), intergalactic extinction, variation of c and G (as mentioned in the previous point), other cosmologies, etc.

- Multiple variations on inflation (alternative proposals such as cosmic strings, walls and other textures). Variations in the number of neutrino families; the formation of structures in a monolithic way (galaxies all formed at once) rather than the standard hierarchical scenario (the galaxies being formed in continuous episodes of accretion and merging), etc.

2.5. Caveats/Problems in the Standard and Alternative Approaches

All models have gaps and caveats in their explanation of certain data derived from observations. The Big Bang has a lot of problems and aspects that do not work properly or are not totally understood yet (see the reviews by López-Corredoira, 2003; Perivolaropoulos, 2008; Unzicker, 2010; Crawford, 2011; Kroupa, 2012; Baryshev & Teerikorpi, 2012). Such problems include: higher metallicity and dust content at high redshift than expected, much higher abundance of very massive galaxies at high redshift than expected, poorly understood extreme evolution of galaxy sizes, galaxies with ^{4}He$<24\%$, ill-understood deuterium abundances, failure in the predictions of Li, Be, ^{3}He, inhomogeneities at scales >200 Mpc, periodicity of redshifts, correlations of objects with low redshift with objects at high redshift, flows of large-scale structure matter with excessive velocity, an intergalactic medium temperature independent of redshift, a reionization epoch different from CMBR and QSO observations, anomalies in the CMBR (alignment quadrupole/octopole, insufficient lens effect in clusters, etc.), wrong predictions at galactic scales (no cusped halos, excessive angular momentum, insufficient number of satellites, etc.), no dark matter found yet, excessive cluster densities, dark energy in excess of theoretical models by a factor 10^{120}, no observation of antimatter or evidence for CP violation, problems in understanding inflation, and so forth.

The expansion itself has no direct proof (nobody has directly observed a galaxy increasing its distance with respect to us); the most direct argument in favour of expansion is the redshift of the galaxies, but the redshift has possible explanations other than expansion. Most tests of expansion are dependent on the evolution of galaxies, so they cannot give us a solution without a priori assumptions on that evolution. There are a few tests which are dependent on other factors; for instance, the Alcock-Paczyński test is independent of the evolution of the galaxies but it presents entanglement on the cosmological effects with the redshift-space distortions (Ross et al., 2007). The CMBR, light element abundances and large scale structure formation also have alternative explanations, as mentioned in previous subsections. Other very recent fashionable topics in cosmology such as Baryonic Acoustic Oscillation (BAO) peaks might be understandable in terms of different interpretations of the large scale structure too (López-Corredoira & Gabrielli, 2013).

Of course, if the Big Bang model has problems, the alternative proposals have their own share of difficulties too, and their problems are more severe (see, for instance, Edward L. Wright's web-page[6]), perhaps because these theories are not as developed and polished as the standard model. For the expansion, either they take it as fact, so they need speculative elements to argue that there was no beginning of the Universe (e.g., continuous creation of matter in QSSC) or an alternative explanation for the redshift of the galaxies. The CMBR has alternative explanations different from the Big Bang, but with some ad hoc elements (e.g., whiskers to thermalize stellar radiation in QSSC) without direct proof. Also, light element abundances require very old populations that have not been observed yet.

Indeed, alternative models like QSSC do not apply a different methodology from the standard model: both standard and QSSC models have some basic tenets and a lot of free parameters and ad hoc elements which are introduced every time some observation does not fit their models. Its modern version (Hoyle et al., 2000) is able to explain most of the difficulties of the previous (steady state) version of the model. They introduce ad hoc elements without observational support in the same way that the Big Bang introduces

[6]http://www.astro.ucla.edu/~wright/errors.html

ad hoc non-baryonic dark matter, dark energy, inflaton, etc. And they continue to skip the inconsistencies ad hoc: for instance, the maximum redshift of a galaxy was set to be 5 in the initial version of QSSC; however the authors have some free parameters which can be changed conveniently when some new observations do not fit the initial predictions, so at the end they can introduce ad hoc corrections which render their theory compatible with any maximum redshift of a galaxy. Indeed, something similar is done with the Big Bang theory: think, for instance, the predictions of the Big Bang for the maximum redshift of galaxy or the epoch of reionization. They do the same kind of re-fitting of parameters. Why, then, are the different theories accepted/rejected with different criteria?

The number of independent measurements relevant to current cosmology and the number of free parameters of the theory are of the same order (Disney, 2007): in the '50s the "Big Bang" was a theory with three or four free parameters to fit the few quantities of observational cosmology (basically, Hubble's constant and the helium abundance), and the increase in cosmological information from observations, with the CMBR anisotropies and others, has been accompanied by an increase in free parameters and patches (dark matter, dark energy, inflation, initial conditions, etc.) in the models to fit those new numbers, until becoming today a theory with around 20 free parameters (apart from the initial conditions and other boundary conditions introduced in the simulations to reproduce certain structures of the Universe). A similar situation is given in particle physics too (Unzicker, 2010).

The number of independent measurements in CMBR anisotropies is also very limited. While its power spectrum shows repeated information in the form of multiple peaks and oscillations, its Fourier transform, the angular correlation function, offers a more compact presentation that condenses all the information of the multiple peaks into a localized real space feature. Oscillations in the power spectrum arise when there is a discontinuity in a given derivative of the angular correlation function at a given angular distance (López-Corredoira & Gabrielli, 2013). These kinds of discontinuities do not need to be abrupt over an infinitesimal range of angular distances but may also be smooth, and can be generated by simply distributing excesses of antenna temperature in filled disks of fixed or variable radii on the sky, provided that that there is a non-null minimum radius, and/or that the maximum radius is constrained. This allows a physical interpretation of these mathematical properties of CMBR anisotropies in terms of matter distribution in the fluid generating the radiation. A power spectrum with oscillations is a rather normal characteristic expected from any fluid with clouds of overdensities that emit/absorb radiation or interact gravitationally with the photons, and with a finite range of sizes and distances for those clouds (López-Corredoira, 2013a). The standard cosmological interpretation of "acoustic" peaks, from the hypothesis of primeval adiabatic perturbations in an expanding universe (Peebles & Yu, 1970), is just a particular case; peaks in the power spectrum might be generated in scenarios that have nothing to do with oscillations due to gravitational compression in a fluid.

The CMBR angular correlation function can be fitted by a generic function with a total of $\approx$6 free parameters; saying that the power spectrum/angular correlation function contains hundreds or thousands of independent parameters for a given resolution is not correct, because their different values are not independent in the same sense that hundreds of observations of the position and velocity of a planet do not indicate hundreds of independent parameters, the information of the orbit of planet being reduced to six Keplerian parameters. Nonetheless, the standard model with six free parameters (there are indeed $\sim$20 parameters, but the most important ones are six in number, the rest producing low dependence) produces a still better fit than the generic fit with the same number of free parameters; it fits third and higher order peaks whereas the generic fit reproduces only the first two peaks (López-Corredoira, 2013a). There are also other theories that reproduce the same data with totally different cosmologies with a similar number of free parameters; e.g., Narlikar et al. (2003, 2007) for QSSC, Angus & Diaferio (2011) for MOND. The fact that different cosmologies with different elements can fit the same data (with a similar number of free parameters to be fitted) indicates that the number of independent quantities in the information provided by the data is comparable to the number of free parameters in any of the theories.

There is near consensus in the values of the cosmological parameters. The independent cosmological numbers extracted from observations are of the same order. Note, however, that there are some numbers which cannot be fitted. And the publication of the measurements of these cosmological parameters may be biased due to the existence of values expected a priori. For instance, the analysis by Croft & Dailey (2011) shows us that: The value of the Hubble constant had a huge dispersion of values around two values of 50 and 100 km/s/Mpc respectively before 1995, whereas immediately after 1995 almost all values clustered with small errors very close to the preferred value of 70 km/s/Mpc given by the HST Key Project; Before 1999, approximately

1/3 of the measurements of Ω_m, using galaxy peculiar velocities, gave values inconsistent with being lower than 0.5 whereas after 1999, all measurements, including some using similar techniques, grouped around the preferred value of 0.25–0.30; The measurements of Ω_Λ, which was considered null before the '90s, have now settled at 0.7 and since 1995 it presents a dispersion much lower than expected statistically from the error bars, which means that either the error bars were overestimated, or that there is a bias in the publication of results towards the preferred value. Other examples could be given.

The development of modern Cosmology is somewhat similar to the development of the Ptolemaic epicyclic theory. However, in this race to build more and more epicycles, the Big Bang model is allowed to make ad hoc corrections and add more and more free parameters to the theory to solve the problems which it finds in its way, but the alternative models are rejected when the gaps or inconsistencies arise and most cosmologists do not heed their ad hoc corrections. Why are the different theories accepted/rejected with different criteria?

3. The Difficulties in Creating Alternative Models: A Sociological/-Epistemological Model of How Modern Cosmology Works

In my opinion, alternative models are not rejected because they are not potentially competitive but because they have great difficulties in advancing in their research against the mainstream. A small number of scientists cannot compete with the huge mass of cosmologists dedicated to polishing and refining the standard theory. The present-day methodology of research in cosmology does not favour the exploration of new ideas. The standard theory in cosmology became dominant because it could explain more phenomena than the alternative ideas, but it is possible that partial successes have propitiated the compromise with a general view that is misguided and does not let other ideas advance that might be closer to a more correct description of the Universe.

3.1. Methodology of science

Basically, there are two different methodologies to study Nature, both inherited from different ways of thinking in ancient Greece: the rationalist–deductive method and the empirical–inductive method (e.g., Markie, 2012).

The rationalist–deductive method: This is the method devised by Pythagoras and Plato. The pure relations of numbers in arithmetic and geometry are the immutable reality behind changing appearances in the world of the senses. We cannot reach the truth through observation with the senses, but only through pure reason, which may investigate the abstract mathematical forms that govern the world. In this way of thinking, there is a predominance of creation of abstract theories, and mathematical modelling predominates over experimental and observational results. There are good cases of success using a rationalist-deductive approach. An example within modern science Einstein's general relativity, which was posited from aesthetic and/or rational principles in a time in which observational data did not require a new gravity theory. *In fact, observational tests proved this theory successful. Present-day physics and cosmology are partially Pythagorean when a theory is created before the observations. It is also common among modern Pythagoreans to approve of statements such as the search for beauty in a mathematical construction describing physical reality, or the Divine plan by which the creator designed the Universe. The physicist–mathematician tries to achieve something close to a mystical approach, tries to read into the Mind of God. Also, analogously with religion, this extremely theoretical physics and cosmology can only be understood by a priestly elite able to think in four or more dimensions or in terms of similar abstractions.*

The empiricist–inductive method: As opposed to the preceding method, this one points out that Nature should be known through observations and extrapolations of them. This is the Anaxagoras' method of how to know Nature. Aristotle uses both inductive and deductive methods, and he says that "the mathematical method is not the method of the physicists, because Nature, perhaps all, involves matter" (Metaphysics, book II). Certainly, mathematics is useful for physicists, in spite of what was said by Aristotle, and this is clear since Galileo Galilei put the bases of the scientific method, but I agree with the Greek philosopher that matter is not the same thing as mathematical entities. Matter is not numbers, or geometry, or arithmetic, or the analysis of functions. Matter (or, better, matter– energy) is the component of the physical Universe, and this is what constitutes the reality of Nature to be studied by physical sciences. The empiricism of Galileo Galilei might be an example within modern science, in the sense that observation and experimenta-

tion are a requisite prior to theoretization, although all scientists, even Galileo, are also partly Pythagorean and all pythagoreans are in part empirists too. These are extreme positions which cannot usually be found in a pure form, but it is clear that, in some researchers, one of the trends dominates. But, apart from a few exceptions, the empirical–inductive method is more usual in science. Dingle (1937) made an aggressive attack against the rationalist–deductive method in favour of the empiricist–inductive method, with terms such as "paralysis of reason", "intoxication of the fancy", " 'Universe' mania", "delusions", "traitors", "treachery". Robertson and de Sitter also favoured an empiricist inductive science. In my opinion, cosmology should be derived empirically by first taking the data without preconceived ideas, and then interpreting them from all possible theoretical viewpoints. Certainly, there are always prejudices and intuitions in our minds that push us towards certain avenues of research, but at least we should openly consider all the theoretical possibilities that can explain the data, rather than taking only one (standard) theory and always trying to squeeze the data into it in some way. In the words of Sherlock Holmes[7]: 'It is a capital mistake to theorize before you have all the evidence' (*A Study in Scarlet*), and 'before one has data, one begins to twist facts to suit theories instead of theories to suit data' (*A Scandal in Bohemia*) [cited by Burbidge, 2006].

Some astrophysicists closer to the observations than theory usually complain about the lack of an empirical approach in cosmology. For instance, Gérard de Vaucouleurs (1918–1995), known for his extragalactic surveys and Hubble's constant measurements, said that there are 'parallelisms between modern cosmology and medieval scholasticism. (...) Above all I am concerned by an apparent loss of contact with empirical evidence and observational facts, and, worse, by a deliberate refusal on the part of some theorists to accept such results when they appear to be in conflict with some of the present oversimplified and therefore intellectually appealing theories of the universe' (de Vaucouleurs, 1970). Certainly, the amount of data for observational cosmology nowadays is much higher than in 1970 (although there were also many of them: CMBR, redshifts of galaxies, abundance of light elements, etc.); however, I think it is still valid nowadays: cosmology has not

[7]The famous character of the novels by Arthur Conan Doyle.

changed its methodology so much.

There is, however, an epistemological optimism encouraging the belief that successful theories are successful because they reflect reality in Nature. The philosopher of science Mosteirín (1989) said that scientists do not have any prejudice to accept alternative cosmologies. He also said, 'there are no working alternatives to the standard big bang cosmological model (or family of models). This fact is not due to the will of the scientists who created the model, still less to the prejudices of the scientific stablishment. On the contrary, it is almost exclusively due to the strong observational constraints which reality puts on the activity of model-making. The standard big bang cosmological model is the model no one wanted, but which recalcitrant experience forced everyone to accept, at least for the moment being.' In my opinion, this kind of statement is somewhat naive and denotes an excessive confidence in a fair application of scientific methodology. Certainly, all the available alternative models may be wrong, but this does not mean that they are rejected fairly; and neither does it mean that the standard model is maintained for fair reasons. This epistemological optimism might be correct in certain branches of science but not in those areas close to metaphysical speculation such as cosmology, where the scientific method is something like:

> — Given a theory A self-called orthodox or standard, and a non-orthodox or non-standard theory B. If the observations achieve what was predicted by the theory A and not by the theory B, this implies a large success to the theory A, *something which must be divulged immediately to the all-important mass media. This means that there are no doubts that theory A is the right one. Theory B is wrong; one must forget this theory and, therefore, any further research directed to it must be blocked (putting obstacles in the way of publication, and giving no time for telescopes, etc.).*
>
> — If the observations achieve what was predicted by theory B rather than by theory A, this means nothing. Science is very complex and before taking a position we must think further about the matter and make further tests. It is probable that the observer of such had a failure at some point; further observations are needed *(and it will be difficult to make further observations because we are not going to allow the use of telescopes to re-test such a stupid theory as theory B). Who knows! Perhaps the observed thing is due to effect 'So-and-so', of course; perhaps they*

> *have not corrected the data from this effect, about which we know nothing. Everything is so complex. We must be sure before we can say something about which theory is correct.* Furthermore, by adding some new aspects in the theory A surely it can also predict the observations, *and, since we have an army of theoreticians ready to put in patches and discover new effects, in less than three months we will have a new theory A (albeit with some changes) which will agree the data. In any case, while in troubled waters, and as long as we do not clarify the question, theory A remains. Perhaps, as was said by Halton Arp, the informal saying 'to make extraordinary changes one requires extraordinary evidence' really means 'to make personally disadvantageous changes no evidence is extraordinary enough'.* (López-Corredoira, 2008)

Halton C. Arp (1927–), a heterodox observational cosmologist, known through his proposal of non-cosmological redshifts (López-Corredoira, 2003, §2.8), would point out: 'Of course, if one ignores contradictory observations, one can claim to have an "elegant" or "robust" theory. But it isn't science.' (Arp & Block, 1991)

3.2. The Snowball Effect

The alternative models try to compete with the standard model, but cumulative inertia gives a clear social advantage to the standard model. This advantage determines that researchers may continue to explore these alternative ideas. Metaphorically, it is like a snowball effect: 'The snowball effect arising from the social dynamics of research funding drove more researchers into the Standard Cosmology fold and contributed to the drying out of alternative ideas' (Narlikar & Padmanabhan, 2001). It is not strange that Jayant V. Narlikar (1938–), one of the creators of the QSSC who still tries to keep it alive, should be frustrated in his odyssey and should link the lack of social success of his theory to how social dynamics works. Anyway, regardless of his frustation, either from dissidence or orthodoxy, what he claims is basically correct and applicable to most speculative sciences or half-sciences such as cosmology. Another creator of the quasi-steady state, Geoffrey R. Burbidge (1925–2010), did not have a higher opinion:

> Let me start on a somewhat pessimistic note. We all know that new ideas and revolutions in science in general come from

> the younger generation, who look critically at the contemporary schemes, and having absorbed the new evidence, overthrow the old views. This, in general, is the way that science advances. However, in modern astronomy and cosmology, at present, this is emphatically not the case. Over the last decade or more, the vast majority of the younger astronomers have been conformists in the extreme, passionately believing what their leaders have told them, particularly in cosmology. In the modern era the reasons for this are even stronger than they were in the past. To obtain an academic position, to obtain tenure, to be successful in obtaining research funds, and to obtain observing time on major telescopes, it is necessary to conform. (G. R. Burbidge, 1997)

Here is a similar opinion from a researcher who is not particularly heterodox:

> It is common practice among young astrophysicists these days to invest research time conservatively in mainstream ideas that have already been explored extensively in the literature. This tendency is driven by peer pressure and job market prospects, and is occasionally encouraged by senior researchers. Although the same phenomenon existed in past decades, it is alarmingly more prevalent today because a growing fraction of observational and theoretical projects are pursued in large groups with rigid research agendas. In addition, the emergence of a 'standard model' in cosmology (albeit with unknown dark components) offers secure 'bonds' for a safe investment of research time. (Loeb, 2010)

The snowball effect, also called Matthew effect (Merton, 1968)[8], is to a certain extent present in the social dynamics of cosmology, as well as in other speculative areas of science (López Corredoira, 2013b, §3.8). It is a feedback ball: the more successful the standard theory is, the more money and scientists are dedicated to work on it, and therefore the higher the number of observations that can be explained with more parameters and ingredients

[8]Merton (1968) gave it the name "Matthew effect" from the Gospel of St. Matthew (25:29): 'Unto every one that hath shall be given, and he shall have abundance: but from him that hath not shall be taken away even that which he hath.'

(dark matter, dark energy, inflation, etc.) introduced ad hoc, and that cause the theory to be considered more successful.

However, not everything is a social construct (as some postmodernists claim): the CMBR, the redshift of galaxies, etc. may be real facts, or at least I have no doubts of their existence although other authors have expressed such[9], and they also have weight in the credibility of the standard model.

3.3. Censorship and arXiv.org

It is also worth noting that the publication of heterodox ideas is far to be free, in particular in recent years. Apart from the refereed journals, which usually reject challenging ideas deviating from mainstream points of view, there is another important tool for communicating scientific results in physics: the preprint server *arXiv.org*. It is a monopoly within physics and has no competitors. Even most of the papers published in journals are posted on this preprint server, and people read them here. The situation is that papers not posted on *arXiv.org*, will receive scant dissemination within the community, particularly when the papers are not published in a reputed refereed journal, which is often the case for non-mainstream positions.

The development of *arXiv.org*, first at Los Alamos National Laboratory and later at Cornell University, was a wonderful example of freedom of expression between 1992 to 2004 that provided everybody with an open forum in which to post their ideas. There was a small fraction of papers with 'exotic' ideas, but they were very few (5% or less), so they did not disturb the flow of information. However, after 2004 there was a change in policy and those responsible for the site decided to block the posting of certain contributions. In 2004, a system was introduced in which in order to post something on the site support was requested from a colleague with experience in the field. The methods of the system would become more subtle in the following years, forbidding some scientists from giving support when arXiv moderators noted that they had allowed the publication of very challenging heterodox ideas, and creating committees to reject papers without having read them and with the absence of a referee's report: the committees just read the title

[9]For instance, there are some authors (Li et al., 2009; Cover et al., 2009) who suspect that all of the reduction of raw data of CMBR have common a priori assumptions which lead to the same measurement of power spectrum, but it could change or even be compatible with no anisotropies with different methodology applied to the analysis of raw data.

and the abstract and, if they did not like the content (and normally they do not like anything that has not been accepted in a refereed journal and smells of heterodoxy, such as denial of the expansion of the Universe or discussions about alternative interpretations of the CMBR), they channel the paper, which formerly would have been placed on 'astro-ph.CO', widely read by astrophysicists, to 'physics.gen-ph', which is hardly read by anybody. In some cases, they remove the contribution totally, without further explanation (e.g., Castro Perelman, 2008). When asked for an explanation for a rejection, they usually reply with set phrases: 'arXiv reserves the right to reclassify or reject any submission. We are not obligated to provide substantive reasons for every rejection, and usually the moderators do not provide more than a sentence or two, often in a form not appropriate for author viewing'. This method of censorship of the promotion of new ideas in cosmology appears to me to be somewhat on a par with certain totalitarian regimes (see further discussion in López Corredoira, 2013b).

3.4. The Influence of Culture and Religion

Another factor that carries some weight in the determination of the dominant scenario in cosmology is the ideology of the researchers, and in the case of religious ideas this is somewhat relevant. The association of cosmology and religion is indeed very old–says Kragh (2007b)–but there are in my opinion older themes that are never overcome.

In Timaeus, Plato says that time was created simultaneously with the Universe. This idea was introduced into Christianity from the third century A.D., after reconciling Christianity with existing Roman society and its ideas influenced by Plato and Emperor Tertullian (Roberts, 1924; Lerner, 1991, ch. 2). Augustine of Hippo later introduced certain Platonic ideas into Christianity, such as the untrustworthiness of the senses senses and the instantaneous creation of the Universe from nothing. A universe of infinite space and time is exclusive to the Deity, and thus prohibited for the material universe.

The astrophysicist Binggeli (2006) compares the standard model of modern cosmology with the cosmology in the Judaeo–Christiano–Gnostic beliefs of the Scholastic Middle Age, depicted in Dante's Divine Comedy (Primum Mobile), and the author finds that there is a perfect correspondence in some essential points between both worldviews. The three basic tenets of Primum Mobile are present in the observable Universe of the Big Bang theory: 1) there is a maximum finite distance from us in the observable Universe, 2) the observable Universe is a sphere with us at the centre; and 3) it has a *hierarchical structure. One may wonder about the cause of these correspondences, and the answer is also given by Binggeli (2006): there must be a psychological mechanism dominating our visions of Nature. The result of our research is not objective but highly biased by the influence of the culture in which we are embedded (which has inherited the Scholastic cosmological view) and our own psychological patterns. Modern cosmology is a symbolic expression of the states of our mind. The author argues that our view of the external reality is indeed a reflection of our interior world, and that the way to understand modern science should go through a psychological analysis. I think that in some degree he is right: cosmology depends on the social and psychological conditions of scientists. Nonetheless, we should not forget that there are also some elements that are not a reflection of our souls but that result from the observation of something which is outside us.*

Because of this historical background and the coincidences of elements of the standard model with certain credos, some authors think that nowadays the Big Bang is simply the scientific version of Genesis, and that to many people, the Big Bang idea is attractive in the same way, being a synthesis of astrophysics and the dogma of a creation ex nihilo (e.g., Jastrow, 1978). Indeed, in 1951 (when the Big Bang was not yet a dominant standard theory), Pope Pius XII asserted that the Big Bang supports the doctrine of creation "ex nihilo" (Pius XII, 1972). He wrote in an address to the Pontifical Academy os Sciences:

> *In fact, it seems that present-day science, with one sweeping step back across millions of centuries, has succeeded in bearing witness to that primordial 'Fiat Lux' (Let there be light) uttered at the moment when, along with matter, there burst forth from nothing a sea of light and radiation, while the particles of the chemical elements split and formed into millions of galaxies... Hence, creation took place in time, therefore, there is a creator, therefore, God exists!*

In 1982, a conference on cosmology was held at the Vatican. The conference was confined completely to Big Bang cosmology and its proponents; radicals such as F. Hoyle, V. Ambartsumian and G. Burbidge were not invited. Many prestigious scientists have also used the ideas of modern cosmology for theological claims. There are many who talk about the Big Bang leading to a proof of God's existence (e.g., Davies, 1983; the debate for and against the *idea in Soler Gil & López Corredoira, 2008). George F. Smoot, when the discovery of the anisotropies of the CMBR were announced, claimed that for a religious person this was looking at the face of God (Wright, 1993). We must also bear in mind that the United States, at present the leading country in cosmological research, is dominated by a much higher proportion of followers of the Christian religion than in other rich countries.*

Christianity is not the only religion to have found this association of concepts. There also seems to be great acceptance of the standard cosmology in other monotheistic religions. The Israeli physicist and cosmologist Moshe Carmeli (2000) says that not only does the Big Bang scenario agree with the idea of creation described in the Bible, but also with the scenario of creation in six days. The Muslim astronomer Kamel Ben Salem (2005) analyses the Quranic description of phenomena linked to the evolution of the universe.

The opposite trend is also observed. Among heterodox scientists and sceptics (myself included) there has been and continues to be a higher ratio of atheists and agnostics. It is known, for instance, that Fred Hoyle was not a believer. And there are cases of practices in communist countries that favoured non-standard cosmologies. For instance, in the People's Republic of China till the '70s, there was some degree of censorship affecting the circulation of ideas relating to the Big Bang (Hu, 2004; Kragh, 2007a, pp. 199-200).

Of course, there are also many atheists who follow Big Bang and vice versa, but there have been correlations between religious dogma and preferred cosmological scenario and these correlations are not fortuitous. This makes us appreciate the weight of ideology in the early development of scientific ideas such as cosmology, i.e. that cosmology is not totally objective. Nonetheless, from what I can observe among my colleagues (almost all cosmologists, either christians or atheists, are pro-Big Bang) once the standard paradigm is in a dominant position, religious ideas do not exert such a strong influence, and other sociological factors seem to be more important.

3.5. The Psychological Profile of Cosmologists

Social trends or ideologies can greatly influence the kind of science that is carried out in a given epoch and the corresponding results. Also, at the level of the individual, the psychological profile of the researcher can produce leanings towards either orthodoxy or heterodoxy. In my experience, cosmologists tend to fall in one of the following extreme categories, with gradations of grey between them:

Heterodox: possessed by the complex of unappreciated genius, *too much "ego" which does not discourage the researcher in the difficulties for the creation of a new alternative model.* Normally working alone/individually or in very small groups, creative, intelligent, non-conformist. His[10] dream is to create a new paradigm in science which completely changes our view of the Universe. Many of them try to demonstrate that Einstein was wrong, maybe because he is the symbol of genius and defeating his theory would mean that they are geniuses above Einstein. But they are not what they think they are, and most of their ideas are ill-founded. *Most of them are crackpots with crazy ideas with little to be said in their support.* Few of them need to be taken seriously.

Orthodox: dominated by groupthink,[11] following a leader's opinion, *as in the tale of the naked king. Any crazy opinion can be accepted if it is supported by the leading cosmologist, and in this sense Big Bang theory, even if it is a very speculative set of hypotheses, still finds a place in the psychology of the wider community of scientists and grow by the snowball effect.* They are good workers, *conformist, domestic, performing*

[10]As far as I know, there are no women doing this kind of research with their own global cosmological model. If somebody knows any exception, let me know it.

[11]In a sociological analysis, Janis (1972) categorizes the symptoms of groupthink as: 1) An illusion of invulnerability, shared by most or all the members, which creates excessive optimism and encourages the taking of extreme risks. 2) An unquestioned belief in the group's inherent morality, allowing the members to ignore the ethical or moral consequences of their decisions. 3) Collective efforts at rationalization in order to discount warnings or other information that might lead the members to reconsider their assumptions before they recommit themselves to their past policy decisions. 4) Stereotyped views of enemy leaders as too deviant to warrant genuine attempts to negotiate, or as too weak and stupid to counter risky attempts made at defeating their purposes. 5) Self-censorship of deviations from the apparent group consensus, reflecting each member's inclination to minimize to himself the importance of his doubts and counterarguments. 6) A shared illusion of unanimity concerning judgments conforming to the majority view (partly resulting from self-censorship of deviations, augmented by the false assumption that silence means consent). 7) Direct pressure on any member who expresses strong arguments against any of the group's stereotypes, illusions, or commitments, making clear that this type of dissent is contrary to what is expected of all loyal members. 8) The emergence of self-appointed mindguards - members who protect the group from adverse information that might shatter their shared complacency about the effectiveness and morality of their decisions (Dolsenhe, 2011, ch. 12). Sanromà (2007) applied the concept of groupthink to present-day cosmology.

monotonous tasks without ideas in large groups, specialists in a small field which they know very well, and in which they do not try to develop new paradigms. *His/her dream is getting a permanent position at an university or research centre, to* dedicate large portions of their time to the administration and politics of science *(i.e. astropolitics;* see López-Corredoira, 2008; 2013b, chs. 3, 6), *to be leader of a project. Many of them are like sheep (or geese*[12]*), some of them have the vocation of shepherds too.*

The sociological reasons for favouring orthodox proposals might be related to the preference of domesticity in our civilization (see López-Corredoira, 2013b, ch. 5). An anarchy in which everybody expresses his or her ideas freely is not useful for the system. *Sheep* rather than crackpots are preferred. Finding a promising change of paradigm closer to the truth among thousands of crazy proposals is very difficult. In orthodoxy, although absolute truth is not guaranteed, at least a consensus version of the truth is offered and that is what has weight. By means of it, if somebody is wrong then everybody is wrong and the fault is diluted among many. Investment in science prefers security, it prefers domesticity and control, rather than a promising and challenging change of paradigm that is uncertain, with the attendent difficulty of guessing from which direction a new paradigm could come. Nonetheless, again I insist, we must not forget that there is empirical evidence in favour of the standard theory. Nature is more than a social construct or similar kinds of postmodern claims.

3.6. An Illustrative Example for the Sociology of Cosmology

Somebody may think that the arguments given in this paper are just pure abstractions. They are not, they are based on observations of real cases. Perhaps the case of a recent experience of mine might be illustrative.

Every year in my research centre (the 'Instituto de Astrofísica de Canarias' *[IAC]*), there is a call for proposals for the following year's Winter

[12] *In Hoyle et al. (2000), a serious and technical book about cosmology, a picture was inserted in which a row of geese are turning around a corner all in the same way, with the following ironic comment: "This is our view of the conformist approach to the standard (hot big bang) cosmology. We have resisted the temptation to name some of the leading geese".*

School for doctorate students and young postdocs. I have submitted a proposal with the title "Different Approaches to Cosmology" *and the following abstract:*

> *The aim of this winter school is to present the status of current cosmology from both a standard and non-standard points of view, discussing successes and failures. In particular, the standard model and a number of non-standard models will be presented to provide the students with a set of tools to carry out and/or devise new experiments to challenge the current paradigm, either to prove or disprove it. Particular emphasis will be given to the comparison between prediction of the different models and observations.*

I also included a list of possible speakers. The topic attracted attention, so I was advised of the interest for the school, which was chosen as the first option among the proposals, provided that the following changes were made: *The first thing that I was told was that I should include the name of some women among the list of possible invited speakers for political correctness of gender balance. I replied that there are no women with their own alternative theories in cosmology, but that we could include some to talk about variations on the Big Bang, or partial aspects of an alternative theory. The second complaint was that there should be a higher ratio of orthodox cosmologists in the school, at least three or four of the total of eight speakers. I accepted this suggestion too.* The last stage came when I sent my list of speakers with the eight names and possible replacements as second options (in total there were sixteen names) including both women and many orthodox cosmologists. *Many of the names were accepted but I received the following new complaint from the head of the research division at the IAC (the original e-mail on 31 October 2011 was in Spanish):*

> I have looked into it further, and I had the luck to get the comments of a very senior astronomer who does not work directly in cosmology (which is an advantage, because he/she is not set in his/her own scientific ways) and has got a very wide experience in editing journals and organizing congresses. (...) [My contact] told me that we could invite (...), but not *Yurij [Baryshev]*, not even as a second option. (...) I like *Eduardo [Battaner]* very much,

> but he is not the appropriate person for the topic of magnetism in cosmology. (...) We cannot invite *Arp*, as he is confrontational (...) [his recent work] lacks a scientific basis. At this point I vetoed it. (...) This topic [Plasma Cosmology and a proposal to invite *Eric J. Lerner*] is too marginal, and I propose to forget it. (...) [*Jayant Narlikar* and the QSSC] No, I vetoed that too. He is totally marginal and the theory is dead. CDM has its problems, but QSSC is not going to solve them. The only thing we could do would be to invite *Simon White* to tell us why the theory does not work, or even organize a mini-debate between perhaps *Kroupa* and another researcher about the topic.

A magnificent example of how cosmology works. A school describing the most important ideas about cosmology, Big Bang and others, was proposed and the idea had been initially accepted as interesting, as a sign of openness of the mind of our scientific community. But what happened? When one gives some names of some of the most important creators of heterodox ideas (Baryshev, Battaner, Arp, Lerner, Narlikar) they were rejected because some members of a committee who were not even cosmologists decreed that these theories were marginal and dead. The name of Virginia Trimble was also rejected for different reasons.

The theories may be marginal and dead but not because irrefutable scientific arguments against them were given, but rather precisely because of this kind of attitude in the organization of social scientific events (journals, meetings, etc.). Alternative theories die because they are being killed by the same people who say that they are dead. *And most of the scientists who claim that these theories are dead/marginal have never read a paper on these ideas and they merely repeat what they have heard from some colleague (groupthink, blindly following the opinion of the leaders).* What was particularly shocking was the rejection of the invitation to *Narlikar* on the grounds that the QSSC theory is dead. *Indeed, what the censors probably meant is that Fred Hoyle (1915–2001, father of the idea) and Geoff Burbidge (1925–2010, a physicist with an important influence in the political decisions on astrophysics; former editor of the highest impact factor journal of astrophysics, the Annual Review of Astronomy and Astrophysics) are dead, certainly, so it is understood that there is now no living sacred cow to respect, and the community decides to declare that the theory is dead.* However, I have not seen any scientific paper in the last decade that demonstrates irrefutably that the basic points of the

QSSC are untenable. The final suggestion was the most revealing one: that we invite *Simon White* to tell us why QSSC is wrong, without giving *Narlikar* the chance to defend his ideas. This is equivalent to organizing a meeting on different religious ideas and inviting only christians to participate, including a speech of the Pope to tell us why hinduism is a false doctrine. Finally, my proposal was rejected because I insisted in keeping at least two of the five rejected names.

4. Limits of Cosmology

> And we would pretend to understand everything about cosmology, which concerns the whole Universe? We are not even ready to start to do that. All that we can do is to enter in the field of speculations. So far as I am concerned, I would not comment myself on any cosmological theory, on the so-called 'standard theory' less on many others. Actually, I would like to leave the door wide open. [Jean-Claude Pecker, in Narlikar et al. (1997)]

I agree with Jean-Claude Pecker (1923–), another classical heterodox dissident cosmologist. Before wondering which is the true model of cosmology, we must wonder whether we are in a condition to create a theory on the genesis (or non-genesis) and evolution of the whole Universe, whether the psychologico–sociological conditions of the cosmologists are or are not weightier factors than observations of Nature. Is present-day cosmology dominated by our culture or by Nature's objective truths?

4.1. The dogma of the cosmologist, according to Mike J. Disney

According to Michael J. Disney (1937-), in his brave paper 'The case against Cosmology' (Disney, 2000), present-day cosmology is a dogma with a serie of gratuitous or quasi-gratuitous assumptions:

The non-theological assumption: speculations are not made which cannot, at least in principle, be compared with observational or experimental data, for tests.

The "good-luck" assumption: the portion of the Universe susceptible to observation is representative of the cosmos as a whole.

The "simplicity" assumption: 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 "non-circularity" assumption: 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.

The "fortunate epoch" assumption: we live in the first human epoch which posseses the technical means to tease out the crucial observations. This is also expressed by Narlikar (2001): 'there is one trait which the cosmologists of old seem to share with their modern counterparts, viz. their fond wish that the mystery of the nature of the universe would be solved in their lifetime.'

From this, Disney (2000) concludes:

> 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.

He also says in another part of his text, referring to the cosmologists who think that they can establish a cosmological model as securely as the Standard Model of elementary particles:

> 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 and an experimental science, and of the peculiar limitations of cosmology as a scientific discipline.

That is the extremely sceptical position of an astrophysicist with a long career who has made significant contributions to extragalactic astrophysics. We may interpret it as too daring, as an exagerated parody that is out of place in the present cosmological scene. Ćirković (2002) criticizes Disney (2000) saying that his claims are rethorical with no new ideas about the sociology/philosophy of science, and that his critique is unfair, biased and constrained in an extreme inductivism. Other disciplines operate in a similar way to cosmology and they are sciences, says Ćirković. But we could also pay attention to some of Disney's sentences and see that there is some background of truth in what he claims, in spite of the exaggeration.

4.2. Is a Science of Cosmology Possible?

I would say that before understanding the Universe, we must understand the pieces of the puzzle separately (galaxies, their formation, their evolution, whether they separate from each other, the origin of the elements, the origin of the CMBR) rather than assembling all of them into a happy idea that could convert astrophysics into a speculative science. There are however many cosmologists, philosophers and historians of science who think that cosmology became an empirical science beyond speculation after the discovery of the CMBR (e.g., Kragh, 2007b). As I have maintained throughout this paper, I do not agree with Kragh's (2007b) statement that cosmology is a proper science like nuclear physics, hydrodynamics, etc. Even if there are aspects which are comparable with observations, they are just a few partial aspects of the whole reality, whereas cosmology stands for a science of the whole Universe and its whole history, something for which we do not have all the empirical/observational information that we need to have to fill in the many gaps in that history that are so far questions of pure speculation and risky extrapolations.

Is cosmology comparable perhaps to palaeontology or a science which tries to reconstruct the facts from fossils (Ćirković, 2002)? No, I do not think it can be put on the same level of scientificity as palaeontology, because the objects of study in palaeontology are much more limited, and the geological and biological processes are known, whereas cosmologists play with elements for which there is no direct experience (dark..., dark..., new physics...), or they must adopt extrapolations and assumptions for which there is no evidence (the cosmological principle, the principle that the laws of physics do not change over time, etc.). This means that the process of choosing between standard and non-standard models in cosmology is less fair (less based on evidence) than in other scientific disciplines. In any case, there are also huge extrapolations involved in disciplines such as palaeogeography and palaeobiology. Certaily, one can doubt the different theories of different fields of science, but for different reasons. The very word "Universe" also merits some consideration: it means everything that exists or has existed, and we have access only to a small part of the observable cosmos (the "good luck" assumption given in the cosmologist's dogma by Disney, 2000). In this aspect, palaeontology is not so different from cosmology because it only has access to a small part of the observable universe.

As Kragh (2007b) remarks (as an argument considering cosmology as a science), Nobel prizes have been given to some cosmologists. In my opinion, this does not mean anything. Nobel prizes are just part of sociological structures. Recognition does not mean a higher value of some knowledge and its creators, but only higher status. *Indeed, there are many social and economic interests in declaring cosmology to be a solid science, there is a lot of money in the game, and this motivates the arrogance of the claim that we can know the whole Universe and its history.* Indeed, there are many social and economic interests in declaring cosmology to be a solid science, there is a lot of money in the game.

5. Conclusions

Alternative theories are not at present as competitive as the standard model in cosmology. If they were more developed, there is a possibility that they might compete in some aspects with the Big Bang theory, but efforts are made in the present-day scientific community to avoid their development. The fact that most cosmologists do not pay them any attention and only dedicate their research time to the standard model is to a great extent due to a sociological[13] phenomenon (the "snowball effect" or "groupthink"). Cosmology, knowledge of the Universe as a whole, shares some characteristics with other sciences, and there is some scientific content in it. However, in my assessment, cosmology is more affected than most other sciences by human factors (psychological, sociological, ideologies/culture, etc.).

Note that I am not defending any specific dogma here: neither the correctness nor the wrongness of Big Bang; neither am I defending constructivism or scientific realism (see discussion on these posisions, for instance, in Soler Gil, 2012). I am just presenting some sceptical arguments expressing certain doubts on the validity of the standard cosmology, and this requires seeing the problem from several points of view: in this paper I have talked more about the social aspects and the alternative models. Nonetheless, there are also reasons to support the standard model in a realist way.

There are limits to cosmology because we are finite human beings limited by our experiences and circumstances, not mini-gods able to read the mind of a god who played maths with the Universe, as some Pythagoreans may think. There is a lack of humility in Pythagoreanism, or in expressions like "precision Cosmology". One of the most reputed physicists of the former

[13]For further reading on my impressions about sociological aspects of science in general, see López Corredoira (2013b).

Soviet Union, Lev Lavidovich Landau (1908–1968), said: ‘Cosmologists are often in error, but never in doubt.’ Great old masters, even the creators of the standard model, were cautious in their assertions. Edwin P. Hubble (1889–1953) throughout his life doubted the reality of the expansion of the Universe. Willem de Sitter (1872-1934) claimed: ‘It should not be forgotten that all this talk about the universe involves a tremendous extrapolation, which is a very dangerous operation’ (de Sitter, 1931). This scepticism is sane since ‘all cautions are too little’ (Spanish proverb). It is not a question of substituting one model for another, since it would be the ‘same dog with a different collar’ (another Spanish proverb) but of realizing the limits of cosmology as a science.

Rutherford (1871–1937) said ‘Don’t let me hear anyone use the word ‘Universe’ in my department.’ In the same style, the astrophysicist Mike Disney (1937–) dared to claim: ‘The word ‘cosmologist’ should be expunged from the scientific dictionary and returned to the priesthood where it properly belongs’ (Disney, 2000). Those are the words of an old-style scepticism. Nowadays, the young bloods of precision cosmology do not care for such statements and proudly claim that people in the past did not know what they know. Cosmologists with no indication of doubt and an amazing sense of security who dissert on topics of high speculation. Of course, science advances, and cosmology advances in the amount of data and epicycle-like patches to the theory to make it fit the data, but the great questions remain almost unchanged. Many wise men have already deliberated on cosmology for a long time, without reaching a definitive solution. Do we live in a fortunate golden age of cosmology that allows us, thanks to our technical advances and our trained researchers, to answer questions on eternity, the finiteness of the Universe, etc.? We could reply as the 19th century German philosopher Schopenhauer did with the Know-alls of his time:

> Every 30 years, a new generation of talkative candid persons, ignorant of everything, want to devour summarily and hastily the results of human knowledge accumulated over centuries, and immediately they think themselves more skilful than the whole past.

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