Alternative Cosmologies

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1 Introduction

This is an survey of current and older alternatives of the standard cosmology. The purpose is to give a clear description of the weaknesses in the Standard Cosmology (hereafter called SC) and the alternatives contrived to overcome those weaknesses and the weaknesses in those theories. Some of them are a bit outdated, but nevertheless still applicable or simply still to complex to throw away because observation techniques aren't good enough yet.
This overview is propably not complete because it is sometimes hard to distinguish real alternative cosmologies from the standard cosmology or they are more theoretical models of which observations haven't been able to see anything of. Still it has been tried to give as many of the best alternatives as was possible, sometimes just as an interesting idea to consider in cosmology.
The widest discussed theory is that of the Quasi-Steady State Cosmology (hereafter called QSSC). The reason for that is that it is the most investigated theory of the last decade, so there are many recent articles available, and that it is hard to find enough good articles of the other theories, sometimes because they weren't locally available. Another reason is that there was a limited time for this report which prohibited a real thorough research of the other theories and that some of them were simply too difficult for me to comprehend yet. That may be a reason that some theories are treated only superficially, although there are quite some articles available. It is hard to give a clear description of a theory and its main features and differences with the SC when mainly the physical and mathematical properties are discussed, a frequent problem I was confronted with when trying to make sense of an article.
The last thing that has to be said is that the SC has been accepted so generally among scientists as the common cosmology that alternatives are often not even considered. The reason for that is that in the past the alternative models became less and less persuasive and that a lot of alternatives were (assumed to be) ruled out by observational tests. Scientists weren't motivated to research something which had a good chance to be a dead end. The research of alternative cosmologies is quite small and most times limited to a small group of people, so that that research is far behind to the level the standard cosmology has been researched. This way they have to concentrate on the fundamental theory and do their research mainly on the weaknesses of the SC to make their theory more accepted.

2 Standard Cosmology

2.1 Successes of SC

The SC is presumed to be known, so there is no need to repeat its fundamental principles and theories, because they will already be partially mentioned while discussing the successes, the weaknesses and the alternatives. Besides that, the SC is already so large and complex that treating all subjects discussed in the alternative cosmologies would double the size of this report and that is not the intention. The main problem of every theory of cosmology is the difficulty to reproduce the theory on laboratory scale. Is it a flaw in the model or are there other sources of energies or such that can't be seen on laboratory scales?
Nevertheless the SC has succeeded to become the best theory. It made a lot of predictions that have been verified. Some of these are:

- Around T $\approx$ (few) MeV, nucleosynthesis takes place in SC, leading to the production of light elements. The helium abundance, which depends crucially on Ω_B (baryon), constrains the number of neutrino species to three, which has been verified. Their observed values give the limits to the size of Ω_B.

- The hot, radiation dominated phase in the early universe causes a Cosmic Background Radiation (hereafter called CMBR) with a Planck spectrum in the present-day universe. Every alternative model produces it from physical processes, as an afterthought.

- In the Sc, the universe is dominated by Ω_B, Ω_{DM} (dark matter), Ω_Λ (cosmological constant) during $z << 10^3$ and as such a host of indirect cosmological measurements constrain these parameters. For example, (a) the number counts of galaxies, (b) the age of the universe, (c) statistical distribution of gravitationally lensed quasar, all depend on these four cosmological parameters in a different matter. There is no a priori reason for any range of values for these parameters to be constistent with these observations. However, that is indeed the case.

- Structure formation in SC proceeds through the evolution of initial homogeneities via gravitational clustering. For this small anisotropies are necessary in the CMBR, which have been found.

2.2 Weaknesses of SC

This is the part which is most important, because they are partially the cause for the existence of alternative theories. The SC had its origin in the Einstein equations, which changed the view on the universe and wiped out all other theories of cosmology until that time. All new cosmologies were (in some way) built from these equations, out of which the SC came victorious. But also the SC turned out to be not perfect. The imperfections were the reason to find a theory that could explain certain phenomena where the SC wasn't capable to explain it.

Although the success and standard acceptation of SC, there are a quite some weaknesses in it, but that is partially not surprising since the theory is much further developed than its alternatives.

SC is thought to have a zero beginning, but it requires three density parameters for baryons, nonbaryonic dark matter and the cosmological constant, that are all of comparable value at the current epoch. This requires extreme fine-tuning of parameters, for which, until today, we have had no good reasons. The constraints on Ω_Λ, Ω_B and Ω_R are:

- The cosmological constant is called a help-factor to make the theory, because of observations, fit. The constant originates as a vacuum transition effect in the early universe, but for that there is no real evidence that it really exist, except as an correction factor.

- The explanation of light nuclear abundances does not account for those of D, He, Li, Be and B. They play a major factor in the limits of the baryon density. To predict them right the SC needs to use very much nonbaryonic dark matter; dark matter that can't be observed or explained. It is of cource not a good thing to include much unexplained parts to make your theory work, although it could be a justifiable explanation.

- Although the SC predicts as only theory that there should be a cosmic microwave background, it isn't capable to predict it's present temperature. It assumed as a given quantity.

These objections to the SC are related to the fact that their numerical values are not determined by a more fundamental principle and need to be fine-tuned in an ad hoc manner.

Other weaknesses are:

- The big bang model offers a universe created in a smooth featureless condition, out of which a highly structured universe is nevertheless supposed to have evolved.
  This finds its origin in the theoretical formulation of the SC, which has internal inconsistency. It is derived form Einstein's field equations, which predict the big bang singularity for reasonable equations of state. The action principle, as well as the local conservation laws, break down at the singularity. The Big Bang is a mythical "creation event", before that there was nothing. Can we really believe in nothing turning to something out of the blue? Where did all that energy for the rapid expansion of the universe and the forming of galaxies and such come from? The current techniques aren't capable to look that far in time to verify it.

The only evidence is the CMBR, but the existence of that background radiation can also be explained by other physical processes in alternative cosmologies. The main difference is that in SC the CMBR comes first, before galaxies exist, whether in the alternatives it comes after the formation of galaxies.

- Inflationary models, that have been created to explain why the universe looks so flat, are not capable of uniquely predicting the initial fluctuations, contrary to claims often made in literature. It is an explanation, but not 100 percent applicable.

- The absence of a workable theory of galaxy formation. The standard approach in the formation of large scale structures consists in starting with prescribed primordial fluctiations of space-time geometry and matter density, evolving them through an inflationary era, having them interact with non-baryonic dark matter and making simulations. It has been built of two already weak parts of SC, so the model isn't very solid either.

- The SC does not explain the phenomena of big outpourings of matter and energy from compact regions, like the QSOs, AGN and radio sources.

An other problem is the photon to baryon ratio. A strange issue is why the density of matter is so close to the critical value separating recollapsing universes from ever-expanding universes.

There are two features of SC that are disturbing and disfavor its continuing research.

- Repeatedly there are added new factors, statements and help-parameters to make the models work. The theory gets more and more elements that can't be explained in a just way. They are used to correct deviations and have to be verified after it. New deviations are found and again explained by new involved factors.

- The need to find certain results causes the neglection of better (but not nice) results or continuing adjustment (ultrafine-tuning) of parameters, like the cosmological constant. This is no the way real research is done, because if the results are not what you expected, you should look what it causes it and not try to change the parameters to make the result the way you want it. That is sometimes what it looks like, although it may not be everytime the case.

2.3 Decisive tests for SC

There are still fundamental factors in the SC that are still not known good enough. Observational results may decide wether the SC theory holds or not, or will lose credibility.

- Non-baryonic matter is still not well defined and unfound to really in such extend that it can exist with suffiecient abundance in the universe to complete the theory.

- The limits of the values of Ω_0 and h in the SC will become smaller in the future. They will decide in which matter the SC will hold on in its boundaries, in such a way that they could become contradictionary to the theory.
  The pattern of microwave background radiation anisotropies has a definite prediction in SC. If it stands the test the SC will become stronger, else weaker. If we find a faint population of galaxies that shows blueshifts, the SC can't be sustained.

- The discovery of very old stars and galaxies, too old to be explained in any fashion within the SC. Already there have been found ages of globular clusters that lie just outside the present limits of the age of the universe according to SC.

- If the amount of baryonic matter becomes too high, the SC stands disproved, because it is strongly limited in its amount.

- If a systematic population of distant objects is found with blueshifted spectra, it signals a contracting phase whereas the SC predicts expansions during the entire redshift range of $0 < z < 10^3$.

3 Quasi-Steady State Cosmology

3.1 The theory of the QSSC

The QSSC was developed in the nineties from older theories, originally as only steady state cosmology by Bondi & Gold (1948) and Hoyle (1948). This theory said that physical conditions at any epoch t are the same. This came from the viewpoint that we use to check the cosmological principle by looking at distant parts of the universe, when we are actually looking in the past. As the universe expands, there is creation of matter to keep the density constant. The cosmology thus has no singular epoch and no hot past. Research in the next decades had no breakthru succes and the theory was abandoned, but returned in the nineties in a new revived form as the Quasi-Steady State Cosmology.

It is based on the Machian theory of gravitation, first proposed by Hoyle & Narlikar (1964, 1966). It has the premise that the inertial mass of any particle is determined by the surrounding universe. It permits broken particle world lines: creation and destruction of matter, which is represented in the Einstein field equations as the scalar C-field. The models are driven by the creation process, that doesn't occur uniformly everywhere, but preferentially near massive objects collapsed close to the state of a black hole. The gravitational field becomes then high enough to reach the creation process through Planck particles that decay rapidly. The creation of matter creates the C-field, this rises and makes space expand rapidly locally (like inflation), thus causes an explosion of matter and energy. These minicreation events (MCE) are represented by quasars, active galactic nuclei, etc.. After a period of activity the C-field becomes to weak to continue MCE, it slows down expansion, even leading to local contraction and so to build-up of the C-field strength.

Thus the activity period of the MCE oscillates in time: there are periods of high activity and expansion and periods of "sleep" in which expansion slows down. The oscillation period, based on the maximum redshift, takes about 4.4×10^{10} years and there have to be at least 20 cycles to make the theory work. In the present we live in the sleep stage to explain the current activity. It may be even so that we live in a "bubble" universe, to devide the active parts from the sleeping parts. The QSSC has a built in negative Λ_0, the magnitude of which can be related to its Machian scale invariant origin. It is necessary to be negative to make the theory work.

Like said before only SC predicts the CMBR. So QSSC has to explain its presence in another way than by the big bang. The QSSC explains the CMBR through the thermalization of starlight. Because there is no actual beginning of the universe there is no lack of metals. Due to supernovae over time a lot of metallic whisker(needle)-like particles are ejected, whose thermalized radiation over several cycles will be smoothly distributed over the universe (as intergalactic dust). They radiate only at microwave wavelengths, without blacking out the extragalactic radio and optical universe. The possible existence of these whiskers have already been verified in laboratory tests and there is strong indication that they also exist in the universe.

Preliminary work on the structure formation has shown that the pattern of filaments and voids for clusters can be generated by mini-creation events.

3.2 Successes of the QSSC

The successes of the QSSC are that they are capable to give a better explanation for certain observations than the SC. They are the reason that the research of this alternative cosmology still continues.

- The explanation of the CMBR by the thermalization of starlight makes it possible to calculate a value of its temperature, because over each cycle the energy density will drop to a minimum value. Calculation of the present-day value gives a temperature of ~ 2.7 K, which corresponds quite good with the actual value. So the QSSC is able to give a good explanation for the CMBR and for its temperature, for which the latter the SC isn't capable to solve.

- Without its age limit the QSSC is capable to explain the observed abundances of the light nuclei from D, He, Li, Be and B. The SC has to explain them from other (non-baryonic dark matter) sources than from stellar origins, but the QSSC has sufficient stars created over time to explain the complete abundance by stellar production, which lowers the amount of non-baryonic matter a lot. Baryonic matter is more than sufficient available because in this cosmology it exists also in the form of low-mass stars, old burnt-out stars, white dwarfs from the previous cycles and this is expected to be non-luminous, thanks to a much greater age of the universe. The QSSC does not need non-baryonic to make the theory fit.

- The QSSC gives a better fit on the redshift-magnitude relation than SC models. The same counts for the angular size redshift on ultracompact radio sources and in getting the observed features on the numbercount curve, without ad hoc evolutionary functions, with a mixed population of strong and weak radio sources in the QSSC. In these researches the QSSC gives the right results without having to fit in extras to make it right like the SC has to do.

- The creation processes taking place in regions of high density in galaxies can explain in an natural way the explosive phenomena in galaxies and QSOs which have been the subject of much discussion for many decades.

All these successes suggest that the QSSC deserves more critical attention than it has so far received.

3.3 Weaknesses of the QSSC

The are no technical reasons that the QSSC is wrong, but it does appear to be vulnerable on some counts:

- The fundamental idea of matter creation is as yet ill defined and ad hoc. The existence of the C-field is still untested in the lab and this is necessary to avoid the occurrence of singularities. The phenomena of the creation of particles with Planck energies that decay in Planck timescales and yet uses the concept of broken world lines to describe the primary creation events.

- The negative energy field (the C-field) induces a fundamental instability in quantum theory. No models haven been made yet in which the process works.

- The SC can make a clear and testable prediction regarding the spectral and angular distortions of CMBR, for which the QSSC can't account for as yet, but these haven't been found in the present, so on that there is no actual problem yet.

- The QSSC lacks predictive power like the SC does. To achieve credibility, the QSSC, for example, should make predictions of anisotropies at smaller angular scales (in the CMBR temperature) before observations become available. Until now it only explains, which leaves other possibilities open.

- The fundamental theory of QSSC is still far behind in development to the SC. The SC has been worked out in such a far extend that it is difficult to make it superior. The theory works, but not in such a fashion that it really is better than SC.

3.4 Decisive tests of the QSSC

As is the case for SC, there are also decisive tests in future research that will determine success or failure of the theory. Unsurprisingly, some are related with SC, but than in the opposite way.

- The discovery of epochs of ultra hight redshifts. These only account for the present cycle and have its limit at $z > 30$. The SC does have higher redshifts, but has other explanations for it.

- The detection of very old stars will sustain the QSSC, but if none are found it will not.

- Finding evidence that metallic whiskers are created by supernovae.

- Finding evidence for explosive events (the MCE). This can be done by the detection of gravitational waves by MCE. It is stated that in the present we are in a sleep stage, but that there really occurs an active stage hasn't been discovered.

- The QSSC predicts the existence of blueshifted spectra from a fraction of the radio sources, but it does not prove the theory. Nevertheless it does will become superior to the SC.

- The finding of baryonic matter well above the limit tolerated by the big bang limit.

4 Large Number Hypothesis (Dirac Cosmology)

In 1937 Dirac drew attention to the existence of large numbers relating constants/parameters of microphysics and cosmology. He found a coincidence with known values and worked it out in the Large Number Hypothesis (herafter called LNH). He thought those numbers reflected the intrinsic properties of nature and that some of them changed with time until their present-day value. This, of course, could be simple coincidence, but it could also be not. If the theory is true, it will have large consequences. Because the numbers aren't always similar to the numbers in SC, it questions its liability.

Those macroscopic quantities which had a definition of time may vary. The macroscopic quantity G should in this way varies with t^{-1}. Another consequence was that the number of particles in the universe increases with time. To solve that Dirac postulated the creation of particles, either additively (in proportion to the spatial volume) or multiplicatively (in proportion to the existing mass in the region). The LNH +additive creation is not inconsistent with observation and stellar evolutionary theories.

Dirac introduced a (electromagnetic) atomic metric, which describes atomic physics, besides the (gravitational) Einstein metric, to fit in the theory with the varying macroscopic quantities, because the Einstein equations were constructed so as to ensure energy conservation by having G strictly constant. The atomic metric is a modification of the Einstein equations.

The CMBR is not only consistent with the LNH, but also indispensable in predicting the scale factor $R(t)$ and the curvature k. The results indicate an open universe with $k = 0$ without having to resort to an m versus z relation, or to any other of the classical cosmological tests. It has to be remarked that the verification of the CMBR has been done in a correlation with photon en nucleon ratios and how they develop. It is fitted to the right temperature and seems to be verified by playing with numbers. Such a computation is of course not very solid, but the LNH leaves it open to use it in that way.

The LNH is also capable to predict a value for the deceleration parameter that is not in conflict with observations. An immediate cosmological consequence of the LNH is that the universe can't be oscillating. It predicts an open universe with a uniform expansion. However, a static universe cannot be rejected.

The LNH is not capable to give good predictions for the luminosities of white dwarfs. Other weaknesses are that it is questionable how many large numbers can be used to be important as fundamental numbers and the LNH can only be used for the present-day. There is no dynamical set of gravitational equations upon which the large numbers can be imposed as boundary conditions.

Observations in the solar system and of pulsar have placed upper limits on the variation of G, which are so small that the LNH prediction is made untenable. Nevertheless the issue of the large dimensionless numbers is still intriguing and something to be considered in the future when more is known.

5 Chronometric Cosmology

The chronometric cosmology (hereafter called CC), proposed by Segal in 1976, involves two time systems, one 'local' and the other 'global'. Globally the cosmos is a spacetime. Locally the time coordinate is Minkowskian and different from the global time. Cosmological observations, like the measurement of the redshift of a distant galaxy can be different in the two systems. This way observations have to be recalculated to the Minkowskian system. For example the redshift-distance formula in this cosmology is quadratic rather than linear, but on this there is no certainty.

The theory is based on considerations of symmetry and on the group theoretical properties of Maxwell's equations. It is developed from general physical principles of causality, cosmic uniformity, and quantum phenomenology. The Einstein energy is the driving energy of the universe, while the Minkowski energy is the locally observed energy. The redshift is correspondingly the excess of the Einstein over the Minkowski energy. CC is devoid of adjustable cosmological parameters, luminosity, or density evolution, implies conservation of the Einstein (but not the Minkowski - they cannot both) energy, and predicts that remnant radiation will be in an isotropic Plank-law state. It is basically an adaptation of principles expressed by Mach, Einstein and Minkowski to the formulation of a non-Doppler, temporally homogeneous, "essential static" model

for the redshift.
The universe is closed and nonsingular and the microwave background is explained by thermalized starlight that circulates round and round until an equilibrium is reached.
CC provides an efficient basis for objective and model-independent estimation of important astrophysical parameters. These include the cosmic distance scale R, the motions of the Galaxy and the CMBR relative to the cosmic inertial frame represented by the Einstein universe, and the multi-wave band luminosity functions of objectivily specified populations of extragalactic sources. Instead of one big bang, CC has a stochastic sequence of mini-bangs, associated with, for example, the formation of galaxy clusters.
The theory has advantages to the SC. For example, many large-redshift quasars have extraordinary luminosities. The SC (especially the Friedman-Lemaitre cosmology) provides a description of these phenomena as a part of evolution, but gives no real explanation. They introduce several adjustable functions as q_0 and Λ. The CC provides an immediately quantitative explanation without these or any kind of evolution. Magnitudes will become fainter with increasing redshift considerably more slowly than in SC. The cutoff in quasar numbers a higher redshifts is an immediate prediction from CC, in contrast to its puzzling character in Friedman-Lemaitre cosmology.
One of the questions is however, if the age of the universe is infinite, should then not all processes have reached equilibrium?

6 The Brans-Dicke Theory

The theory of Brans and Dicke (1961) is one of the Machian cosmologies, based on Mach's Principle, which says that the acceleration of particles can only be measured relative to other matter in the universe, the existence of inertia for a particle must depend on the existence of other matter. The inertial mass of a particle should depend upon the distribution of matter about it, and therefore should be a function of space-time position.
The theory differs from general relativity in it's description of the early universe. In the recent epochs there is no difference between general relativity and the Brans-Dicke theory.
Like in the LNH there is a second version of the Brans-Dicke theory that uses a varying G (or active gravitational masses) with position, in which it behaves as a scalar field, which has the primary function to determine the local value of the gravitational constant. Another version, with constant G, considers the case of varying particle masses.
Using these concepts different cosmologies are possible. The theory is still alive, but there is not much progress in its development. The idea seemed to solve the graceful exit problem of the original inflationary model but ran into trouble because the distortions it produced in the cosmic microwave background were directly contradicted by the observations.

7 Hoyle-Narlikar Cosmology

This is also a G-varying cosmology, using also Machian theory of gravity, but it's more strongly rooted in it than any other theory. It is based on a conformally invariant action principle and its form can be uniquely deduced from considerations of symmetry. It is consistent with the cosmological observations like the Hubble relation, source counts, angular sizes and gammy ray background.
I have the idea that this theory was implemented by Hoyle and Narlikar in the steady state cosmology to make the QSSC, because in some of the QSSC articles there is refered to the original articles, although nowhere is explicitly mentioned that the theory was used. I was not able to see which elements had been used, although the varying G seems to be gone, partially because the articles I had about the theory did not show its theory better than I have been able to describe. Besides that is the fact the QSSC arose not long after the last news of the Hoyle-Narlikar cosmology.

8 Universes with rotation and shear

This theory, proposed by Kurt Gödel in 1949, suggests the idea of a spinning universe, within the framework of general relativity, largely to demonstrate the "antiMachian" result that in such a universe the distant parts (made of stars, galaxies, etc.) rotate with respect to the local inertial frame. In Friedman-Lemaitre-Robertson-Walker models the universe is isotropic and spatially homogeneous, so their shear, vorticity and acceleration are all zero. Later research used the equation of Raychaudhuri (1955) in which the shear and spin of the universe are included. It was however impossible to avoid the singularity, which was a fundamental part of general relativity. Later anisotropic models were used with large-scale observations, but they were very limited. Any rotation would be extremely small a thus very hard to detect. The existence of such a small rotation, when taken in consideration during the early stages of the universe , would play a prominent role in the dynamics of the universe as well as in the processes that involve the formation of galaxies and other cosmological objects. Although Gödel didn't found an exact cosmological solution of the Einstein equations for rotating matter, Kerr found an exterior solution that may represent the field of a rotating fluid mass. The slowly rotating perfect fluid solutions can serve as mathematical models for neutron stars.

The difficulty in this theory is to actually find the rotation when there is no frame to look at the universe from the outside, in other words: relative to what is the cosmos rotating? Nevertheless, if there is rotation, how small it may be, it should effect its interior due to centrifugal forces. It could have been larger during the big bang phase and been slowing down ever since. Through inflation it could be that there are regions have died away and is still significant in other regions. In that case it could be so that we ourselves live in a region with negligible rotation.

9 The Static Spherically Symmetric (SSS) Universe

In this theory by Ellis, Maartens and Nel (1978), the homogeneity assumption of the SC is dropped, because this assumption is made rather on philosophical than observational ground. The present observations can also be explained by a static spherically-symmetric universe model with two centres, and our Galaxy near one of its centres. The systematic redshifts of galaxies are interpreted as cosmological gravitational redshifts, while the CMBR originates from a hot gas surrounding a singularity situated at the second centre of the universe, that is non-expanding.

Assumed is that space-time is filled by a family (a 'congruence') of world lines representing the average motion of matter at each point, and the universe is precisely isotropic about some particular observer.

The second centre could be the source of the matter and radiation in the universe, absorbing and emitting radiation and matter, controlling the boundary conditions for differential equations. All past radial null geodesics intersect it, whereas in the Friedmann-Robertson-Walker case, all past directed time-like geodesics intersect it. So the universe is spatially finite and bounded. There could take place a continual circulation of matter from one to the other singularity, breaking apart and forming in an continual process. The big difference with the singularity of the big bang is that that is inaccessibly in the past, while in this universe it is still there, and it has continuous interaction with the universe. The redshifts might correspond to rather different distance scales than in the FRW case.

The problem of this theory is that it is difficult to find a viable cosmological model of this kind. For example, there is lack of pressure and the model cannot be made almost static near the singularity. The theory may not be completely true, but there is still a possibility that there are inhomogeneous spherically-symmetric universe models which are expanding, but retain some of the interesting features of the SSS universe models.

10 Matter-Antimatter Cosmologies

This are models which are based on the assumption that the universe contains as much anti-matter as matter. This follows from relativistic quantum mechanics. According to SC there is in the present-day more matter than anti-matter. For that the antiparticles had to be annihilated by particles at the big bang and the annihilation radiation is cause of the current CMBR. This means that the symmetry is violated at the origin of the universe.

10.1 The cosmological model of Alfven and Klein

During the 1950s and 1960s Alfven and Klein created the Matter-Antimatter Symmetric Cosmology. The idea of a baryon symmetric universe was resurrected in the modern framework of grand unified theories. In the initial state the universe is taken

to be a thin, very low density plasma which is homogeneous. Its volume is larger than that of the observable universe. It is assumed that the initial temperature is non-zero and that a magnetic field is present. The first is necessary to cause matter-antimatter collisions, and the second to provide a mechanism for the separation of matter from antimatter. The sphere collapses under its own gravity, and as the density increases the annihilation rate goes up. The ensuing radiation exerts a pressure opposing gravity and turn the collapse into an expansion.
Future tests come from the gamma ray background spectrum and the cosmic neutrino background.

10.2 Baryon Symmetric Big Bang Cosmology

This theory was developed by Omnes and others. He considers a big bang model which is initially at a very high temperature and density. Bosons and fermion-pairs exist in thermodynamic equilibrium with photons at the black body radiation field. When equilibrium exists the number of baryon-antibaryon pairs in the universe is the same as the number of photons. In present-day that number is smaller. An explanation could be that there was a small excess of baryons over antibaryons or that the universe is symmetric in particles and antiparticles and there occurs a seperation at high temperature energies. On this last explanation a theory was developed.
Others have shown that in one of Omnes' models no nucleosynthesis can take place at all. The radiation emitted in the annihilation of matter and antimatter in this cosmology would cause distortion of the microwave background spectrum.

11 Other alternative cosmologies

11.1 The Kinematic Relativity of E. A. Milne

The aim of E. A. Milne's kinematic relativity proposed in 1935 was to deduce as much as possible about the structure of the universe merely from a cosmological principle and the basic properties of space and time and the propagation of light. In this way it looks like the steady state cosmology, but kinematic relativity covers not only cosmology but a great part of theoretical physics as well. In order to define and apply a cosmological principle, it is necessary to identify a set of fundamental observers, located on "fundamental particles", for whom the principle will be valid. The system of fundamental particles plays the part of a imaginary homogeneous background against which the inhomogeneities and the random motions, which lead, for instance, to the formation of galaxies, have to be considered. It is assumed that each observer can caussally order local events, and label them with real numbers (like clocks). This way there are infinitely many time scales available. Kinematic relativity leads to new theories of photon and electromagnetic fields and even supplies a new basis for atomic and nuclear theory.

11.2 Einstein-Cartan Cosmologies

In the Einstein-Cartan gravitation theory, the influence of the intrinsic spin of matter on space-time geometry is considered. This happens in microscopic situations where it does have effect. This is done in the Einstein-Cartan-Kibble-Sciama theory by making the affine connection asymmetric and relating its antisymmetric part to the spin of the momentum tensor. In the theory spinless free massive particles move along timelike geodesics and photons along null geodesics.

11.3 The Anthropic Principle of Wheeler and Carter

Our very existence as observers in the universe is not accidental and must relate (or reflect) a set of circumstances of a special nature. This was called the anthropic principle. An example is that the age of the universe is also related to the time our sun needed to be developed, to form planets and life, which created the observer. Carter related the formation of planets to the existence of convective stars on the main sequence (sun-like stars). These stars had no enough energy and formed a planetary disk. If the fine structure constant or the gravitational constant would have been different, the main sequence would not have any convective stars at all, and thus no planets and life.

12 Conclusions

With these various alternative cosmologies it is clear that was is called the Standard Cosmology is merely one road taken a long way. The other theories show still enough liability or interesting viewpoints toward SC. The most important weakness of all alternatives is the shortage of continuing research. Their arrear on SC has become so large that it would almost seem that few would want to rebuild the complete cosmology on an alternative of which it is not certain if it still will appear to be wrong. This makes it hard for the reseachers to get their theory more widely developed, in other directions than just trying to compete with SC. In the time they need to improve their theory, the SC is able to create more and more corrections and justifications on the theory to keep it on working, what is one of its major weaknesses. But the large distance in research between the SC and the alternatives could cause this too, because the alternatives still work on clear fundamental and primairy theory, while the SC theory is much further developed. The same contamination could arise when the alternatives reach the same level as the SC. Some alternative cosmologies look at each other and sometimes try to implement useful components in their own theory. For each alternative looks at the universe in a different but applicable way and as long as the theory hasn't been proven to be (completely) wrong, it can help improve your own theory. This is, of course, a part of the problem of the SC: the ignorance of alternatives, even if it could be fitted in its own theory, something where the alternative theories have no problem with. The theories which have the strongest chance of survival and making it to the be the real Standard Cosmology are Quasi-Steady State Cosmology, the Chronometric Cosmology and the Hoyle-Narlikar theory, of which the latter I suspect to be implemented in the QSSC to make it stronger. Still it is, of itself, a strong theory. The CC is the furtest away as a theory from what we are used to know, but like the QSSC its research is still continued and holding on.

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