CHAPTER VI

THEORIES OF COSMOLOGY

ALTERNATIVE COSMOLOGIES

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ABSTRACT. This review highlights some of the cosmological theories proposed as alternatives to the standard hot big bang model. Specific ideas discussed here are the matter - antimatter symmetric cosmologies, the empirical two-component model, the G-varying cosmologies, the chronometric cosmology and a simplified quantum cosmology. It is argued that many alternative cosmologies have contributed useful concepts and offered observational tests that have enriched the field of cosmology as a science.

1. INTRODUCTION

Speaking at the Vatican Conference of 1970, Fred Hoyle [1] made the following comment on the state of physics and cosmology:

"I think it is very unlikely that a creature evolving on this planet, the human being, is likely to possess a brain that is fully capable of understanding physics in its totality. I think this is inherently improbable in the first place, but, even if it should be so, it is surely wildly improbable that this situation should just have been reached in the year 1970."

Hoyle's reposte was meant as a caution against the categorical claims made at the time about the state of the universe and the knowledge of physics they were based on. The details of the 1970 - argument are not important; but even in the relatively short span of a decade and a half Hoyle's caution has been vindicated. The attempts at unification of fundamental forces and their implications for the structure of the universe, the discovery of superclusters, strings and voids, the possible implication of dark matter for galaxy formation, etc. are fresh inputs into cosmology that did not exist in 1970. By a similar token one may question the finality of many of the statements that are being made today, at this conference and elsewhere.

Alternative cosmologies describe attempts to understand the universe through theories and models other than the standard one. The motivation for exploring alternatives comes from Hoyle's cautionary remark just mentioned, against putting all one's eggs in one basket. Even amongst the believers in the standard picture all except the hard

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core would be willing to admit that the picture has still a number of difficulties and enigmas to resolve, although they may attach varying degrees of significance to them in a purely subjective judgment. To name a few examples: the problem of singular origin, flatness and horizon, the photon to baryon ratio, the absence of a workable theory of galaxy formation, the apparent mismatch of the age of the universe vis-a-vis the ages of its constituents, the large dimensionless ratios of physical constants, etc. So the need for exploring alternatives is justified.

There is another motivation for exploring alternatives to a standard theory. The conflicting predictions of two rival theories act as a greater stimulus to the observer than the predictions of just the standard theory. Cosmology as a science stands to gain considerably from such an exercise, whatever its outcome.

Here I shall review a few alternative cosmologies. To fix ideas I have taken standard cosmology to mean relativistic models with a hot big bang beginning, followed at some early stage by an inflationary stage of transient duration, followed by a near $\Omega = 1$ Friedmann model. Is all this really well established? Judging by the output of literature on the early universe it seems to me that workers in the field have made up their minds that whatever its drawbacks inflation did occur; it only remains to decide when, how and for how long. Likewise, the proponents of hidden mass subconsciously assume that the unseen component must be so much as to make $\Omega = 1$.

Limitations of time and space necessarily make this presentation sketchy. For details see references [2, 3]. Although my main brief is to highlight theoretical ideas, I cannot do so without referring to some relevant observations. I shall proceed in what I consider to be an increasingly radical order of departure from standard cosmology.

2. MATTER-ANTIMATTER SYMMETRIC COSMOLOGY

During the 1950s and 1960s Alfven and Klein produced cosmological models with perfect symmetry between matter and antimatter [4, 5]. The baryon symmetric plasma was supposed to have been separated by hydromagnetic processes in the early universe. In reference [2] a detailed discussion of these models is given.

The idea of a baryon symmetric universe was resurrected in the modern framework of grand unified theories. In standard cosmology CP violation in GUTs is used to generate a net baryon number. The intention behind the gymnastics is to produce a photon to baryon number ratio in the range $10^8 - 10^{12}$ where it remained essentially frozen to this day.

However, as argued by Stecker and his colleagues [see for example, Ref. 6] spontaneous soft CP violation within the context of specific GUTs based on SU(5) and SO(10) gauge groups, leads to the universe breaking into domains of predominantly matter separating domains predominantly made of antimatter. In other words, on a sufficiently large scale containing several domains the universe has no net baryon number.

For details of these theories see [7]. Since photons on which most astronomy is based treat matter and antimatter alike it is not easy (except for 'local' observations within the Galaxy or possibly the Local group) to say what the overall composition of the universe is like. Steckar [7] reviews indirect evidence in the form of the gamma ray background spectrum over ~0.5 - 200MeV as well as the antimatter composition of cosmic rays to make a case for the baryon symmetric universe. Future more direct tests of the theory may come from observations of the cosmic neutrino background by underwater detectors.

3. THE STEADY STATE THEORY

From its inception in 1948 till the mid-sixties the steady state cosmology had provided a competing alternative to the big bang. Here I shall be concerned more with Hoyle's approach using field theory [8] than with the deductive approach of Bondi and Gold [9] using the perfect cosmological principle. Contrary to the generally held view (even by professional physicists and astronomers), the steady state theory in Hoyle's version does not violate the law of conservation of matter and energy. This can be seen almost straight away in the C-field version outlined by Maurice Pryce [private communication, but see Ref. 10] where the entire theory is derived from an action principle and therefore, by Noether's theorem, obeys the conservation laws.

The C-field appears as an extra scalar field on the right hand side of Einstein's equations. Thus while matter may be created continuously, the total energy and momentum of all physical quantities stays conserved. The C-field itself has to modes. In the creative mode there is an exchange of energy between it and other fields leading to matter creation. In the noncreative mode, the universal expansion simply dilutes the intensity of the C-field and there is no matter creation.

The unusual feature of this version of the steady state theory lay in the fact that the C-field has negative energy and negative stresses. In a somewhat different theoretical framework proposed by McCrea [11] in 1951, the steady state expansion was achieved by intrinsic negative stresses in the cosmological medium.

Although these concepts were considered of doubtful validity by the theoreticians of the 1950s and the 1960s, they have become respectable in the 1980s. In the typical inflationary scenario the same de Sitter expansion of the steady state theory is achieved by negative stresses in the vacuum, produced by a phase transition. Moreover, the idea of 'cosmic baldness' in which the de Sitter expansion wipes away relic inhomogeneities in the inflationary model is strongly reminiscent of the same concept in the steady state theory [10].

Although the perfect cosmological principle strait-jacketed the universe in a steady format, the C-field version permitted radical departures from it. In the bubble universe version [12] the presently observable universe was seen as a tiny fraction of a large super-dense steady state universe. While the creation of matter was supposed to go on steadily in the latter, the former arose as a phase transition in which the C-field switched to the non-creative mode. Again, this concept of a Friedmann-like bubble in a de Sitter spacetime bears a striking similarity to the inflationary models of today. [for a detailed comparison see Ref. 13].

The particle physicists were unhappy with the steady state model because it implied nonconservation of baryons. That objection need not hold today since the baryon number is no longer believed to be a conserved quantity in the wider framework of grand unified theories. It is worth mentioning that probably the first application of a result from particle physics to astrophysics and cosmology is found in the 'hot universe' model of Gold and Hoyle [14]. Here the created matter was in the form of neutrons. The creation of a neutron and its subsequent decay generating high kinetic temperature led naturally to the idea of superclusters of galaxies. Superclustering on a scale of 30-100 Mpc was not viewed with favour by astronomers three decades ago: it is now taken as an accepted feature of the observable universe.

It is evident therefore that the steady state model generated a number of ideas that were considered too radical at the time they were proposed but which have subsequently found their way in the standard scenario in different contexts. The main observational difficulty that the steady state model faced came, however, from the microwave background radiation. The simplest and historically anticipated [15, 16] interpretation of this radiation is as the relic of a hot dense primordial epoch in standard cosmology. This interpretation could not be invoked in the steady state model except in its bubble version.

Is an alternative interpretation possible for this radiation? On this question hangs the fate of not only the steady state cosmology but also of any other cosmology that does away with a hot dense epoch. Attempts in the past [17 - 20] based on thermalization of excess stellar radiation by dust grains in intergalactic space have only partially succeeded in providing an alternative to the relic picture. In favour of these attempts is the result that the starlight generated by making all the observed helium in stars or very massive objects would have energy density comparable to that found in the microwave background [17]. The detailed theory producing the correct spectrum and isotropy still eludes us, however. This may be partly due to our imperfect understanding of the intergalactic medium. We should also remember that even in the standard picture, isotropy of the microwave background presents a problem.

4. AN EMPIRICAL APPROACH

The standard picture implies an evolving universe. Evolution is of two kinds: (i) the change in the large scale geometry and the overall physical characteristics of the universe and (ii) the change in the physical properties of populations of discrete objects with the cosmic time. What evidence do we have for evolution of either kind?

Except for the relic interpretation of the microwave background, our studies of the universe take us to redshifts of $z \lesssim 4$, if the QSOs are at cosmological distances and to $z \lesssim 2$, if we consider only galaxies.

Attempts to detect non-Euclidean geometrical effects of the first kind by observations of discrete objects have always been foiled by their mixing up with effects of the second kind. Moreover, the apparently Euclidean effects seen in the log N - log S test and the θ - z test for radio sources have been interpreted as a combination of both kinds of evolution.

Burbidge and this author [21] therefore considered in 1980 an empirical approach to cosmology wherein the universe was considered as a two-tiered system. The larger structure (length scale $\sim 2 \times 10^{30}$ cm, time scale $\sim 3 \times 10^{19}$s) was provided by a radiation dominated universe with general relativity deciding the dynamics while the shorter structure (length scale $\sim 2 \times 10^{28}$ cm, time scale $\sim 3 \times 10^{17}$s) was provided by discrete objects whose distribution and dynamics were essentially described with (i) Euclidean geometry and (ii) no evolution. The shorter structure was interpreted as 'super super-cluster (SSC)', and it was argued that the larger structure contains numerous SSCs.

This model was consistent with all observations of discrete objects as well as with the intensities of background radiations of various kinds. The only objection to it, so far as I am aware, was that the relatively small peculiar velocity of the Sun with respect to the microwave background rest frame forces the Galaxy to be close to the centre of the SSC.

Regardless of the validity of this approach, the question of the evolution of discrete source populations needs to be examined ab-initio. DasGupta et al [22] for example, have recently argued that the redshift-flux density distributions in complete samples of radio galaxies like the 3CR can be explained entirely in terms of non-evolving radio luminosity functions.

5. G-VARYING COSMOLOGIES

In spite of the successes and internal consistency of general relativity, gravity is still on enigma at the microscopic level. For this reason, many physicists have tried to venture into a field that Isaac Newton himself was reluctant to tread (vide his famous remark 'Hypotheses non-fingo'.). In particular, the validity of the inverse square law and the constancy of the gravitational constant G have been questioned. Let us consider the spatial dependence first.

The Solar-System tests of Newtonian gravity and general relativity inspire confidence in the validity of these theories at distances of the order of a few astronomical units. The success of stellar structure and evolution theory (solar neutrinos not-withstanding) provides indirect test of validity over distances of 10^6 - 10^{12} cm. But what about smaller and larger scales?

For example, the dynamical arguments deducing missing mass (e.g. flat rotation curves, intra-cluster velocity dispersion, etc.) could also be turned round to question the validity of the inverse square law at galactic or clustering scale. So far as I am aware, no alternative cosmology has emerged from such a radical interpretation.

More recently Fischbach et al [23] in a reanalysis of the classic Eötvos experiment, have questioned the validity of the inverse square law at the scale of a few metres. In particular, they suggest a modification of the Newtonian potential energy of two masses m_1, m_2 at a separation of r, from the value Gm_1m_2/r to

$$V(r) = -G\frac{m_1m_2}{r}\left(1 + \alpha e^{-r/\lambda}\right) \qquad (1)$$

where $\alpha = -(7.2 \pm 3.6) \times 10^{-3}$, $\lambda = (200 \pm 50)$m. These numbers have been obtained empirically but can be explained, according to these authors by a fifth force of repulsive nature coupling baryon number to hypercharge.

Since the distance scale of this force, even if it is confirmed, is only $\sim$ 200 metres, it cannot be relevant to extragalactic astronomy or cosmology

So far as alternative cosmologies are concerned the possible temporal variation of G has generated considerable discussion. Pioneering work in this field came from Dirac [24] in 1937. Dirac was concerned with the largeness of large dimensionless ratios of physical constants:

$$\frac{e^2}{Gm_pm_e} \sim 10^{40}, \qquad \frac{m_ec^3}{e^2H} \sim 10^{40}. \qquad (2)$$

Here G and H (Hubble's constant) are macroscopic while e (electron charge), m_e (electron mass), m_p (proton mass) are microscopic. Arguing that it cannot be coincidental that two large dimensionless numbers are comparable in magnitude, Dirac suggested that they are related. Known as the 'large numbers hypothesis' it implies that since in an evolving universe H is epoch dependent, so is G. More than three decades later Dirac returned to this conjecture and gave quantitative formulation [25, 26]. In particular, he considered two different time coordinates, t_a for atomic processes and t_g for macroscopic gravitational processes with

$$\beta = \frac{dt_g}{dt_a} \qquad (3)$$

an epoch-dependent quantity. Dirac offered two versions of cosmological models, one in which there is additive creation and another with multiplicative creation.

Later Canuto and others [27] offered a field theory, the so called Scale Covariant Theory of Gravity (SCTG) for describing Dirac cosmologies, and have discussed extensively the observable consequences for celestial mechanics of the Solar System, stellar and galactic evolution and cosmology. The variation of G with epoch in these model is usually of the form $G \propto \beta^n$ where n is a constant positive or negative index.

The SCTG has been criticized by A.K. Kembhavai [28] on the grounds that its scale invariance makes it indistinguishable from general relativity and that the claimed observational differences are spurious. This has been hotly debated by Canuto [29]. In any case it is clear that the present formalism of SCTG does not clarify where and how the scale-invariance symmetry is broken; nor does a unique G-β relation emerge from the formalism of the theory.

The second path to G-varying cosmologies is via Mach's Principle. Brans and Dicke in 1961 offered an interesting alternative to general relativity [31] by starting from Mach's principle in the following way. If we consider a typical Friedmann model we find the following relation between the G, the characteristic cosmological distance R and M the mass contained within it:

$$\frac{1}{G} \sim \frac{2M}{Rc^2} \Omega^{-1} \sim \frac{M}{Rc^2} . \tag{4}$$

Brans and Dicke took this relation as determining G^{-1} through inertial contributions of all the masses m_1 , m_2 ,... at various distances r_1 , r_2 ,... in the universe:

$$\frac{1}{G} \sim \sum_i \frac{m_i}{r_i c^2} . \tag{5}$$

Thus G is not a constant but its reciprocal behaves as a scalar field. The Brans-Dicke theory therefore starts with an action in which the standard Hilbert term of general relativity is modified thus:

$$\frac{c^3}{16\pi G} \int R \sqrt{-g}\, d^4x \rightarrow \frac{c^3}{16\pi} \int \phi R \sqrt{-g}\, d^4x \tag{6}$$

where ϕ is a scalar field. To determine its dynamical behaviour typical (the standard massless) scalar field Lagrangian is used with an effective coupling constant ω. The field equations tend to those of general relativity as $\omega \rightarrow \infty$.

The accuracy of the Solar System tests have already forced ω to be larger than 500, thus making the Brans Dicke theory practically indistinguishable from general relativity in the weak gravity limit [2, 3]. However, cosmologically the theory can still offer differences from relativity. In particular it can lead to $|\dot{G}/G| \sim \omega^{-1} H$ at the present epoch. The present accuracy of radar/laser ranging of the Moon and the nearby planets does not rule out G-variation of this order. The sign of $\dot{G}$ depends on the model chosen. The theory also differs from standard cosmology in the 'early universe' phase, e.g. in the primordial production of light nuclei [2, 3]. Its consequences in even earlier phases of the universe have not been explored so far.

Another Machian theory of gravity was proposed by Hoyle and the author [31] in 1964 and further explored later [32 - 35]. It is based on a conformally invariant action principle and its form can be uniquely deduced from considerations of symmetry. The theory is naturally expressed in action at a distance format but can also be recast as a field theory. On the Solar System scale it does not generate any new results vis-a-vis general relativity.

However, cosmologically it produces new results under two scenarios. It has models in which G varies with epoch. Canuto and the author [36] and canuto et al [37] have shown that the G-caryįng cosmology is consistent with whatever cosmological observations presently available , such as the Hubble relation, source counts, angular sizes, gamma ray background, etc.

Earlier Rana and the author [38, 39] had fitted a G-varying cosmology to the microwave background spectrum including the data of Woody and Richards [40]. The fit could be obtained within 1σ at both short and long wavelengths thus apparently doing better than standard cosmology. However, since then the Woody-Richards data have been revised [41] and the new curve appears to be consistent with standard cosmology.

What is the observational status of $\dot{G}/G$? Laboratory measurements are not yet capable of measuring the small effect predicted by most theories. The best-bet seems to be to study the motions of the Moon and the planets for apparent secular effects. Reference [3] summarizes the state of affairs till ∿ 1982. The lunar motion is complicated by tidal interactions and although there have been claims [see 42 for example] that a clear nonzero value of $|\dot{G}/G|$ is indicated by the data, they are contested. However, the range measurements between tracking stations of Deep Space Network and the Viking landers on Mars as analyzed by Hellings et al [43] seem to rule out most G-varying cosmologies. Again, the accuracy of planetary ephemerides on which this analysis is based may be questioned [44].

A somewhat more radical application of HN theory was pointed out by the author [45]; to explain the apparent anomaly in the redshifts of quasars. For, in certain cosmological models the theory predicts a steady growth in the inertial mass m of a typical particle. Furthermore, light propagation in these models leads to a relationship

$$1 + z \propto m^{-1} \tag{7}$$

between redshift z and the typical particle mass m in the object. If a quasar is made out of material recently fired from a galaxy, it will exhibit larger redshift than the parent galaxy although both are physical neighbours. Das and the author have shown how the theory can be applied to the observations of anomalous redshifts of quasar galaxy associations [46]. Of course, it must be stated that in spite of numerous claims of observed cases of noncosmological redshft [for a review see Ref. 47] the issue is still considered controversial.

6. CHRONOMETRIC COSMOLOGY

Introduced in 1976 by Segal [48] this cosmology also involves two time systems, one 'local' and the other 'global'. Globally the cosmos is a spacetime with the topology R x S. That is, the time coordinate, t, is given by the real number line R while the space is the three dimensional surface of a 4-sphere. Locally, however, the time coordinate x_0 is Minkowskian and different from t. A cosmological observation like the measurement of the redshift of a distant galaxy can distinguish between x_0 and t. The mathematical part of the theory describes how to connect the local Minkowski spacetime with the global R x S type of spacetime. Physically, one has to consider the operation of physics in the global spacetime and then deduce its observable consequences in the local Minkowski spacetime.

For example, the wave equation describing photon propagation in this spacetime gives a redshift-distance formula that is quadratic rather than linear. Nicoll and Segal have claimed that the redshift magnitude relation for QSOs satisfies the quadratic law rather than Hubble's law [49]. Even for galaxies, Segal claims that quadratic law gives a better fit than the linear law [50]. This inference is debated on the grounds as to whether the effect is real or attributable to selection effects.

Segal [51] has also considered background radiations, in particular, the microwave background which is usually claimed as the best proof of a hot big bang. In Segal's model the universe being closed and nonsingular, radiation would circulate round and round and an equilibrium Planckian spectrum reached in which emission from sources is balanced by absorbers. The actual temperature would depend on the total energy available to thermalize. Segal gives qualitative argument to relate the ratio of starlight to thermalized radiation, to the number of circuits of the closed universe that the radiation has made. By contrast the X-ray background in Segal's theory is not Planckian because it has not yet been fully randomized. The argument here is that the X-ray photons being more energetic, cannot be so easily absorbed and hence more circuits of the universe are needed for them. This, however, raises the question of time scales. What is the age of the universe? If it is infinite, then should not all processes have reached equilibrium?

7. QUANTUM COSMOLOGY

This discussion so far has centred around classical theories of gravity. Would any difference be made in the outcome of this discussion if gravity were quantized? A simple argument can be given to show that quantum gravity becomes relevant at the so called Planck scales of length and time

$$L_p = \sqrt{\frac{G\hbar}{c^3}} \sim 1.6 \times 10^{-33}\,\text{cm}, \quad T_p = \sqrt{\frac{G\hbar}{c^5}} \sim 5.4 \times 10^{-44}\,\text{s}. \tag{8}$$

That is, if we were to follow the standard model back to the big bang epoch $t = 0$ then we can no longer trust its classical foundations for $t \lesssim T_p$. Hence the important question of cosmology 'Did the universe originate in a big bang?' remains shrouded in quantum gravity.

There are several attempts underway to quantize gravity [see Refs. 52 - 54 for sample reviews]. The nonlinearity of general relativity and the intimate relationship of gravity with spacetime geometry make the task of quantization immensely difficult. It would be out of place to spend time on formal approaches in a conference devoted to observational cosmology. In any case the approaches described in the above references have little bearing on the cosmological question posed above.

There is, however, a more simple-minded approach that leads to interesting cosmological conclusions. In relativity the geometry is specified by a symmetric metric tensor g_{ik} which has ten components. These are subject to four coordinate conditions, thus leaving essentially six continuum degrees of freedom. In a fully quantized theory all $6 \times \infty$

degrees of freedom must be quantized. The most important of these, especially for cosmology are the conformal degrees of freedom that set the scale of the expanding universe. For example, if the metric of the Minkowski spacetime of special relativity is multiplied by a conformal factor Ω^2 where Ω is a function of time only, we get the Robertson-Walker spacetime with $k = 0$. Robertson-Walker spacetimes with $k = \pm 1$ are also obtained this way provided Ω is a suitable function of cosmic time and the radial coordinate. The spacetime singularity of the big bang comes from $\Omega = 0$.

We may generalize this notion to metrics of the form $\bar{g}_{ik}\,\Omega^2$ where $\bar{g}_{ik}$ is the solution of classical Einstein equations, and explore the consequences of Ω treated as a quantum operator. Then $(\Omega-1)$ is the quantum conformal fluctuation from the classical metric and we have a range of 'nonclassical' cosmologies in the era $t \lesssim t_p$. A wavefunctional $\psi(\Omega)$ describes the quantum evolution of the universe. In particular, if the universe came out of a singularity, it would be characterized by functions Ω that tend to zero. The probability measure $|\psi|^2$ of all such functions in a suitably defined function space gives us the probability that the universe came from a singular state.

Recent work by the author [55] has shown that this probability is vanishingly small. In other words, given the quantum regime of Ω, it can be asserted that almost certainly the universe did not originate in a big bang singularity. It may have passed through a stage where its characteristic linear size was as small as L_P; but it was unlikely to have been zero as implied by standard (classical) cosmology.

Padmanabhan has constructed cosmological models which explicitly take account of the dynamics of quantum conformal fluctuations and [56] which are nonsingular. For $t \gg T_P$, These models merge into the standard models. It is also possible to construct stationary state models in which the conformal fluctuations keep the universe unchanging at a finite size $\sim L_p$.

The elimination of the singularity removes the horizon problem since the past light cone in a quantum universe is not terminated at $t = 0$. The flatness problem is also resolved [57] if we assume that the universe evolved from quantum conformal fluctuations of an empty Minkowski spacetime. For, it can then be shown that with almost unit probability the universe would go into the $k = 0$ Robertson-Walker model.

Thus, incredible though it may seem, some of the observable features of the present day universe can be traced to its seeds in the quantum era. The details of this approach are given in a recent review [58; see also 59].

8. CONCLUDING REMARKS

This brief survey of alternative cosmologies by no means exhausts the full range of ideas in the literature. Nor does it offer any unique alternative to the standard cosmology. Rather, it is meant to highlight the important possibilities, both theoretical and observational, that exist in the present literature once one ventures beyond the child's garden of standard cosmological models. As mentioned here, we have instances of ideas once considered nonstandard, gaining respectability later. Of course, one can cite older references of this happening right from the days of Copernicus through successive stages in which the establishment view on the Sun's position in the Galaxy, the extragalactic nature of the nebulae, and the value of Hubble's constant had to be revised.

Alternative cosmologies stimulate observational checks on the universe whenever they come up with alternatives to the standard predictions. If cosmology is to be treated as science and not the religious dogma that it once was, alternatives to the establishment views have to be encouraged.

While I am willing to admit the possibility of all alternative cosmologies being proved wrong, I find it hard to take the complacent view that in standard cosmology we are so close to solving the profound problem of the universe that deviating from it is a waste of time. After all, to quote J.B.S. Haldane "The universe is not only queerer than what we suppose, it is queerer than what we can suppose."

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DISCUSSION

YU XIN: (1) Is there any observational evidence that matter is being continuously created in the universe? (2) Do you think that there might be intrinsic spin in spacetime? - If so then spacetime singularities might be avoided.

NARLIKAR: One could interpret the explosive outpouring of matter in quasars and active galactic nuclei as evidence for matter creation. Regarding intrinsic spin, it is hard to cite evidence. However, the Einstein-Cartan type theories do describe torsion in spacetime by having a non-symmetric affine connection. There are cosmological models in such theories (e.g. those discussed by Trautmann) which are nonsingular.