Title: The Case for an Alternative Cosmology

Date: May 06, 2014 11:00 AM

URL: http://pirsa.org/14050034

Abstract: This talk will describe the Quasi-Steady State Cosmology proposed in 1993 by Fred Hoyle, Geoffrey Burbidge and Jayant Narlikar. Starting with the motivation for this exercise, a formal field theoretic framework inspired by Machâ€™s principle is shown to lead to this model. The model is a generalization of the classical steady state model in the sense that it is driven by a scalar field which causes creation in explosive form. Such â€˜minicreation eventsâ€™ lead to a universe with a long term de Sitter expansion superposed with oscillations of shorter time scales. It is shown that this cosmology explains all the observed cosmological features and that there exist potential tests to distinguish between this cosmology and the standard big bang cosmology.

A Case for Alternative Cosmology

Jayant Narlikar

IUCAA

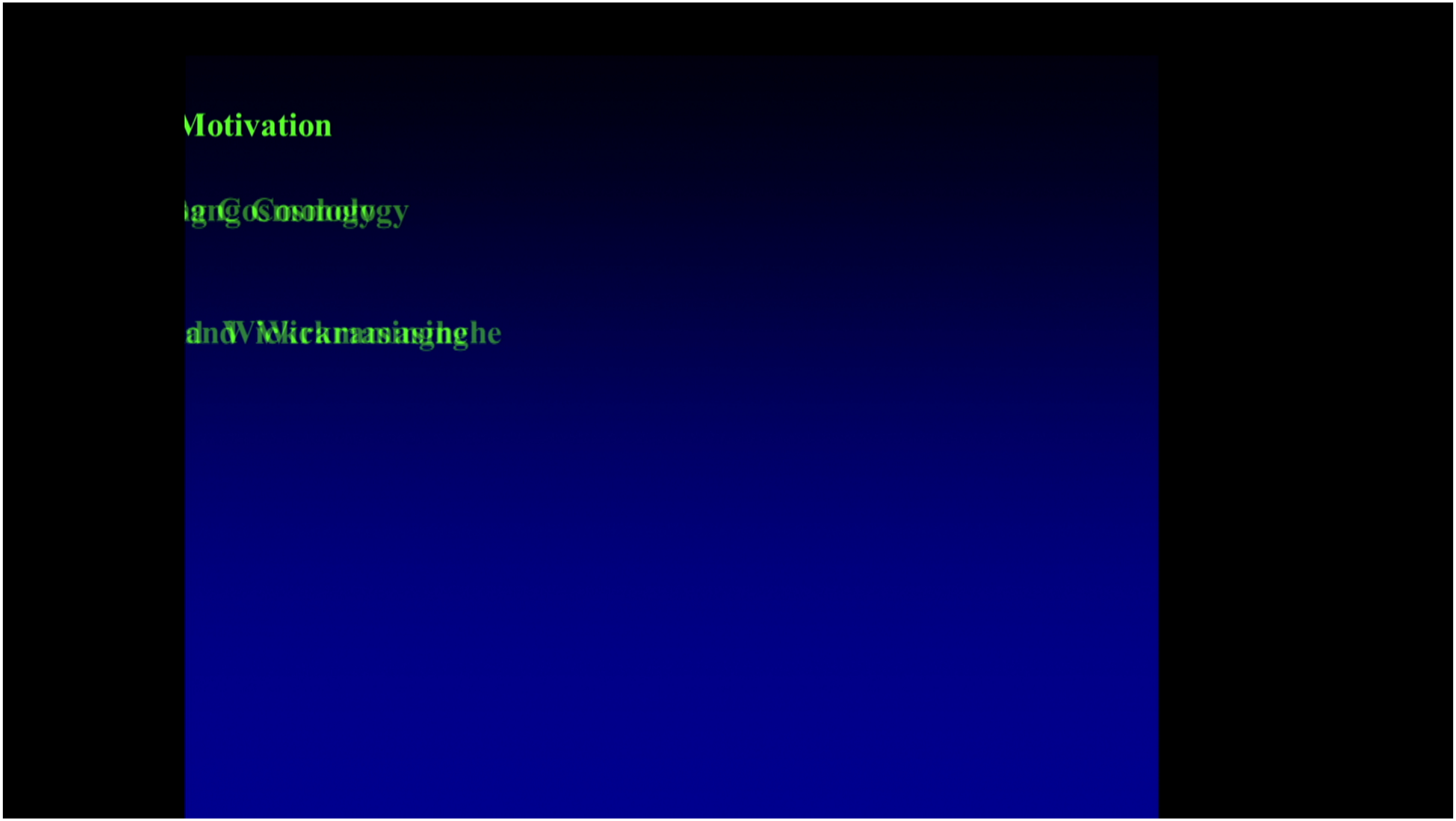
Inter-University Centre for Astronomy and Astrophysics

A Case for Alternative Cosmology

Jayant Narlikar

IUCAA

Inter-University Centre for Astronomy and Astrophysics


Motivation

Motivation

1990: A critique of the Standard Big Bang Cosmology (SBBC)

by Arp, Burbidge, Hoyle, Narlikar and Wickramasinghe [*Nature*, vol 346, 807]

"The extragalactic universe: An alternative view…"

Why is the SBBC *not* the last word in cosmology?

It can be argued that there are several unsatisfactory features of the standard model, e.g.,

a) Beginning in a spacetime singularity

b) The age problem

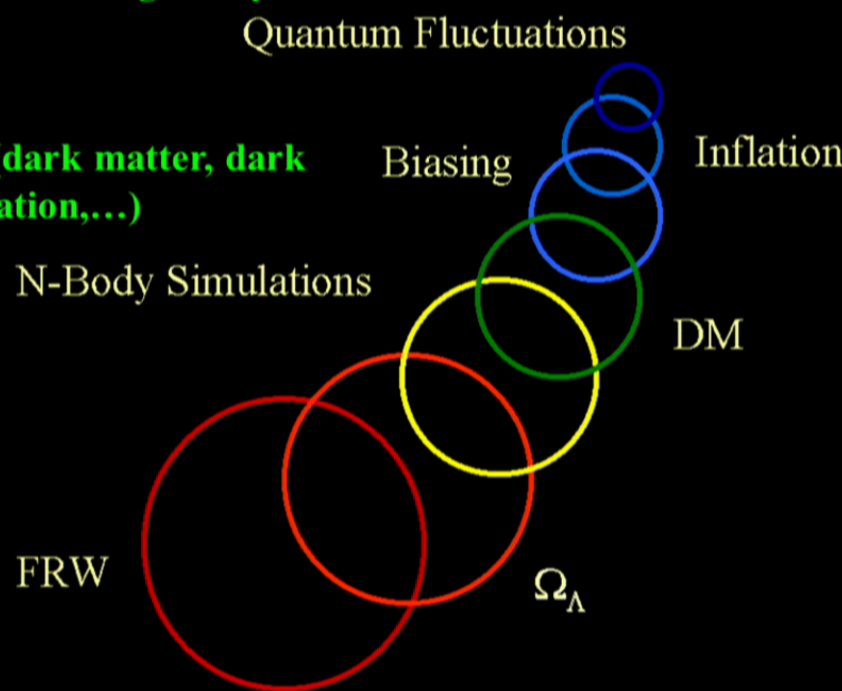
Why is the SBBC *not* the last word in cosmology?

It can be argued that there are several unsatisfactory features of the standard model, e.g.,

a) Beginning in a spacetime singularity

b) The age problem

c) Too many epicycles (dark matter, dark energy, biasing, inflation,…)



Why is the SBBC *not* the last word in cosmology?

It can be argued that there are several unsatisfactory features of the standard model, e.g.,

a) Beginning in a spacetime singularity

b) The age problem

c) Too many epicycles (dark matter, dark energy, biasing, inflation,…)

d) Highly speculative, i.e., most of the present work is based on initial conditions and modes of evolution that are neither directly observable, nor based on established physics

Counter criticism: If there is no other model, we have to make do with SBBC and expect that these difficulties will either be solved or go away.

Counter criticism: If there is no other model, we have to make do with SBBC and expect that these difficulties will either be solved or go away.

An Alternative

1993: An alternative cosmology was proposed by F. Hoyle, G. Burbidge and J.V. Narlikar (*Ap.J.* vol 410, 437)… it was called the Quasi-Steady State Cosmology (QSSC).

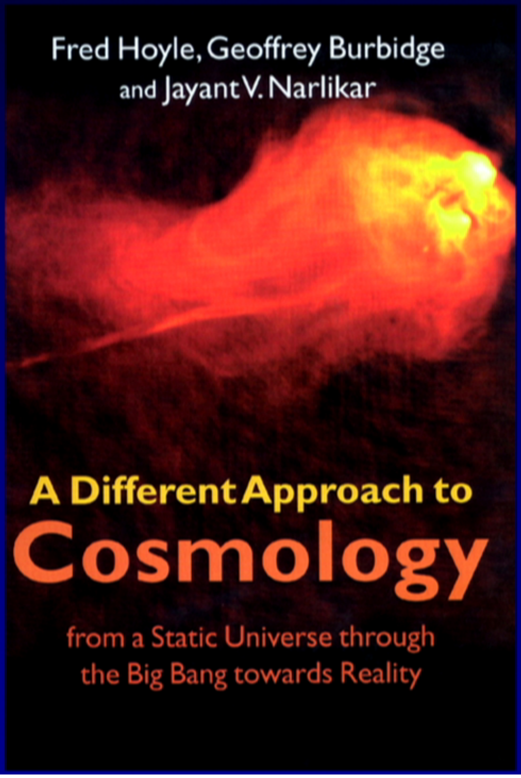
Several publications on the QSSC have since appeared in MNRAS, ApJ, A&A and other journals as well as conference proceedings.

An Alternative

1993: An alternative cosmology was proposed by F. Hoyle, G. Burbidge and J.V. Narlikar (*Ap.J.* vol 410, 437)... it was called the Quasi-Steady State Cosmology (QSSC).

Several publications on the QSSC have since appeared in MNRAS, ApJ, A&A and other journals as well as conference proceedings.

For details see the book "*A Different Approach to Cosmology*" by the same authors (Cambridge 2000).



What is QSSC?

What is QSSC?

What are its parameters / epicycles?

How does it explain the present phenomena of relevance to cosmology?

Basic features

Underlying field theory: A theory of gravity that originates in Mach's Principle and leads to gravitational equations similar to general relativity (with the addition of a scalar field):

$$R_{ik} - 1/2\, g_{ik} R + \lambda g_{ik} = 8\pi G \{ T_{ik} - f(C_i C_k - 1/4\, C_l C^l g_{ik}) \}$$

Basic features

Underlying field theory: A theory of gravity that originates in Mach's Principle and leads to gravitational equations similar to general relativity (with the addition of a scalar field):

$$R_{ik} - 1/2\, g_{ik} R + \lambda g_{ik} = 8\pi G \{ T_{ik} - f(C_i C_k - 1/4\, C_l C^l g_{ik}) \}$$

The cosmological constant originates from the inertial interactions between particles in the universe and has the 'right' order of magnitude ($\approx 10^{-56}$ cm^{-2}).

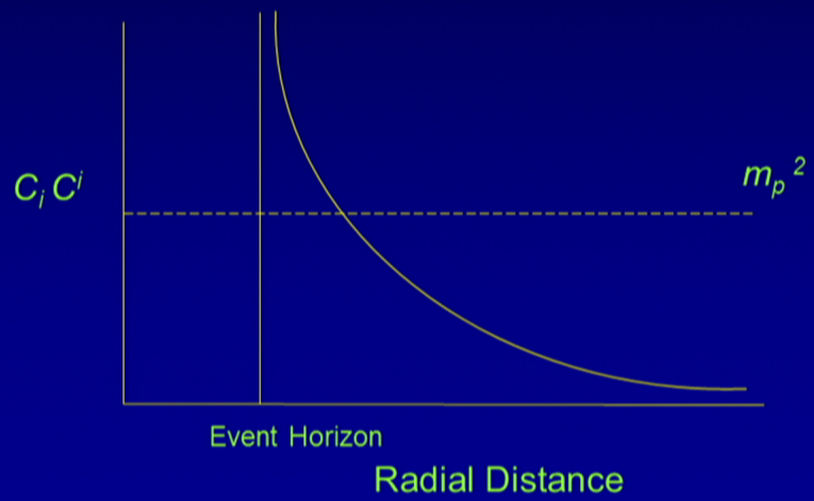
However, this constant is *negative.*

The C- field terms arise from inertial contributions at the ends of world lines of particles and describe the dynamics of creation. For example, one arrives at the typical created particle of Planck mass, Creation of matter: The action principle from which the above field equations are derived requires the end-point condition to be satisfied at creation of matter:

Creation of matter: The action principle from which the above field equations are derived requires the end-point condition to be satisfied at creation of matter:

$$m_P{}^2 = C_l C^l.$$

Particles can be created only where the strength of the C - field is high enough to match the rest-mass energy of the created particle.



In general this condition is not satisfied, except near compact massive objects. There one has, at a distance R from mass M, the following relationship:

$$C_l C^l \propto 1 / (1 - 2GM/R).$$

Near such a mass, close to the Schwarzschild radius there is creation of new matter. As it creates the negative energy C - field also, the spacetime expands rapidly near such an object and the created matter is blown outwards.

Contraction

- strengthening of the C- field intensity
- creation centres become more effective
- contraction slows down because of repulsion of C -field and a bounce occurs

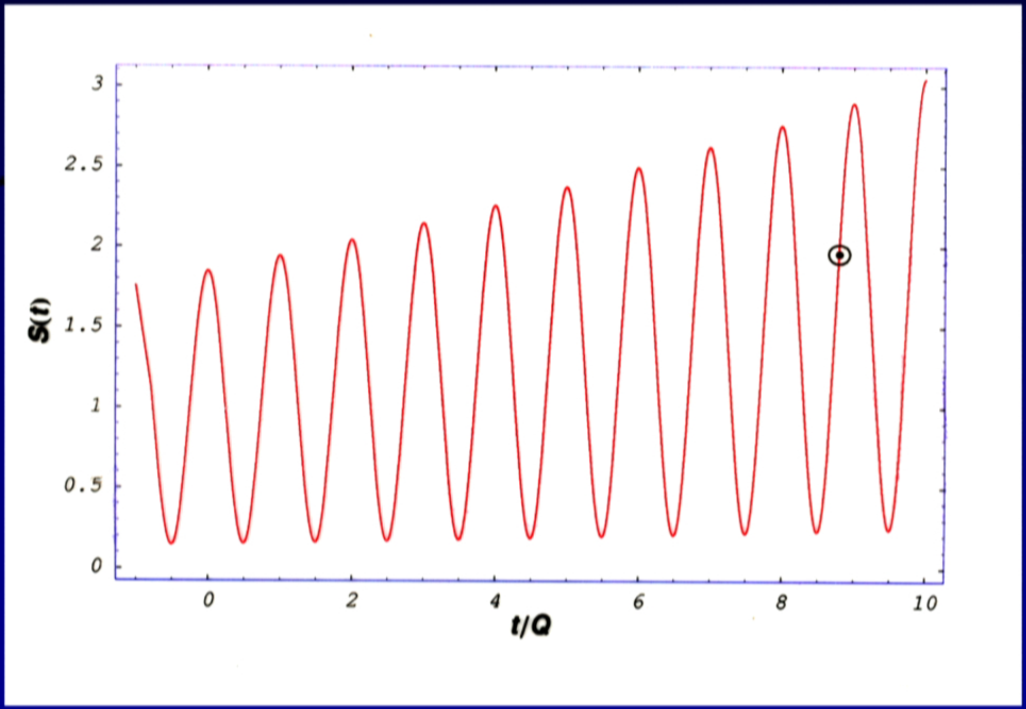
The universe has thus a scale factor like:

$$S(t) = \exp\,(t/P)\;\{\,1 + \eta \cos 2\pi t/Q\,\}$$

The universe has thus a scale factor like:

$$S(t) = \exp(t/P)\ \{\ 1 + \eta \cos 2\pi t/Q\ \}$$

Typically, Q = 50 Gyr, and P = 1000 Gyr, and η = 0.8. Our present epoch is fixed by the measurement of Hubble's constant.



Comparison with SBBC and observations

A) Theoretical aspects

Comparison with SBBC and observations

A) Theoretical aspects

The QSSC does not have spacetime singularity as the negative energy field violates the Hawking-Penrose energy condition.

Also, the magnitude of the cosmological constant does not present any problem. In the SBBC, there is the cosmological constant problem wherein the relic λ from inflation is some 10^{108} times higher than the present observed value.

Comparison with SBBC and observations

A) Theoretical aspects

The QSSC does not have spacetime singularity as the negative energy field violates the Hawking-Penrose energy condition.

Also, the magnitude of the cosmological constant does not present any problem. In the SBBC, there is the cosmological constant problem wherein the relic λ from inflation is some 10^{108} times higher than the present observed value.

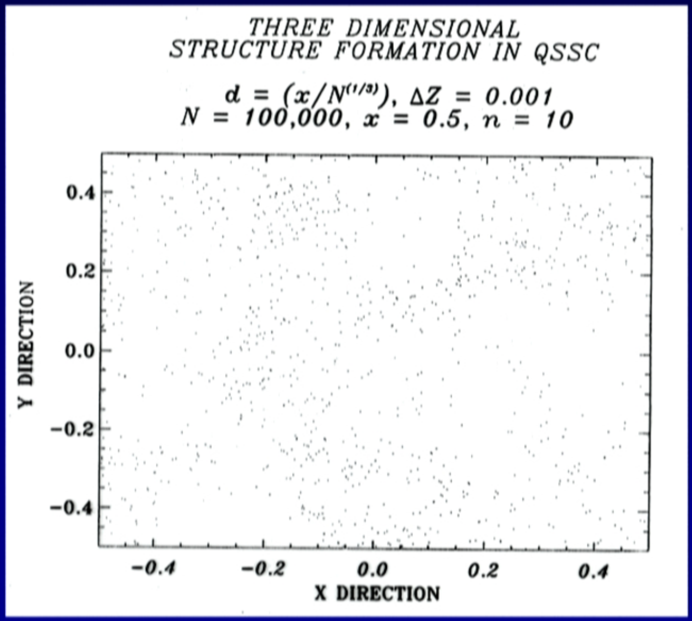
The question of quantization of the negative energy C - field, however, remains, since the back reaction of the quantum creation process on the metric is difficult to work out. Till then the 'creation rate' has to be put in by hand.

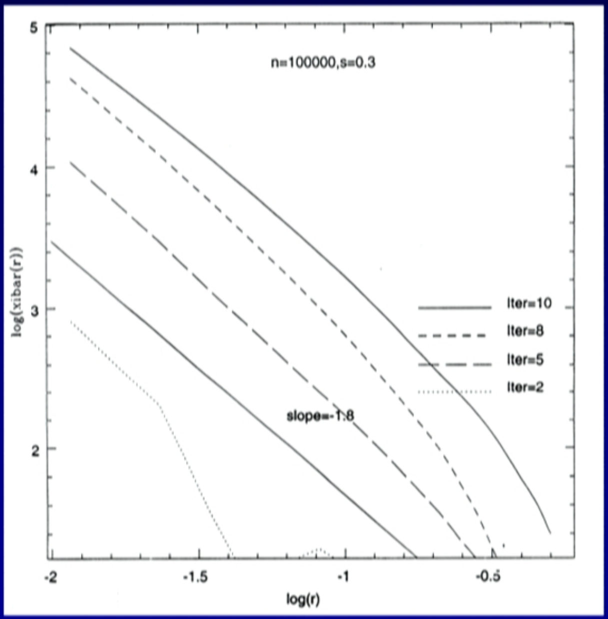
3) Explosive phenomena

Unlike the SBBC, the QSSC has an intimate link with high energy events in the universe, through the mini-creation events.

The gamma ray bursts, radio jets, AGN, and even the origins of clusters may be linked to the minibangs.

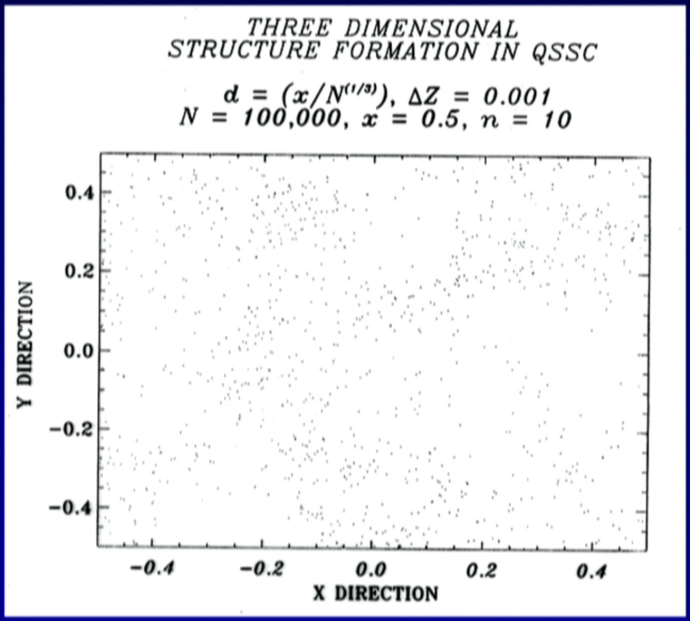
A toy model linking formation of galaxies and clusters to minicreation events using the preferentiality of creation near a compact massive object, has shown how clustering can take place with the observed 2-point correlation function. (See Nayeri et al, *Ap.J.* vol.525, 10.)

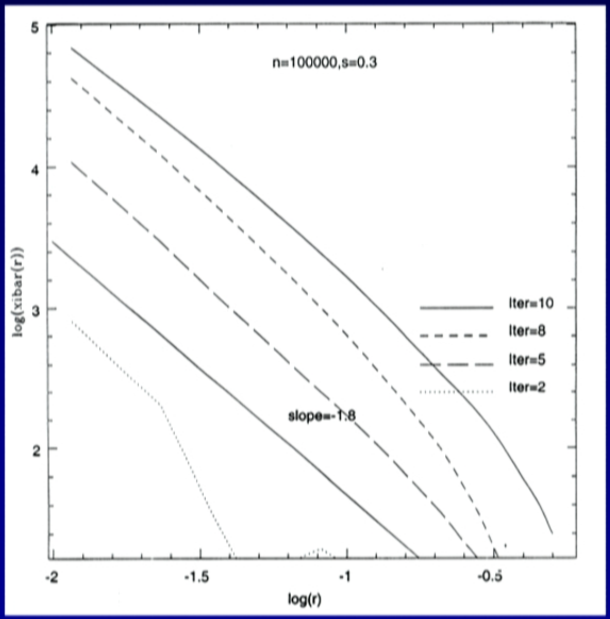




C. Structure Formation

A toy model linking formation of galaxies and clusters to minicreation events using the preferentiality of creation near a compact massive object, has shown how clustering can take place with the observed 2-point correlation function. (See Nayeri et al, *Ap.J.* vol.525, 10.)





D. CMBR

CMBR is the relic starlight left over from previous cycles. The estimated energy density of such radiation at the present epoch comes out to be $\sim 4\times 10^{-13}$ erg cm^{-3} , which on thermalization gives a temperature of 2.7 K.

). CMBR

CMBR is the relic starlight left over from previous cycles. The estimated energy density of such radiation at the present epoch comes out to be $\sim 4\times 10^{-13}$ erg cm^{-3} , which on thermalization gives a temperature of 2.7 K.

What agency thermalizes it?

Metallic whiskers that are formed from condensation of metallic vapours ejected by supernovae…

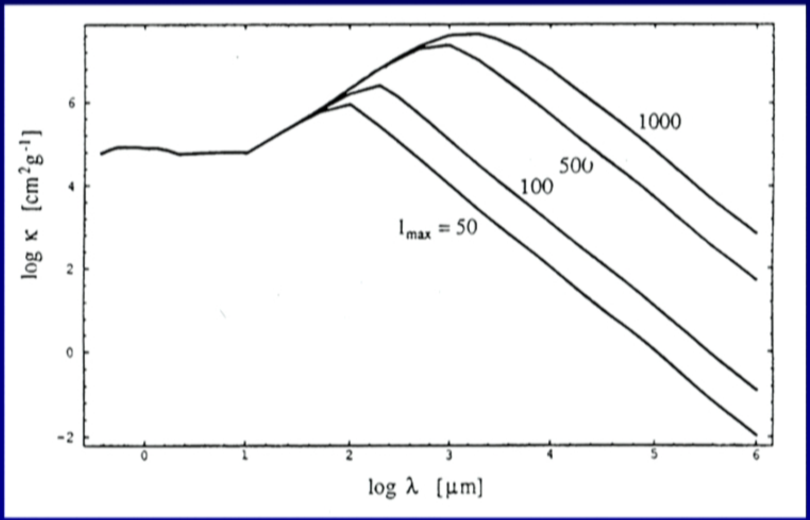
Laboratory experiments show that such vapours condense as whiskers and not as spherical balls.

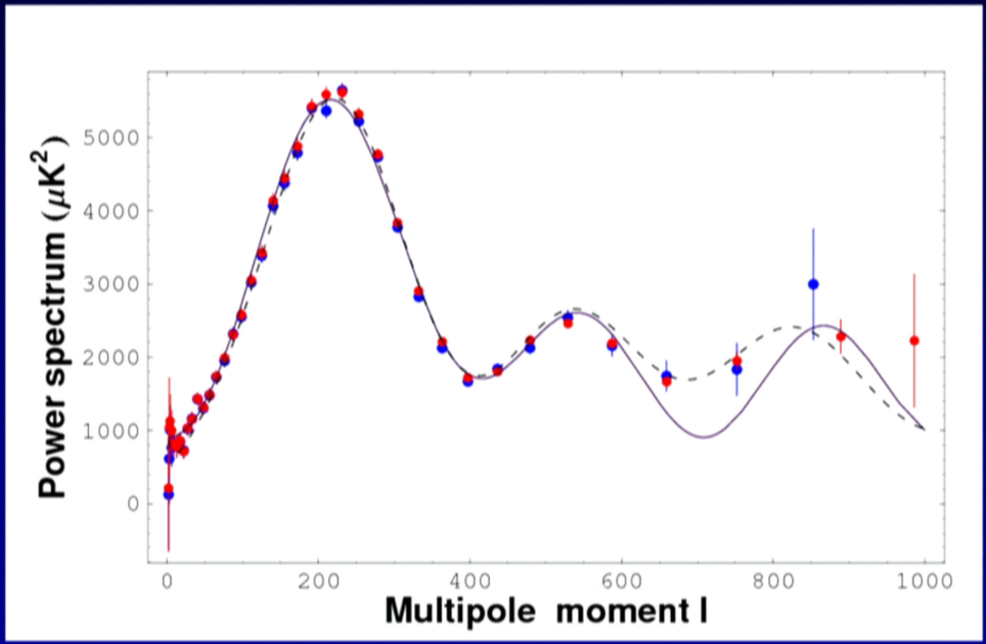
What agency thermalizes it?

Metallic whiskers that are formed from condensation of metallic vapours ejected by supernovae…

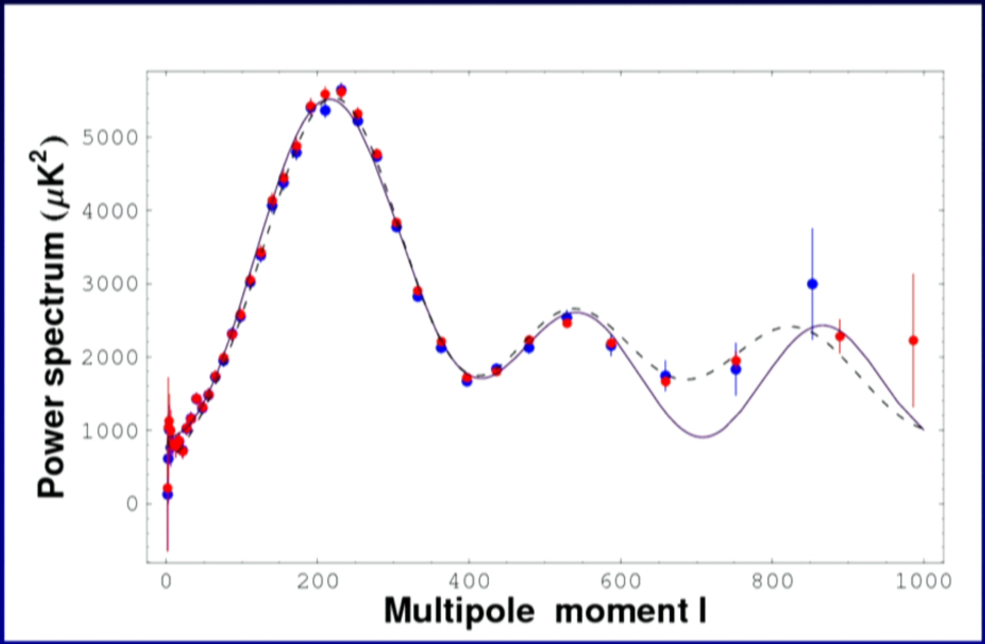
Laboratory experiments show that such vapours condense as whiskers and not as spherical balls.

Dust density, typically ~ 10^{-35}- 10^{-34} g cm^{-3}, made of such whiskers is adequate to thermalize the relic starlight.

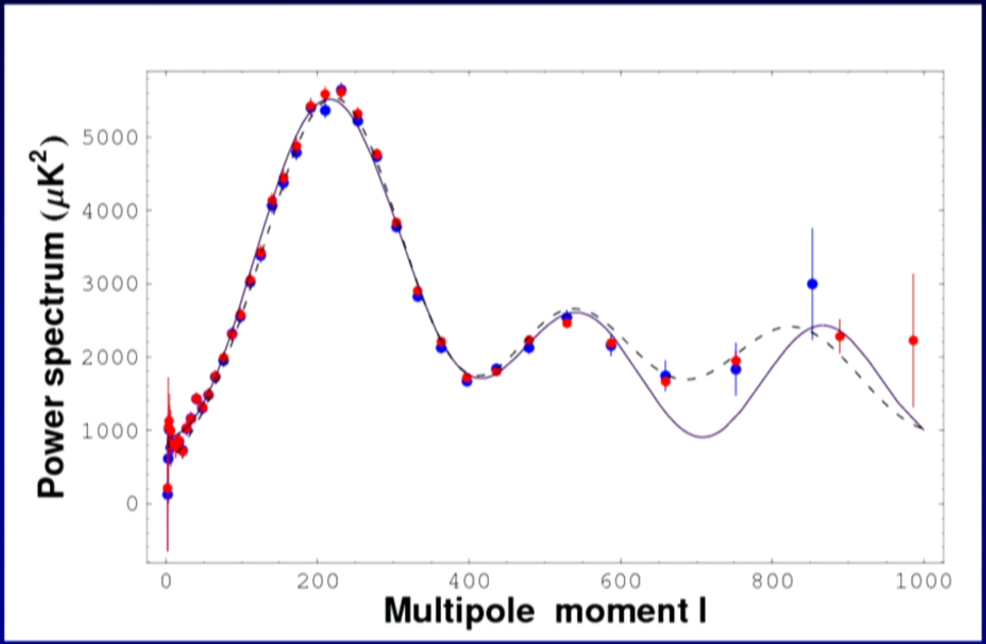



Power spectrum (μK^2)
5000
4000
3000
2000
1000
0
0
200
400
600
800
1000
Multipole moment l

The contributions from the latest star-clusters (of the present cycle) appear as minor fluctuations. The power spectrum of such inhomogeneities has been computed and may be compared with observations.

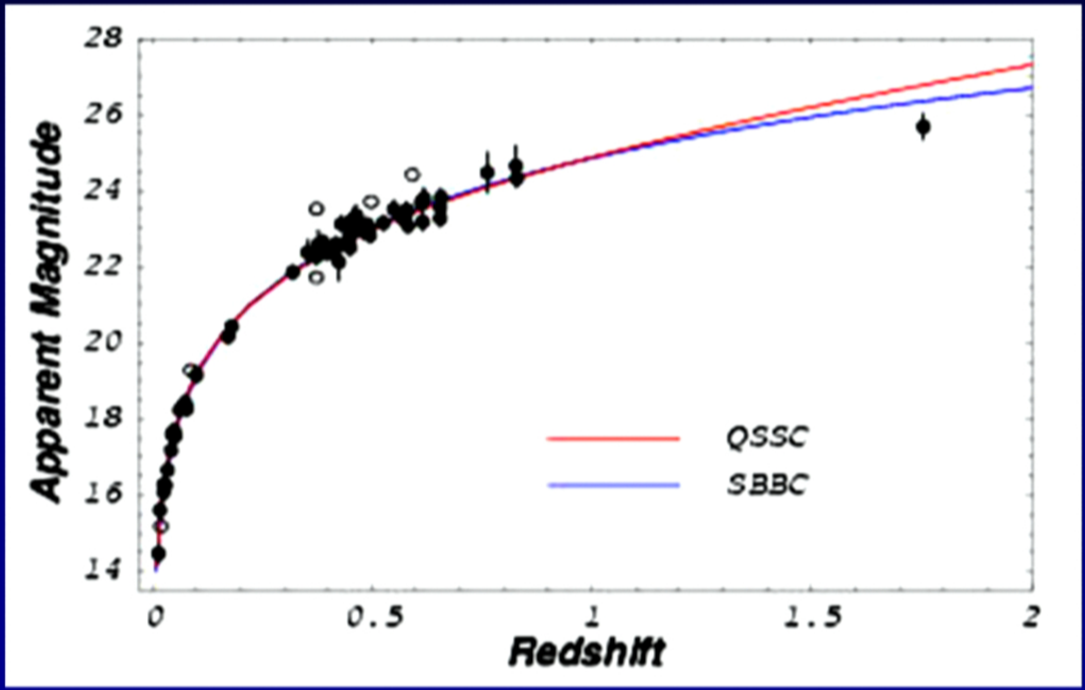


The contributions from the latest star-clusters (of the present cycle) appear as minor fluctuations. The power spectrum of such inhomogeneities has been computed and may be compared with observations.



E. The *m*-*z* relation for high redshift supernovae

This relation has been worked out on the assumption that there is extra dimming by intergalactic whisker-dust.



Taking the dust density as a free parameter, one can work out the best fit curve to the data. One gets a fit comparable to the best-fit big bang model, for *a density that is consistent with the density required for CMBR thermalization!*

F. Gravitational Waves

The mini-creation events will generate gravitational waves if they are anisotropic. The expected peak effect is not in the optimum range of LIGO and other observatories, but even the 'tail' end may be detectable.

Distinguishing tests

1. <u>High redshift objects</u>:
   The QSSC does not have epochs of very large redshifts: finding objects of redshifts greater than or equal to, say 10, will pose embarrassment for the QSSC.

Distinguishing tests

1. High redshift objects:
   The QSSC does not have epochs of very large redshifts: finding objects of redshifts greater than or equal to, say 10, will pose embarrassment for the QSSC.

2. Near absence of dark matter:
   The density parameter $\Omega 0$ exceeds unity in the QSSC, for flat models. Hence if we do not find sufficient dark matter to make up for high omega, the simplest (flat) QSSC models are ruled out.

3. <u>Lack of optical depth of mm-waves:</u>

The MBR in the QSSC requires thermalizers in the form of metallic whiskers which are strong absorbers of the mm-waves. If we see bright emitters of such waves of high redshift, say, around 4-5, then the QSSC has to assume that the high redshift is largely non-cosmological.

3. <u>Lack of optical depth of mm-waves:</u>

The MBR in the QSSC requires thermalizers in the form of metallic whiskers which are strong absorbers of the mm-waves. If we see bright emitters of such waves of high redshift, say, around 4-5, then the QSSC has to assume that the high redshift is largely non-cosmological.

4. <u>Magnitudes of high redshift supernovae of Type Ia:</u>

The supernova m-z relation in the QSSC has shown why the distant supernovae are dimmer: because the intergalactic dust in the QSSC causes extra absorption. If dust causes extra dimming (and not the cosmological constant) then absence of progressively larger dimming with increasing redshift would rule out the model.

6. **Observations of blueshifts:**

The QSSC predicts some blueshifts of galaxies in the past epochs close to the oscillatory maximum. The blueshifts predicted are small ~ 0.1, but if they are found they will decide in favour of the alternative cosmology *QSSC.*

6. **Observations of blueshifts:**

The QSSC predicts some blueshifts of galaxies in the past epochs close to the oscillatory maximum. The blueshifts predicted are small ~ 0.1, but if they are found they will decide in favour of the alternative cosmology *QSSC.*

7. **Observations of old stars:**

If stars much older than, say, 20 Gyr are found, then they will be hard to accommodate within the SBBC. These could be, for example, low mass (half the solar mass, say) giants or very faint white dwarfs.

6. <u>Observations of blueshifts</u>:

The QSSC predicts some blueshifts of galaxies in the past epochs close to the oscillatory maximum. The blueshifts predicted are small ~ 0.1, but if they are found they will decide in favour of the alternative cosmology *QSSC.*

7. <u>Observations of old stars</u>:

If stars much older than, say, 20 Gyr are found, then they will be hard to accommodate within the SBBC. These could be, for example, low mass (half the solar mass, say) giants or very faint white dwarfs.

Flock of Geese