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COSMOLOGY IN THE PLASMA UNIVERSE

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Abstract

Space observations have opened the spectral regions of X-rays and γ-rays, which are produced by plasma processes. The Plasma Universe derived from observations in these regions is drastically different from the now generally accepted "Visual Light Universe" based on visual light observations alone. Historically this transitions can be compared only to the transition from the geocentric to the heliocentric cosmology.

The purpose of this paper is to discuss what criteria a cosmological theory must satisfy in order to be acceptable in the Plasma Universe.

COSMOLOGY IN THE PLASMA UNIVERSE

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I. The Copernican and the Sputnik revolutions

The "Copernican revolution" was to a large extent due to Galilei's introduction of the telescope. This new instrument made it possible to observe for example that Jupiter was surrounded by a Copernican system in miniature but found no trace of the crystal spheres of the geocentric system. At the same time Tycho Brahe made observations of unprecedented accuracy and they allowed Kepler to find his laws from which a straight road led to the Newtonian mechanics.

When in our epoque Korolev launched the first Sputnik and van Allen and his students developed a sophisticated technique of making observations from spacecraft a similar jump in our possibilities to study the Universe has occurred. Measurements of magnetic and electric fields, and of electric currents and plasma densities together with studies of the X-ray and γ-ray spectral emissions, which largely derive from cosmic plasma phenomena are now the observational background for studying the "Plasma Universe". This is drastically different from the earlier "Visual light Universe" which was based on observations in one narrow visual light octave, during the last decades supplemented by radio observations.

The aim of this paper is to discuss in what ways the present cosmologies must be modified in order to make them acceptable in the Plamsa Universe.

II. Properties of the Plasma Universe

A survey of the "Plasma Universe" has been published in Physics Today September 1986 and many properties of it have been discussed in a number of papers in IEEE Plasma Physics December 1986. The latter has as an introduction a paper by C.-G. Fälthammar which describes the manifestations of the Plasma Universe near the earth with extensive references to the literature. Some of the highlights of the new views of the Universe are:

1. The same general laws of plasma physics hold from laboratory and magnetospheric heliospheric plasmas out to interstellar and intergalactic plasmas.

2. In order to understand the phenomena in a certain plasma region, it is necessary to map not only the magnetic but also the electric field and the electric currents, .

3. A number of plasma phenomena, like double layers, critical velocity, pinch effect and the properties of electric circuit are of decisive importance. The phenomena mentioned are well-known since decades (or even more than a century) but up to now they have systematically been neglected in cosmic physics. If they are taken into account, not only interplanetary space but also interstellar and intergalactic space must have a cellular structure (CP Ch. I.3; II.10; VI.1.3; VI.2.2; VI.3.4; CP is a reference to the textbook Cosmic Plasma by H. Alfvén).

4. Space is filled with a network of currents, which transfer energy and momentum over large or <u>very</u> large distances. The currents often pinch to <u>filamentary</u> or <u>surface</u> currents. The latter are likely to give space, also interstellar and intergalactic space, a cellular structure (CP Ch. VI.13).

In the present paper we shall analyse whether these drastic changes in our picture of the Universe have any cosmological consequences. It is not the intension to question that there has been a Big Bang. However, the new views of the "Plasma Universe" may call for a modification of some aspects of it.

III. Is the Plasma Universe matter-antimatter symmetric?

As a consequence of Dirac's theory Oskar Klein suggested that the Universe might be matter-antimatter symmetric. This occured a quarter of a century ago at a time when the cosmological interest was focussed on the fight between the Continuous Creation and - what was later called - the Big Bang. To both of these cosmologies a symmetric universe was an unpleasant concept which it was important to get rid of. This was attempted by demonstrating that a homogeneous symmetric universe was out of question. Indeed this would be completely annihilated in a time of the order of millions of years.

As a starting point Klein considered a homogeneous universe but neither he nor anybody else claimed that the present universe should have any similarity to a homogeneous model. This did not help. It became a "generally accepted" view that a matter-antimatter symmetry was out of questions. A number of attempts to rectify this conclusion and open a free and unbiased discussion have been in vain. All such attempts have been met with the answer that no one has demonstrated in an unquestionable way the cosmic existence of antimatter. This may be true. But no one has either demonstrated that the Universe is not symmetric (see W.B. Thompson).

The Plasma Universe model introduces important new arguments in this discussion. From magnetospheric studies we know that there is a current layer in the magnetopause which separates space into two regions with different magnetisation, different temperatures and densities and frequently different chemical composition. Indeed, outside a layer associated with the magnetopause there is solar wind hydrogen whereas inside this layer oxygen evaporated from the ionosphere often dominates. The magnetopause is surprisingly "water tight" (or rather "plasma tight") although in rare cases there is a leakage of e.g. oxygen out into surrounding - apparently mostly at largely perturbed events. (Solar wind hydrogen also reaches the regions inside the magnetopause in several ways.) Thus the magnetopause seems to act as an (almost) impenetrable cell wall giving rise to a cellular structure of the magnetosphere. A detailed analysis of this aspect of the magnetopause is very important for the general discussion in this paper.

As has been shown similar phenomena are observed in all the regions accessible to spacecraft. As it is impossible to claim that such a basic property of a plasma as its tendency to produce cellular structures should be confined to the regions at present available to spacecraft it is impossible to avoid the conclusion that space in general has a cellular structure (see a general discussion in CP). In interstellar and intergalactic space the different chemical composition on both sides of the magnetopause may instead be a difference in the kind of matter; ordinary matter (koinomatter) on one side and antimatter on the other. This conclusion should be combined with the theory of Leidenfrost layers as analysed by Lehnert, 1977, 1978 (Fig.1). it is important to observe, that such layers - if static - emit a negligible amount of radiation. They should be depicted as thin very hot layers of almost complete vacuum.

The result is that we have little reason to question that in the present state of development of our concept of interstellar and intergalactic space the Plasma Universe could very well be matter-antimatter symmetric.

IV. Structure of the Plasma Universe.

The result of extensive discussions about the structure of the Plasma Universe is depicted in Fig. 2. We should distinguish between two regions. One is the "reliable diagnostic regions", comprising laboratory plasmas and those regions of the magnetospheres and the heliosphere which are accessible to spacecraft.

The other part of the Universe comprises all other regions, viz those outside the outer planets, and the sun, where our knowledge of the properties of plasmas depends on extrapolation from results obtained in the reliable diagnostic regions.

V <u>Does α Centauri consist of matter or antimatter</u>?

How little we know about the Universe outside the reliable diagnostic region can be demonstrated by asking whether one of our closest stars, say α Centauri, consists of matter or antimatter. "Of course of matter" is the obvious reply, but how can this be proven? An antimatter star should emit exactly the same spectrum. Certainly the sign of the rotational Faraday effect is different for electrons and positrons but as we do not know the sign of the magnetic field, this does not help.

It may be suggested that if the solar wind (from our sun) approaches α Centauri and this star also emits a solar wind, the collisions between these two winds would give rise to violent annihilation with detectable γ-ray emission. However, there is plenty of room for a large number of Leidenfrost layers.

The absense of large quantities of antiparticles in the Cosmic Radiation is another argument. If the sign of primary Cosmic Rays were known for energies $> 10^{14}$ eV this would be a strong argument. However, the sign of primary cosmic radiation is known only up to less than 10^{11} eV. Such particles have Larmor radii which are very small and all the CR in this energy range could very well be generated inside an extended heliosphere.

So once again, we do not know enough to exclude a Dirac Klein symmetry. On the other hand there is no decisive argument in favour of antimatter. (In Chapter VI of CP this problem is discussed in some detail.)

Hence it must be considered legitimate to study the consequences of both hypothesis; the Plasma Universe is symmetric or it consists of exclusively ordinary matter. As the second alternative is treated in a gigantic literature, it is appropriate that we here concentrate on the first alternative.

VI. Klein's cosmological model

Klein makes the natural assumption that the Dirac matter-antimatter symmetry is valid also in the universe. - Klein uses the old term "metagalaxy", because he does not take for granted that the region of space we can observe is the whole universe -. He assumes that our metagalaxy "initially" was in the form of a gigantic homogeneous cloud of ambiplasma (koinomatter and antimatter mixed homogeneously). (Fig. 3) Its density is so extremely small that annihilation is negligible. This sphere contracts under the action of gravitation. When it has reached a size of perhaps 10 R_H (R_H = Hubble distances) annihilation becomes important and produces a force opposite to the gravitation, which slows down the contraction. Annihilation increases very rapidly with increased density, and eventually it is large enough to convert the contraction into expansion. After the turning which may take place at say 0.1 R_H the sphere expands again. This expansion is identical with the Hubble expansion. The annihilation energy which is released at the turning and converted into kinetic energy of the Hubble expansion, and different kinds of radiation - among them cosmic background radiation - amount to some 10%. (The time scale before the turning should be much larger than in the figure.)

VII. Prophetic or actualistic approach to the history of the Universe

When discussing how to approach the cosmogonic problem (origin and evolution of the solar system) Gustaf Arrhenius who is a geologist pointed out that when the geological history of the earth is studied the actualistic approach is very valuable. This principle says: the present is the key to the past. In other words we should not approach a historical problem in science by making a guess about how the conditions were in a certain region several billion years ago because the probability that such a guess is correct is very close to zero. Instead we should start from the present conditions.

In fact, during the ages innumerable such guesses have been made. They have survived to our times only in cases when the guesses have been claimed to derive from divine inspiration. This means that the guesses must have been made by great religious prophets. Hence we find such guesses included as important parts of holy religious scriptures.

Hence there are two different ways of approaching the prehistory of the present state of the plasma universe or part of it.

1. The prophetic approach. A guess is made about the state very long ago, and this is made credible by prophetic authority. This approach often assumes that there was a "creation" at a certain time, and it is often claimed that we know more about this event than about somewhat more recent times.

2. The actualistic approach. We start from the observed present state and try to extrapolate backwards in time to increasingly more ancient states. From this follows that the further backwards we go the larger is the uncertainty about the state. This approch does not necessary lead to a "creation" at a certain time, but it does not either exclude this possibility. However, in principle it is also reconcilable with a Universe which is "ungenerated and indestructable" as Aristoteles put it.

VIII What does the Hubble diagram tell us?

The Hubble diagram is usually plotted in a logarithmic scale. Taking account of the great uncertainties it is reconcilable with a picture of a universe in which the expansion derives from a big bang at a singular point. However, this does not mean that the Hubble diagram proves this. This orthodox conclusion is based on an elementary logical mistake ("All dogs are animals" does not prove that "all animals are dogs".) First of all the observed red shifts do not necessarily derive from a longitudinal Doppler effect, they could just as well in part derive from a transverse Doppler effect. But even if we assume that they are caused by a longitudinal effect, the reconstruction of the orbits of the individual galaxies leads to the diagram which shows that once they were much closer together. In fact it seems legitimate to conclude that the metagalaxy (the "Universe" according to the Big Bang hypothesis) was about 0.1 R_H, but it seems not legimate to conclude that it was ever smaller. For a discussion of this see also CP Chapter VI. This is discussed by B. Bonnevier (1981).

IX A Bigger Big Bang

Let us for a moment drop a number of "prophetic" ad hoc hypotheses, viz.

(a) There is some orders of magnitude more mass in the universe than is really observed ("missing mass").
(b) The Hubble expansion was caused by supernatural effects at a singular point.
(c) The present Universe does not contain an appreciable amount of antimatter.
(d) cosmology can be treated by homogeneous models.

We try to construct a Universe which

(α) is essentially matter-antimatter symmetric
(β) the Hubble expansion is caused by well known processes (among them energy release by annihilation) in a region of 10^9 light years (a Bigger Big Bang)

(γ) does not contain large quantities of missing mass
(δ) we try to construct a Universe which is highly inhomogeneous and has a cellular structure.

What is said above does not lead to the conclusion that we accept the Klein cosmology as it was presented.

X How to approach cosmology

In fact Klein bases his analysis on the assumption that very long ago the Universe consisted in an extremely large sphere of matter and antimatter. This classifies his theory as "prophetic". However the picture he gives of the evolution after the turning (the Bigger Big Bang) can probably serve as a guide line to an evolutionary actualistic approach. Whether this is correct or not can only be found if the observed present state of the Universe is used as a basis for a reconstruction of increasingly old states. It is reasonable to use well established laws of nature as a first approximation. The enormous mass of observations should be subject to an unbiased application of modern plasma physics as derived from extrapolation of studies of the reliable diagnostic regions etc.

The primary aim should be to try to reconstruct evolutionary history back to the "turning" (Fig.3). If this attempt runs into difficulties the time is ripe for drawing conclusions about missing mass etc.

XI Reconstruction of the evolutionary processes

Space research has resulted in a model of the "Plasma Universe" (see Fig.2). In his paper "Magnetosphere-Ionosphere Interactions - Near Earth Manifestations of the Plasma Universe" Fälthammar 1986 shows how successful the model is as the key to ionospheric and magnetospheric phenomena. In a recent paper Arp (1986) demonstrates the inadequacy of the conventional theories of galaxies, and suggests that an introduction of plasma effects - so far almost completely neglected - may lead to a better understanding. At the Venice conference in the honour of Arp it is suggested that the solution of the difficulties may be that the Plasma Universe approach be used (Alfvén 1987).

In the Plasma Universe not only the present state but also its prehistory is of importance. As discussed in § VII above there are two different types of approaches which are called "prophetic" and "actualistic". It has been proved that in cosmogony the actualistic approach is preferable (Alfvén 1986) and a number of prophetic approaches are now falling down. Because the galactic problems are similar to the ionospheric-magnetospheric problems this approach is likely to be preferable also in this field.

However, this does not mean that we necessarily should accept it in the case of cosmology.

We have above given a brief summary of the Klein cosmology. The conventional Big Bang is too well-known to need a recapitulation. Let us first state the respects where there are agreements. Both attribute the Hubble expansion to a big bang, and both are prophetic theories. Further, as Fig.3 shows they both give a similar Hubble diagram between now and back to about 0.1 T_H (T_H = the Hubble time).

However, this does not mean that the properties of the expanding plasma is the same. These properties are derived from the general properties of the early time plasma of the two prophetic theories.

As the cosmological problems are outside the "reliable diagnostic region" in Fig. 2 it is appropriate to derive the properties of the expanding plasma after 0.1 T_H from the Plasma Universe model. Hence we should apply an actualistic approach to this part of the Hubble expansion, and leave the discussion of what happened before 0.1 T_H for a later discussion. If this extrapolation seems reasonable i.e. if we succeed in a reconstruction of the state at 0.1 T_H we could use this as a basis for a discussion of earlier periods, but this is outside the aim of this paper.

XII Conclusions

What has been said above means that we should try to adopt the big bang cosmology to the Plasma Universe model in two different ways. Both may run into difficulties and only a free and unbiased discussion can clarify how to deal with these.

The first one is that we start from the traditional big bang, which necessarily leads to a number of difficulties. It is basically a "prophetic approach". The second approach starts from the present state of the Plasma Universe and attempts to reconstruct earlier states. Hence it is essentially an "actualistic approach". This certainly contains a number of uncertain and doubtful points. An essential point is that the Hubble expansion was caused by annihilation in a large region (10^9 light years). We call this a "Bigger Big Bang". We leave the early time part of the Klein cosmology - which is prophetic - outside the discussion.

Acknowledgements

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Figure Captions

Fig. 1 Leidenfrost layer. At the boundary between a region of matter and a region of antimatter there is a proton-antiproton annihilation which produces mesons rapidly decaying into 10^8 eV electrons and positrons. These from a very hot and extremely thin boundary layer separating the matter and antimatter regions. The radiation from this layer is so small that it is difficult to detect.
See B. Lehnert 1977, 1978, Astrophys. Space Sci., 46, 61; 53, 459. See also CP, Fig. VI.4.

Fig. 2 The Plasma Universe consists of a "Reliable diagnostic region in which laboratory experiments and *in situ* measurements makes a sophisticated study of a plasma possible. Outside the reach of spacecraft (black line) investigations must be based on a symbiosis between observation and the knowledge of plasmas gained from the reliable diagnostic region.
Introductory lecture at the MIT Plasma Physics Symposium, Jan. 9, 1987, Cambridge, Mass. (In press).

Fig. 3 Evolution of the Metagalaxy in Klein's model.
See CP Fig.VI.3. The time scale before the turning should be enlarged.

Fig. 4 Properties of magnetized plasmas.
From the Introductory lecture at the MIT Plamsa Physics Symposium Jan. 9, 1987, Cambridge Mass. (In press).

Fig. 5 The Big Bang which causes the Hubble expansion is, in the conventional Big Bang theory, attributed to a supernatural phenomenon at a singular point in time. In a Plasma Universe which is matter-antimatter symmetric it may instead be produced by a Bigger Big Bang with a size of 10^{+25} m, in which energy is released by annihilation according to well-known basic laws of physics, such as annihilation.

TWO KINDS OF BIG BANG

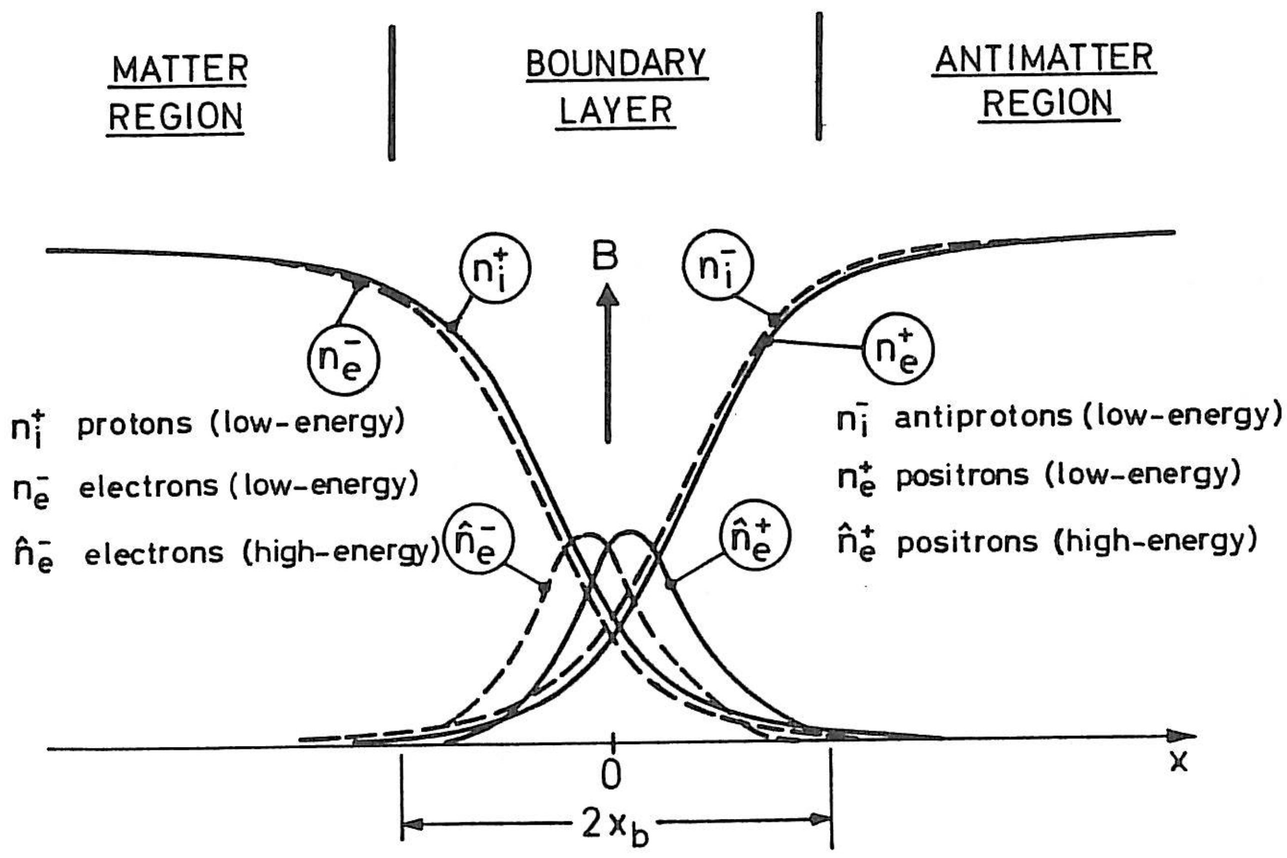
	SINGULAR BIG BANG	"BIGGER" BIG BANG
CELLULAR STRUCTURE OF SPACE	NEVER DISCUSSED	YES
ANTIMATTER	NO	YES
ISOTROPY OF RADIATIONS	ISOTROPY OF MICROWAVE BACKGROUND IS EXPLAINED	ISOTROPY OF COSMIC RADIATION IS EXPLAINED BY PLASMA PROCESSES. PROBABLY THE MICROWAVE ISOTROPY CAN BE EXPLAINED IN A SIMILAR WAY

IN MANY PLACES ONE OBSERVES SO LARGE ENERGY RELEASES THAT THEY CANNOT BE DUE TO NUCLEAR REATIONS. THERE ARE THREE AND ONLY THREE POSSIBLE SOURCES OF THESE. (1) GRAVITATION. (2) ANNIHILATION. (3) NEW LAWS OF PHYSICS.

QUASARS AND SIMILAR OBJECTS	GRAVITATION: COMPLICATED THEORIES BASED ON BLACK HOLES	ANNIHILATION
ACCELERATION OF OF THE HUBBLE EXPANSION	NEW LAWS OF PHYSICS	ANNIHILATION
MISSING MASS	ABOUT 100 TIMES THE OBSERVED MASS	NO MISSING MASS

IN THE PLASMA UNIVERSE THE MAIN CONSTITUENT OF INTERPLANETARY-INTERSTELLAR--INTERGALACTIC SPACE IS OBSERABLE PLASMA. THE MASS MEASUREMENTS COULD NOT BE WRONG BY A FACTOR 100. A LARGE QUANTITY OF MISSING MASS MUST BE A NON--IONISED MEDIUM WITH A RATHER SMALL INTERACTION WITH THE OBSERVED PLASMA UNIVERSE.

	SINGULAR BIG BANG	"BIGGER" BIG BANG
GEOMETRY	FOUR-DIMENSION. OBEYING GENERAL RELATIVITY. BASICALLY UNIFORM IN SPACE	BASICALLY EUCLIDEAN. GENERAL RELATIVITY IMPORTANT AS A 10% CORRECTION AND OF DECISIVE IMPORTANCE IN CONDENSED OBJECTS E.G. NEUTRON STARS. THE PLASMA UNIVERSE IS HIGHLY ANISOTROPIC.
GENERAL APPROACH	PROPHETIC	ACTUALISTIC (AFTER THE TURNING)
CREATION?	THE UNIVERSE WAS CREATED <u>EX NIHILO</u> IN A SINGULAR POINT OF TIME.	THE MATTER IN OUR METAGALAXY MAY EITHER HAVE EXISTED FOR AN INFINITE TIME OR IT MAY HAVE BEEN CREATED AT A TIME MUCH EARLIER THAN THE HUBBLE TIME.



MATTER REGION
BOUNDARY LAYER
ANTIMATTER REGION
n_i^+
B
n_i^-
n_e^-
n_e^+
n_i^+ protons (low-energy)
n_e^- electrons (low-energy)
$\hat{n}_e^-$ electrons (high-energy)
$\hat{n}_e^-$
$\hat{n}_e^+$
n_i^- antiprotons (low-energy)
n_e^+ positrons (low-energy)
$\hat{n}_e^+$ positrons (high-energy)
0
x
$2x_b$

FIG. 1

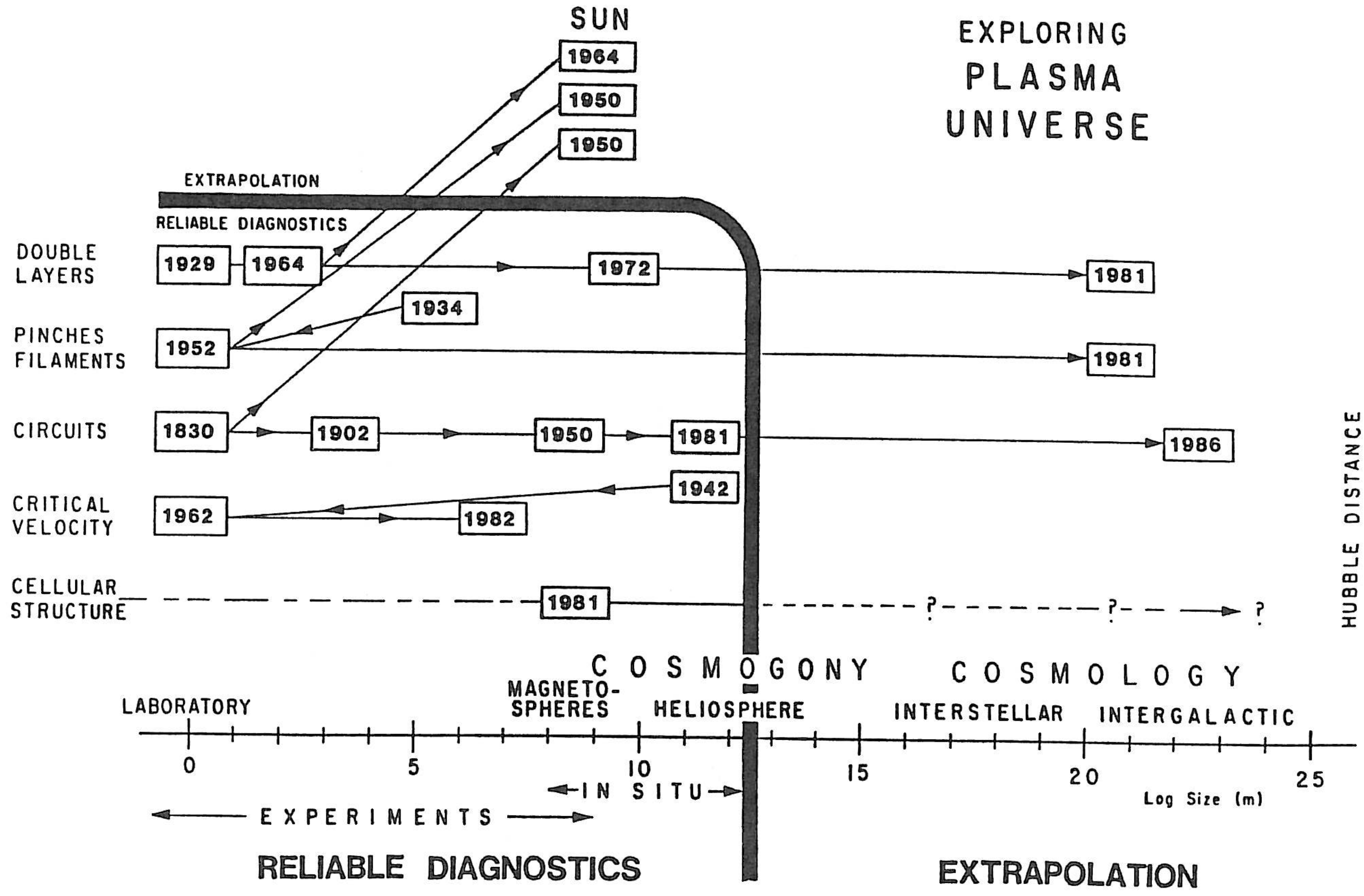

SUN
1964
1950
1950
EXPLORING
PLASMA
UNIVERSE
EXTRAPOLATION
RELIABLE DIAGNOSTICS
DOUBLE LAYERS
1929
1964
1972
1981
1934
PINCHES FILAMENTS
1952
1981
CIRCUITS
1830
1902
1950
1981
1986
HUBBLE DISTANCE
CRITICAL VELOCITY
1962
1942
1982
CELLULAR STRUCTURE
1981
?
?
?
COSMOGONY
COSMOLOGY
LABORATORY
MAGNETO-SPHERES
HELIOSPHERE
INTERSTELLAR
INTERGALACTIC
0
5
10
15
20
25
Log Size (m)
IN SITU
EXPERIMENTS
RELIABLE DIAGNOSTICS
EXTRAPOLATION

FIG. 2

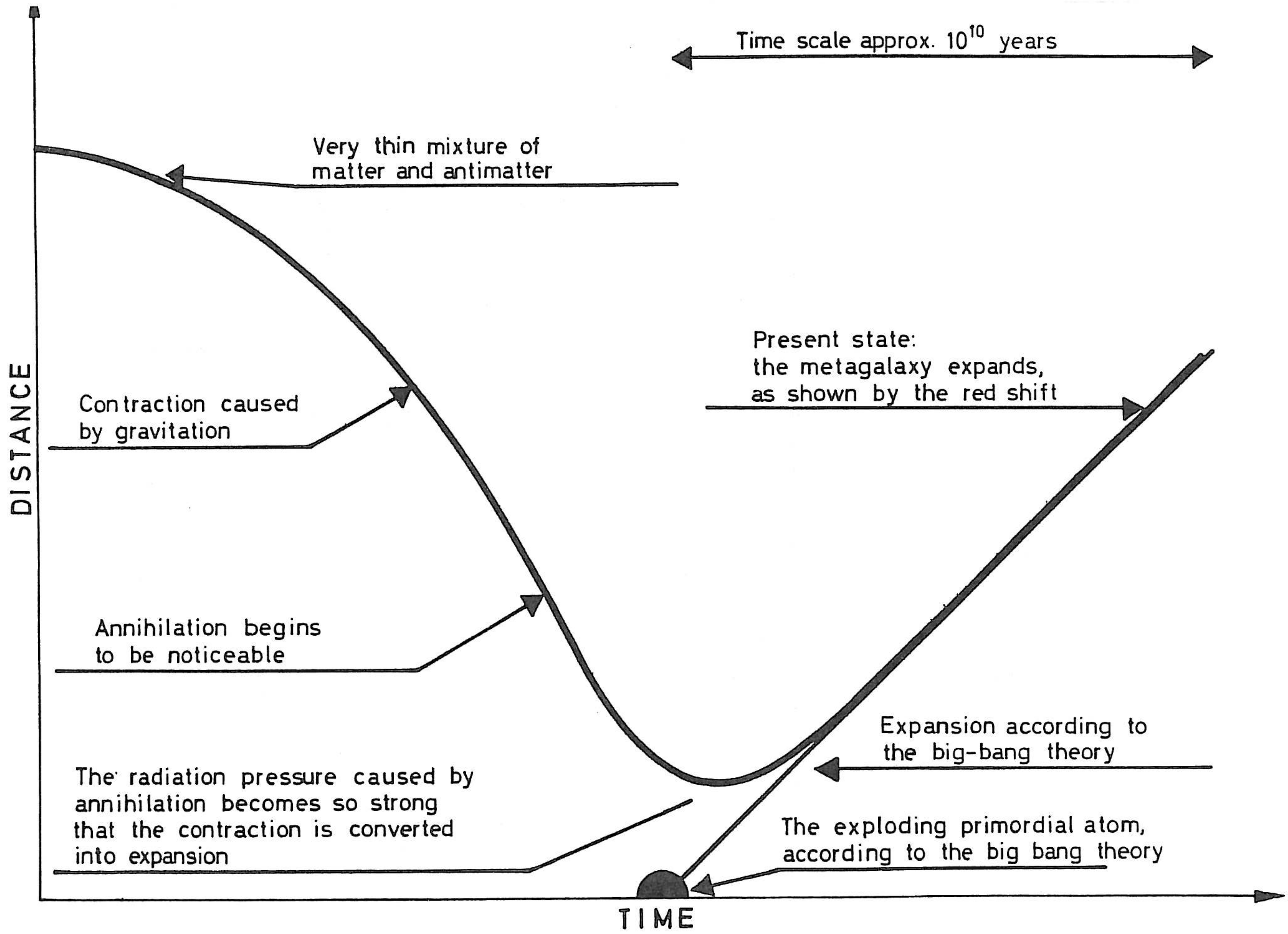

Time scale approx. 10^{10} years
Very thin mixture of matter and antimatter
DISTANCE
Contraction caused by gravitation
Present state: the metagalaxy expands, as shown by the red shift
Annihilation begins to be noticeable
Expansion according to the big-bang theory
The radiation pressure caused by annihilation becomes so strong that the contraction is converted into expansion
The exploding primordial atom, according to the big bang theory
TIME

FIG. 3

	FLUID PLASMA (MAGNETO-HYDRODYNAMIC)	PARTICLE PLASMA (COLLISIONLESS)
ENERAL PROPERTIES	SIMILAR TO FLUID	AN ASSEMBLY OF PARTICLES IN BALLISTIC ORBITS
OTION IN ELECTRIC FIELD	THERMAL MOTION SUPERIMPOSED BY ELECTRIC FIELD DRIFT	BALLISTIC ORBITS IN MAGNETIC AND ELECTRIC FIELD
ELOCITY DISTRIBUTION	ESSENTIALLY MAXWELLIAN	OFTEN ANISOTROPIC HAS A TENDENCY TO GENERATE VERY HIGH ENERGY PARTICLES: MAGNETOSPHERE KEV SOLAR ATMOSPHERE MEV GEV INTERSTELLAR SPACE POSSIBLY 10^{14} EV OR MORE
XISTS IN:	SOLAR, STELLAR PHOTOSPHERES IONOSPHERES COMET COMA	SOLAR CORONA ACTIVE REGIONS IN MAGNETOSPHERES COMET TAILS INTERPLANETARY, INTERSTELLAR, INTERGALACTIC SPACE
ADIATES	THERMAL (ESSENTIALLY VISUAL) RADIATION NO X-RAYS OR γ-RAYS	X-RAYS, γ-RAYS (BY COLLISIONS WITH RESIDUAL PARTICLES) "NOISE" GENERATION, ESPECIALLY IN CONNECTION WITH PRODUCTION OF HIGH-ENERGY PARTICLES
NERGY TRANSFER	LOCAL THEORIES CORRECT	ONLY GLOBAL THEORIES CORRECT BECAUSE CURRENTS TRANSFER ENERGY OVER LARGE DISTANCES (OFTEN MUCH LARGER THAN SIZE OF BALLASTIC ORBITS)
ROZEN-IN MAGNETIC FIELD	YES	NO
NERGY RELEASE THROUGH AGNETIC MERGING	POSSIBLE	NO. THIS IS LIKE COLUMBUS'S MISTAKE

FIG. 4

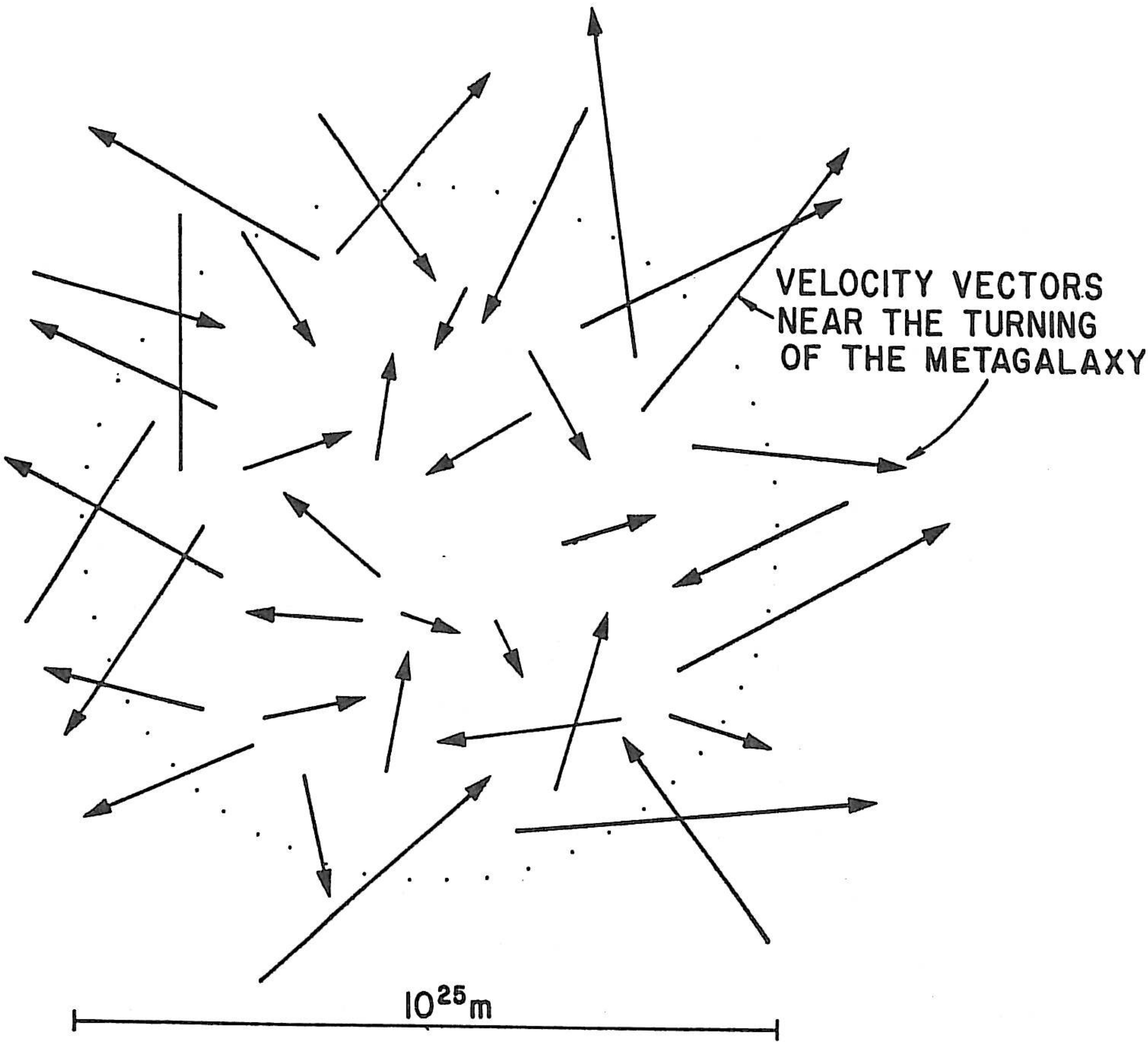


FIG. 5

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The purpose of this paper is to discuss what criteria a cosmological theory must satisfy in order to be acceptable in the Plasma Universe.

Key words: Cosmology, Plasma Universe, Big Bang, Reliable diagnostic region of space, Leidenfrost layer.