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The Cosmic Web, the Seed of Galaxies- Are Also Made of Warm Intergalactic Medium(WHIM) and Dark Energy?

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Abstract- Universe consisted of mysterious Dark energy (70%), Dark matter(25%) and that make up now 95% of matter in the universe which revel it self as gravity. Enormous filaments and blobs of dark matter in early universe condensed as universe condensed. Within the cosmic webs, all galaxies, stars, planets were next created. Galaxies are not dotted randomly throughout universe but are generally either concentrated in groups or in clusters, which are connected again by multitude of filaments and voids. These filamentary distributions of galaxies explained by vast quantities of dark matter enveloping galaxies and filamentary cold gas flowing within them, responsible for star formation within them and the dark matter ISM is the dominant mass in the universe. Galaxies over passing time, clumped itself in a filamentary networks.

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Strictly as per the compliance and regulations of :

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The universe is so permeated by a network of filaments, sheets, and knots collectively forming a "cosmic web." The discovery of the cosmic web, especially through its signature of absorption of light from distant sources by neutral hydrogen in the intervening intergalactic medium, exemplifies the interplay between theory and experiment that drives science and is one of the great examples in which numerical simulations have played a key and decisive role. We authors in this article recount the milestones in our understanding of cosmic structures; summarizing its impact on astronomy, cosmology, and physics; and look ahead by outlining the challenges faced as we prepare to probe the cosmic web at new wavelengths.

Keywords: large scale structure of universe; galaxies: clusters, cosmic webs WIMPs.

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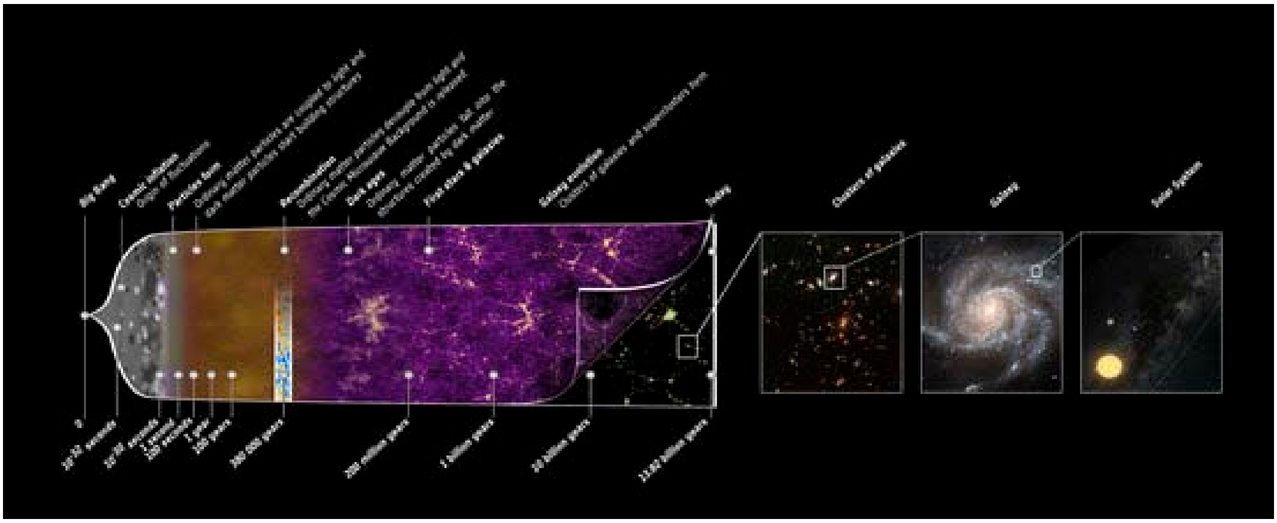

Figure 1

I. The Cosmic Web

The web is the frame work on which our universe was built, if at all it was once created. It consisted primarily of “dark matter,” a mysterious stuff that makes up 85% of the matter in observable universe but has revealed itself only through its gravity. Enormous amount of filaments and blobs of the stuff was condensed as the universe gradually matured and expanded. Within them seeds of galaxies and their stars, planets creating streams of light stretching between inky large voids. Voids are empty spaces filled with dark energies. Dark energy pervades everything, stretching space time and affecting the evolution of the cosmic webs.

So our universe is made of voids, filaments, knots and sheets known as cosmic webs. Each point in space time may be classified in one of four possible cosmic web types: voids, sheets, filaments and knots. Voids co-exist with a net of interconnected filaments. The entire observable universe is tangled in a web like structure, the frame work, on which universe was once built up. We all today know it also that universe consisted of mysterious *Dark energy* (70%), *Dark matter*(25%) and that make up now 95% of the matter in universe and which revel it self as gravity. Enormous filaments and blobs of dark matter in early universe condensed as universe condensed. Within these cosmic webs, all galaxies, stars, planets, planetismals, asteroids were actually created. Our universe consists of billons and billions numbers of galaxies, some are larger, some smaller, some are spiral disc shaped, like our Milky way, some non spiral, elliptical, some dwarf galaxies, some dark galaxies, some as say ferst galaxies some are in clusters. More than 700,000 galaxies, whose observed Doppler colors indicated a significant red shift and are therefore presumed to be at large cosmological distances. Galaxies are however not dotted randomly through out universe but are generally either concentrated in groups or in clusters, which are connected again by multitude of filaments. These filamentary distributions of galaxies can be explained by vast quantities of dark matter enveloping galaxies and filamentary cold gas flowing within them, responsible for stars formation within them and the dark matter ISM is the dominant mass in universe.

The observed large scale structure of universe is thought to be due to gravitational growth of density fluctuations in post-inflation era. In this model, the evolving cosmic web is governed by non-linear gravitational growth of the initially by weak density fluctuations in the dark energy dominated cosmology. The cosmic web can be now traced by a tiny fraction of luminous baryonic matter.

[Red shift - what is red shift? What is its relation with expansion of our universe? The red shift *termed as* *z*, of any kind of luminous sources is increase of measured radiations wavelength with respect to emitted one. It can be defined with mathematical equation as $z \equiv \lambda o - \lambda e \,/\, \lambda e$ where λe is wavelength of the radiation emitted by the luminous source and λo is the observed person one’s position in the earth measuring red shift of distant luminous objects. The physical explanation of the red shift, of course, is a direct consequence of expansion of our universe from Big Bang. In fact, one can demonstrate that expansion of space time caused also an increase of wavelength of emitted photons from the luminous source towards the observer person in the earth. One can demonstrate that the expansion of space time causes also an increase of the wavelength of the emitted photons from the source towards the observer. Using equation when applied to light rays in space time that travels along a geodesic of the space-time, which may be defined by $ds^2 = 0$, if one can fix te and t_0 as times when the radiation was emitted and observed, respectively, we have equations like $\int_{te}^{t0} cdt \,/\, a(t) = \int^{r}_{0} dr' / \; (1-Kr'^2)^{1/2} = fK(r)$. The light emitted from the source at the time $te + \delta te$ is then seen by the observer at $t_0+\delta t_0$ and since the two objects are following the cosmological expansion we have equation that $fK(r) = \int_{0}^{t}{}^{+\delta t}{}_{0\ te+\delta te}\, cdt/\ a(t)$, we obtain then $\delta t_0 / a_0 = \delta te/\ a(te)$ or when $a_0 = a(t_0)$, or equivalently $a(te)\ /\lambda e = a_0/\lambda_0$. From this relation it is also clear that the red shift and the expansion parameter of our universe are always interconnected. For a generic instant t we have, in fact, $1+ z = a_0 /a_{(t)}$ shows that the objects at the present time in observable universe have red shift $z = 0$ and that the red shift (z) grows at lower expansion factors]

At very high red shifts ($z > 1100$) the pre-galactic medium was very hot, was relatively dense, ionised, with a substantial pressure of radiations. The cosmic microwave background (CMB) observations constrain the amplitudes of density in homogeneities to be very small at the last scattering red shift $z \sim 1000$. The universe then expanded, the matter cooled, and eventually recombined, being mostly in neutral phase during the "Dark ages" of the universe. At some red shift, $6 < z < 14$, hydrogen in the universe was re-ionised, likely due to UV radiation from the first luminous objects, leaving the intergalactic medium (IGM) highly re-ionised state. The re-ionisation indicated the formation of the first luminous objects at the end of the "Dark ages", either by star forming galaxies or as Active Galactic Nuclei (AGN). At the same evolution stage, formation of strong density in homogeneities in the cosmic structure occurs. Since then the non-linear dynamical flows in the vicinity of density in homogeneities would have created large scale cosmic structure shocks of modest strength, thus heating up the baryonic matter and simultaneously producing highly non-equilibrium energetic particle distributions, magnetic fields and electromagnetic emission.

The most current theory of structures formation in the observable universe aims to explain, the structures were mostly homogeneous but slightly inhomogeneous too, Universe that we observe around us, 13.7 Gyr after the Big bang, as the outcome of the growth of the primordial density fluctuations of quark gluon plasma that are observed as the temperature variations in the CMB. The formations of galaxies were possibly the most prominent visual aspect of the formation of cosmic structures that were shaped by the interplay next between the pull of the gravity and the expansion of space under influence of Dark energy. Baryonic gas condensed in the gravitational wells that had already been established by the gravitational contraction of dark matter density perturbations. This condensation was followed by the formation of stars as filamentary cold gas flowed within them ,responsible for star formation within galaxies and thus the emission of photons. All galactic structures [galaxies over passing time , clumped itself in a filamentary network] through the gravitational instability, eventually formed a cosmic net work of voids, filaments, knots and sheets, because gravity was purely then attractive force, and regions of slightly higher density in the early universe accreted matter from their surroundings and grew more over dense, with time. In the cosmic web hypothesis, spherical structures appeared probably first within filaments, growing in between them, followed by the great walls [planar structures] connecting the filaments of cosmic Web. These filaments were spreded millions of light years long and did constitute the skeleton of the early Universe: Galaxies gathered around them, and immense galaxy clusters were formed at their intersections, lurking like giant spiders waiting for more matter to accreted. Scientists and physicists are today struggling to determine how they swirl into existence. Although massive filamentary structures have been often observed at relatively small distances from us. The filament is located about 6.7 billion light-years away from us and extends over at least 60 million light-years even. As our early universe evolved, the cosmic web gradually sharpened more & more, under dense regions known as voids, empty material known as filaments and these materials subsequently flowed into over dense knots.[In the cosmic web, under dense, almost empty regions of the universe, the voids, are delimited by great wall-like sheets and very elongated filaments of matter, which sporadically intersected each other, gave rise to very high-density regions, the clusters. Galaxies, including the most massive ones, are found in large concentrations at such 'nodes' of the web, the clusters; less massive galaxies are prominent in filaments; only very few galaxies inhabit the voids. Large scale structures in the distribution of galaxies were thought to have evolved through gravitational instabilities from small density fluctuations in the (largely homogeneous) early Universe. These structure of galaxies consisted of rich and poor clusters, were connected by filaments and sheets, with regions largely devoid of galaxies (voids) in between. Numerical simulations of the growth of initial density fluctuations through a nonlinear regime, motivated by the likely physics of the early Universe, also show a network of filaments and voids, but the origin of this picture of filaments as the dominant structure was not well understood. J. Richard Bond, Lev Kofman & Dmitry Pogosyan[1] showed in 1996 that the 'web' of filaments that defined the final state in these simulations was present also in the initial density fluctuations; the pattern of the web was defined largely by the rare density peaks in the initial fluctuations, with the subsequent nonlinear evolution of the structure bringing the filamentary network into sharper relief. Applying these results to the observed galaxy distribution, they suggested that 'superclusters' were filamentary cluster–cluster bridges, and we predict that the most pronounced filaments will be found between clusters of galaxies that are aligned with each other and close together.

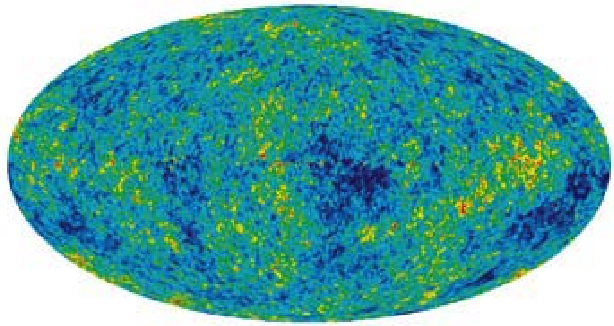

Figure 2

[All sky high resolution map of the microwave light emitted only380'000 years after the big bang and detected by the WMAP satellite. Colors correspond to temperature variations with amplitude of 10−5 around the2.7K black body spectrum. (Image courtesy of the NASA / WMAP Science Team]

a) *Between inflation and the release of the cosmic microwave background (t <1 sec to t =380,000 years)*

After the end of inflation, the universe so consisted of more or less uniform bath of fundamental particles, like zero rest mass particles(as it was told by Rupak Bhattacharya), Higgs particles(many kinds of Higgs particles are there), quarks, electrons and their all their anti-particles. There were also neutrinos, photons, dark energies, gravitons and dark matter particles- an unknown type of massive particle that did not interacted with photons and is therefore called as dark (as it does not emit light). At this time there was slightly more matter than anti-matter, but as the particles collided with their anti-particles they were annihilated, leaving the universe dominated by particles, and by some unsown mechanisms all anti-matter disappeared. Where and why all antimatters disappeared not known to us very well. Quarks then teamed up in trios, forming protons or neutrons – the constituents of atomic nuclei as we know them today. This all happened within the first second after the Big Bang epoch. About three minutes after the Big Bang, protons and neutrons had combined to form the nuclei of hydrogen and helium.

The density and temperature of particles in early universe were so extremely high, and collisions between the particles were then very frequent. Cosmologists refer to this by saying that ordinary matter (such as electrons, protons, neutrons and the few atomic nuclei that had formed by then) was tightly coupled to the photons. Because of these frequent interactions, photons could not travel freely: the universe was then opaque. Besides, ordinary matter is subject to gravity(by a particle called Gravitons) and ideally any denser region – such as the seed fluctuations that were present at the end of inflation – would draw more matter from their surroundings, growing denser and more massive. However, ordinary matter at this epoch was coupled to photons, and radiation pressure of photons pushed away any concentration of matter that may be created under the effect of gravity. This phenomenon prevented any fluctuations in the distribution of ordinary matter to grow denser as long as matter is coupled to the photons. At the same time, dark matter particles were not bound to the photons, since the two species do not interact with one another. This type of dark matter particle is also referred to as cold dark matter (CDM) because the velocity of these particles is much lower than the speed of light. Hence, fluctuations in the distribution of cold dark matter can grew denser and more massive even before the release of the cosmic microwave background. Astronomers also refer to hot dark matter (HDM), or they are neutrinos – particles with a very small mass and no electric charge that travel almost nearly at the speed of light. In the first second of the universe, neutrinos were coupled to photons, but these two types of particles decoupled immediately after. Since they do not interact with light during most of the universe's history, neutrinos considered as a type of dark matter, and since their velocity is close to the speed of light, they are regarded also as hot dark matter. Fluctuations in the distribution of hot dark matter grew denser and more massive, but due to their high velocity, these particles tend to dissipate and their fluctuations are damped on small scales so, effectively, only fluctuations on intermediate and large scales can grow. The growth of primordial fluctuations in hot and cold dark matter give rise to two completely different distributions of cosmic structure. In hot dark matter models, the first structures to form are the most massive, that subsequently fragmented into smaller and smaller structures. This has been discarded on the basis of observations of galaxies in the early universe: since the first objects that are seen to emerge in cosmic history had low mass, and they gradually evolved into more massive structures, cosmologists have established that the bulk of dark matter in the universe was enough cold. However, a small fraction of hot dark matter is present in the universe as neutrinos. Depending on the mass of neutrinos (which has not been determined yet but has mass) the effect of hot dark matter could be more or less evident in distribution of cosmic structure on different scales, since neutrinos tend to smooth out the formation of small-scale structures.

b) Between the release of the cosmic microwave background and the formation of the first stars and galaxies (t = 380,000 years to t = a few hundred million years)

About 380,000 years after the Big Bang epoch, the universe had expanded enough so that its density was much lower than at earlier epochs. Likewise, the temperature of the universe had also cooled down from the billions of Kelvin of the first few minutes and had reached about 3000 Kelvin. Protons and electrons could finally combine to form atoms of neutral hydrogen. Electrons disappeared from the view of photons and these two species decoupled from one another. This marked the beginning of the period known as the Dark Ages – a name arising from the fact that there were no individual sources of light, like stars, only clouds of neutral hydrogen was there.

The decoupling had two effects: photons became free to propagate across the universe, which was then largely transparent, and which we now can observe as the cosmic microwave background (CMB); on the other hand, ordinary matter particles were free to assemble under the effect of gravity. From this moment on, ordinary and dark matter could both react to gravity: denser concentrations of matter (both ordinary and dark) grew denser and more massive. Since dark matter particles was already created a network of dense and empty structures (voids), ordinary matter particles could feel the gravitational attraction from the densest concentrations of dark matter and fall toward them. But ordinary matter could also get rid of energy quite effectively by heating up and emitting radiation, which caused it to sink even further into the already existing regions of high matter density. These processes gave rise to a highly sub-structured network of sheets and filaments of ordinary and dark matter known as the cosmic web, which constitutes the skeleton supporting the later emergence of stars and galaxies. Eventually the densest concentrations gave rise to the first stars, leading to the end of the Dark Ages. The Light appeared from the first stars

c) After the formation of the first stars and galaxies (t = a few hundred million years to t = now)

A few hundred million years after the Big Bang, distribution of matter in the universe produced very dense knots at the intersections of the sheets and filaments that made up the cosmic webs. In these knots, the density of ordinary matter was so high that the formation of stars and galaxies became possible. Eventually the first stars and galaxies sparked into existence and light could escape from them, revealing the distant universe to telescopes today. The first stars were formed almost exclusively out of hydrogen and helium and are believed to have been extremely massive (about 100 times the mass of the Sun or more) and to have lived very short lives, exploding soon after their formation as supernovae and releasing their material in the surroundings, triggering the birth of new stellar generations. Later generations included other elements formed in the nuclear furnace of previous stars, and their masses were typically smaller. The first generation of stars formed in relatively low-mass galaxies. Massive galaxies, and even more massive structures such as galaxy clusters, formed later.

d) How did the formation of structure affect the cosmic microwave background?

The birth of first stars and galaxies had an interesting effect on the cosmic microwave background (CMB) photons. Ultraviolet radiation released by these objects ionised hydrogen atoms, turning them back into protons and electrons. This created a series of expanding bubbles of ionised gas – a bit like the holes in Swiss cheese – and within a few hundred million years these bubbles had merged and the entire Universe was ionised again, a period of time termed re-ionisation according to late Prof Meghnad Saha.

The CMB photons were affected by the re-ionisation; they were scattered off the free electrons in the re-ionised universe, washing out some of the primordial fluctuations in the CMB as we observe it today. Since this happened when the universe was already matured and had reached a substantial size, the effect of re-ionisation can be detected in the fluctuations of the CMB on large scales. This effect is expressed in terms of the 'opacity', which describes the average density of free electrons that are present along the line of sight between an observer (in this case, the telescope on board Planck) and the CMB. This parameter also provides a tool to estimate when the first stars formed.

e) How is the history of cosmic structure encoded in the cosmic microwave background and power spectrum?

The variations in the density of matter at the time when the cosmic microwave background (CMB) formed derive from the seed fluctuations that were produced at the end of inflation and can be deciphered by looking at the power spectrum for cosmic structure in the universe at a range of scales. At scales smaller than about one degree – or twice the size of the full Moon on the sky – the graph shows the imprint and oscillation pattern of sound waves that were present in the fluid of ordinary matter and radiation in the very early universe, before the CMB was released. The sound is like Hissss and ever fantastic rythmical musical one of finest tunes. At this epoch, ordinary matter was tightly coupled to the photons, and the radiation pressure of photons pushed away any concentration of matter that might have been created under the effect of gravity. The interplay between gravity, which pulled together the fluid of matter and radiation, and the radiation pressure, which pushed it away, caused a series of rhythmical compressions and rarefactions everywhere in the fluid. This results in the pattern of fantastic sound waves that

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is visible in the central part of the power spectrum graph. Since gravity is caused by both dark and ordinary matter particles, but the radiation pressure of photons is only experienced by ordinary matter (because dark matter particles are not coupled to photons), the shape of these oscillations contains information about the amount of ordinary matter relative to the amount of dark matter. As dark matter was not bound to the photons, any concentration of dark matter could grow denser and denser even before the release of the CMB. The relative contribution of ordinary matter particles (also referred to as baryons) to the overall cosmic budget is expressed in terms of the 'Omega_b' parameter, where b stands for baryons, and the relative contribution of cold dark matter particles is expressed in terms of the 'Omega_c' parameter, where c stands for cold. The 'cold' in cold dark matter refers to the low speed of these particles ('warm' dark matter particles move at higher speed and 'hot' dark matter particles move at the speed of light).

While gravity pulls matter together to form structures, the expansion of the universe may counteract this effect and hamper the formation of cosmic structure. For this reason, the amount of fluctuations in the universe depended also on the speed of cosmic expansion, and that quantity can be extracted from the shape of the oscillations in the power spectrum of the CMB. The speed of the universe expansion is expressed in terms of the Hubble constant, H_0, which quantifies the expansion of the Universe at present time.

f) What does the cosmic microwave background tell us about the overall 'shape' of the Universe?

The CMB holds clues to the nature and distribution of structure in the universe, and the average density of this matter played a key role in determining the geometry of the universe. The geometry of the universe could take on one of three shapes: it can be curved like the surface of a ball and finite in extent (positively curved); ii) curved like a saddle and infinite in extent (negatively curved), or iii) it can be flat and infinite. The geometry and density of the universe are related in such a way that, if the average density of matter in universe is found to be less than the so-called critical density (roughly equal to 6 hydrogen atoms per cubic metre) the universe will be open and infinite. If the density is greater than the critical density the universe will be closed and finite. If the density just equals the critical density, the universe is flat.

Cosmologists studied the relative sizes of the oscillations of the fluid of matter and radiation at the time the CMB was released to learn more about the shape of the universe. The oscillations translated into regions of higher and lower temperature on the CMB map, and contain information about the amount of particles present. More specifically, the shape of the universe can be determined by looking at where the first of these oscillations appears in the power spectrum. The location of the first oscillation corresponded to a specific size in the early universe called the sound horizon – the maximum distance that a sound wave could have crossed from the Big Bang until the time of the CMB release. To cosmologists, the sound horizon works like a standard measure of known length. By measuring its length in the temperature fluctuations of the CMB, it is possible to determine if the universe is flat or curved. This is expressed in terms of the parameter 'Omega_K' and is equal to zero for exactly flat space

II. The Formation of Structures in the Universe

One of the main goal of todays cosmology is understanding of formation of the structures that we observe in the universe nowadays as various types of galaxies, super clusters, all stars and planets ,satellites asteroids . The Jeans theory of *gravitational instability*, is able to explain mechanism of formation of stars from a quasi homogeneous gas/or fluid, can also be used in the framework of the expanding universe in order to describe, at first order, the formation of galaxies. The standard model predicts the existence of small fluctuations in density field, originated in first instants after the Big Bang by quantum oscillations of the scalar field driving the expansion in the inflationary epoch. The CMB observations measured the amplitude of fluctuations of the primordial universe and it is possible to show how their gravitational amplification could explain formation of large scale structures of universe. As and according to the standard model the scenario of formation predicted that galaxies which were first objects to form, while the structures on larger scale (e.g. clusters and super clusters) were generated via merging of smaller objects: therefore, this picture is called hierarchical clustering. We authors of this article let now describe the basis of the Jeans theory that is able to explain the growth of small density fluctuations: the basic concept is that the perturbations of a uniform fluid are able to grow if self-gravity is able to dominate the stabilizing effect of pressure. The basic laws that describe the dynamics of a self-gravitating fluid are the continuity, the Euler and the Poisson equations

$$\partial\rho / \partial t + \vec{\nabla} \cdot (\rho \vec{u}) = 0$$

$$\partial\vec{u} / \partial t + (\vec{u} \cdot \vec{\nabla}) \sim u = -1/\rho \vec{\nabla} p - \vec{\nabla} \Phi$$

$$\nabla 2 \Phi = 4\pi G \rho$$

where ρ, $\vec{u}$ and p are the density, the velocity and the pressure of the fluid element and Φ is the gravitational potential. In this analysis we neglected the effects of thermal conduction and viscosity. This means that we are assuming the conservation of entropy per unit of mass S, described by the following equation

$$\partial \vec{S}/\partial t + \vec{u} \cdot \vec{\nabla} S = 0$$

The system composed by the last 4 equations admits a static solution of the kind $\rho = \rho 0$, $\vec{u} = 0$, $S = S0$, $p = p0$, $\vec{\nabla}\Phi = 0$. However this is not compatible with the cosmological principle, because from the Poisson equation a uniform density implies that Φ varies spatially. In other words this means that a fluid with homogeneous density distribution cannot be stationary and must be globally expanding or contracting. For what concerns cosmology, we must consider the solution corresponding to the expansion (or contraction) of a homogeneous and isotropic distribution of matter:

$$\rho(t) = [\alpha 0/\alpha(t)]^3 \rho(t0)$$

$$\vec{u} = \dot{\alpha}(t)/\alpha(t)\vec{r}$$

$$\Phi = 2\pi G/3\,\rho r^2$$

$$p = p(\rho, S)$$

$$S = const$$

This solution also has the problem that both u and Φ diverge for $r \to \infty$ that can be solved adopting the more accurate relativistic solution, If now we introduce small perturbations δ, $\vec{v}$, φ, dp and dS to all the physical variables, so that

$$\rho = \rho 0 + \delta\rho 0 = \rho 0(1+\delta)$$

$$\vec{u} = \vec{u}_0 +, \vec{v}, \Phi = \Phi 0 + \varphi, p = p0 + dp, S = S0 + dS$$

where the index '0' represents the zeroth-order solutions, and put these new values into the system, neglecting the second-order terms, we obtain the new system of equations:

$$\delta. + 3a/ax\delta + \dot{}a/a(\vec{r} \cdot \vec{\nabla})\delta + (\vec{\nabla} \vec{v}) = 0$$

$$\dot{\vec{v}} + \dot{}a/a\,\vec{v} + \dot{}a/a(\vec{r} \cdot \vec{\nabla})\vec{v} = -1/\rho\,\nabla dp - \nabla\varphi$$

$$\nabla 2\varphi - 4\pi G\rho 0\delta = 0$$

$$.dS + \dot{}a/a\,(\vec{r} \cdot \vec{\nabla})dS = 0$$

perturbations in the form of small plane-wave departures by the unperturbed one:

$$du_i = u_i(t)e^{i\vec{k}\cdot\vec{r}},$$

where the variables ui (i=1, 2, 3, 4, 5) correspond to the small perturbations in the different variables and the wave vector $\vec{k}$ corresponds to a wavelength λ that varies with time following the Hubble expansion:

$$k = 2\pi/\lambda = 2\pi/\lambda 0 \times a_0/a = k_0 x a_0/a.$$

These primordial perturbations are considered that constituted the "seeds" for the formation of the structures in the early universe But The Jeans theory is valid only for $|\delta| \ll 1$, while the structures observed nowadays correspond to over densities $|\delta| \gg 1$, for example a cluster of galaxies correspond to a value of δ of several hundred.

III. Current Results on Cosmology The CDM Model

Current observational data suggest as a favourite scenario the so-called *"concordance" Cold Dark Matter* (ΛCDM) model. In this picture the Universe remains flat with the energy density at the present epoch dominated by a cosmological constant and the remaining fraction mainly due to non-baryonic, non-collisional dark matter (DM) with low primordial velocity dispersion. The fraction of density due to standard baryonic matter Ω_b is only of few percent. After the radiation epoch ($z \sim > 104$), the DM component starts to dominates driving the growth of the density fluctuations up to the epoch of recombination when they become observable as gas temperature fluctuations imprinted in the CMB anisotropies. Since the CDM particles have a low velocity dispersion, the typical perturbations that survive to the effect of free-streaming correspond to masses of the order of $M \approx MJ(z_{rec}) \approx 10^5 M\Theta$, thus to the typical scales of proto galaxies.

Therefore, in this scenario galaxies form first while clusters are created via merging of smaller objects: this picture is called *hierarchical clustering* of structure formation. The dark energy component starts to dominate the expansion at $z \leq 0.5$ and, it has the effect of accelerating the expansion of the Universe. The main problem with the existence of this energy component, its physical origin is still unknown: the most natural explanation is the vacuum energy but the energydensity $\varrho\Lambda$ currently estimated is of the order of

a) Cosmic web even in dwarf and local group galaxies

The near by filaments of the cosmic web connected also our local group of galaxies to large scale cosmic web and computer simulation model reveal that these filaments should channel a steady rain of pristine dwarf galaxies which are too composed of dark matter into the local environment. Because filaments fall into them, also in firm large distances and accrete over a large fraction of the age of universe. These dwarf galaxies that are in process of arriving today can be expected to exhibit very large speed gas is also conveyed into galaxies along the filaments but because of presence of gravitational forces this is rapidly slowed down, first shock heating and then condensing into clouds that fall into the center of gravitational well and contribute to build up gaseous disk component of galaxies. Cloud of active hydrogen known as high velocity cloud surround so our milky way and andromeda galaxies. Hence both large galaxies within local group appear to be continuously accreting gas fed to them from the cosmic web. The question still to be solved as per authors, is how the large-scale cosmic environment of a CDM universe affected the internal properties of dark matter haloes and of the baryonic galaxies, they hosted during their formation and the subsequent billion years of cosmic evolution in 2003, NASA's Wilkinson Microwave Anisotropy Probe (WMAP) spacecraft mapped the afterglow of the big bang, the cosmic microwave background (CMB), to produce, in essence, the universe's baby picture. The universe supposedly sprang into existence infinitely dense and hot and immediately doubled its size 100 times over. After about 10–32 seconds of such "inflation," the expansion slowed, and 400,000 years later, the universe cooled enough to allow free-flying protons and electrons to form hydrogen atoms. That transformation freed light trapped by the particles, which has since stretched into microwaves and cooled to 2.725 kelvin. The CMB is not exactly uniform. Inflation magnified infinitesimal quantum fluctuations in the newborn universe, which eventually seeded the filaments in the cosmic web. The fluctuations also caused the temperature of the CMB to vary across the sky by about 0.001%.

The COBE (Cosmic Background Explorer Study) could detect small anisotropy, subsequently mapped in sharp detailed by WMAP (Wilkinson Microwave Anisotropy Probe) imprinted on the cosmic Microwave Back Ground (CMB) when universe was 3, 80,000 years old. COBE study fueled the model of growth structure universe and mini scale fluctuations in very early universe. The fact, very little is known about the energy and Mass of the Universe, within the frame work of Standard cosmological model. 95% of the universe (Ω the mass density of the universe divided by the Critical density for closed universe) is corporated primarily of Dark energy (72%) and Dark Matter(23%) and only 5% is the detectable matter. As baryons [most of which is hydrogen and helium], - the protons, atomic nuclei that constitute of ordinary matter, galaxies, Stars, planets, Planetismals, all comets, all planets, all living and dead trees, all animals and ourselves and all the materials we see, The remaining 95% matter is mysterious in nature. The dark energy is assumed to be uniform, but the normal and dark matter are not. The balance between dark matter and dark energy determines both how the universe expands and how regions of unusually high or low matter density evolved with time. We can, should detect and measure it in physical state. From studies of Quasars we know that clouds of baryons were present in the early universe about 4 billion years ago(red shift $Z > 2$) in the form of Photo Ionized diffuse high speed intergalactic gas as told just in previous paragraph and that accounted 3/4th of total baryonic mass in the universe. When nucleon synthesis happened with observed light elements at $Z>2$, $\Omega b>3.5\%$, 75% estimated baryons mass were involved. These clouds of Photo ionized intergalactic gas became more and more sparse as time moved towards present and structures like galaxies, galaxy groups, galaxy clusters started to be assembled, only a small fraction of the baryons that were present in Intergalactic medium(ISM) at red shift $Z>2$ are found in stars, cold or warm ISM hot inter cluster gas and residual photo ionized inter galactic medium and it is estimated that 50% of baryon mass is still missing. Most of the baryons in the local universe are also missing in that they are not in galaxies or in the previously detected gaseous phases. Rupak Bhattacharya and Pranab Bhattacharya suggested that these missing baryons are so predicted may be in a moderately hot phase, 1E5 to 1E7 K, largely in the form of giant cosmic filaments that connect the denser virialized clusters and groups of galaxies. These filaments can be detected through absorption lines they produce in the spectra of background AGNs. Models show that the highest covering fraction of such filaments occurs in super clusters and the archive has two AGNs projected behind superclusters, both of which show absorption systems (in LyalphaLybetaOVI) at the super cluster red shift.

b) Question to be solved yet

The question still to be solved as per authors are what are the properties of dark matter and dark energy? Precisely how is the web organized? Exactly how do galaxies form in it? The web spans size scales from individual galaxies to the breadth of the observable universe. In its evolution, it traces the complexity we see today back through time to the big bang how the large-scale cosmic environment of a CDM universe affected the internal properties of dark matter haloes and of the baryonic galaxies, they hosted during their formation and the subsequent billion years of cosmic evolution?.

Unlike the ''baryonic' matter (neglecting the real fact that there are also leptons that, however, contributed very negligible mass of universe), dark matter does not interact appreciably in any other way than through gravity —the weakest but only real long-range force among the four fundamental forces that govern the laws of universe. The best candidates for dark matter is probably till date so far is Cold Dark Matter(CDM), a kind of dark matter that has non-relativistic energies already at very early times and thus led to a bottom-up theory of galaxy structures formation in the early universe in COBE. Dark energy is on the other hand required to explain the observed accelerated expansion of space time (or in other way, equivalently, the weakening of gravity on very large scales and responsible for the expansion of the universe). Baryonic matter thus appeared to be a subdominant component that, while making up all the visible objects in the Universe, is not the most important ingredient in the attempt to understand the structure of the Universe.

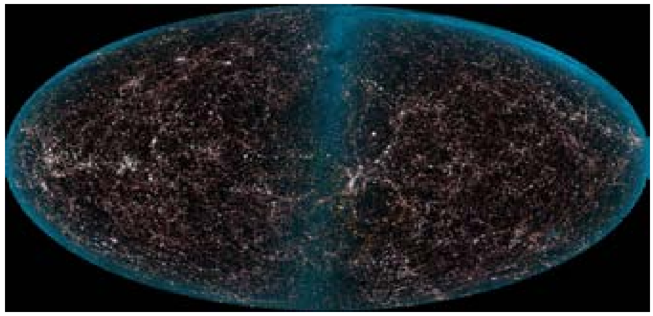

Figure 3

[The highly inhomogeneous universe in 13.7 Gyr, all sky distribution of infrared sources (mostly galaxies) from the Two Micron All Sky Survey (2MASS) in the nearby Universe. The filamentary nature of the cosmic web is clearly visible. (Atlas Image courtesy of 2MASS/UMass/IPAC-Caltech/NASA/NSF).]

c) N body Simulations study of Cosmic Web

This cosmic web is the large-scale environment, in which galaxies formed and evolved and its existence had been established in large red shift surveys($z > 2$)of many hundred thousand galaxies over the last decades. Since dark matter interacts only gravitationally, it is thus relatively easy to model and computationally affordable. For many years, the numerical study of cosmic structures formation had therefore been focused on the realm of N-body simulations [Simulations that use a particle discretisation of the phase-space are known as N-body simulations. In these simulations, the phase-space density $f(x, p, t)$ is discretized with massive particles and evolved according to the collision less limit of the Boltzmann equation, Thus, in the N-body method, the initial phase space is sampled with particles representing a small sub volume of the full 6-dimensional phase space. Each one of these particles is then evolved in a self-consistent way, fulfilling Liouville's theorem (cf. e.g. Hockney & Eastwood, 1981). The numerical evolution thus requires two steps: (1) a gravity solver, to compute the particle accelerations, and (2) a time integrator, to update particle positions and momentum.]i.e. the Vlasov equation, under self-gravity]: which have had a huge success in showing that the spatial distribution of gravitationally collapsed structures — the dark matter haloes — is highly compatible with the observed distribution of galaxies. Dark matter haloes are connected to each other by large-scale filamentary structures. Cold gas flowing within this 'cosmic web' is believed to be an important source of fuel for galaxy and star formation at high red shift. These simulations are still giving important insights into the detailed aspects of spatial clustering, mass distribution and even internal properties of galaxies through additional semi-analytic models that attempt to relate the properties of galaxies to those of the dark matter haloes in which they are embedded. The physics of baryonic matter is in contrast very complex and computationally expensive. However, it is baryonic galaxies that we see and use to constrain our cosmological theories to reproduce the one Universe in which we live. Including baryonic matter in our simulations of the universe is a challenging necessity to bring our understanding of structure formation to the next level. Only rather recently, the huge growth in available computer power has opened the spectacular possibility to study the condensation of the baryonic gas component into galaxies in cosmological simulations. Gas is able to radioactively cool and thus settles in the centers of the dark matter haloes. 'Sub-grid' models capture the collapse of gas clumps below the resolution limit, making it possible to simulate the formation of stars. The simulated disk galaxies thus consist of a dark matter halo filled with hot gas, a cold gaseous disk and a stellar disk. The quest has indeed started to use such hydrodynamic cosmological simulations to further our detailed understanding of the formation and evolution of galaxies and structure in the universe.

From the point of view of cosmology, the vacuum or voids appears to have an energy density, which may be called "dark energy" or the "cosmological constant" From a particle physics viewpoint, the vacuum is also permeated by a "Higgs Field" - named after physicist Peter Higgs,

Since 2010 , many important studies across the world, showed that the main constituents of the universe, across 90 percent of its history, from the formation and evolution of structures such as galaxies, clusters of galaxies, and the "cosmic web" of intergalactic matter, to the stars, gas, dust, super massive black holes, and dark matter of which they are composed. These elements are coupled in a complicated evolutionary progression as matter accreted into galaxies, stars form and evolve, black holes grew, supernovae and active galactic nuclei expelled matter and energy into the intergalactic medium (IGM), and galaxies collide and merge. There remained four questions to be solved yet ,form the focus for research in the coming decade. The questions are: (1) How do cosmic structures form and evolve? (2) How do baryons cycle in and out of galaxies, and what do they do while they are there? (3) How do black holes grow, radiate, and influence their surroundings? (4)

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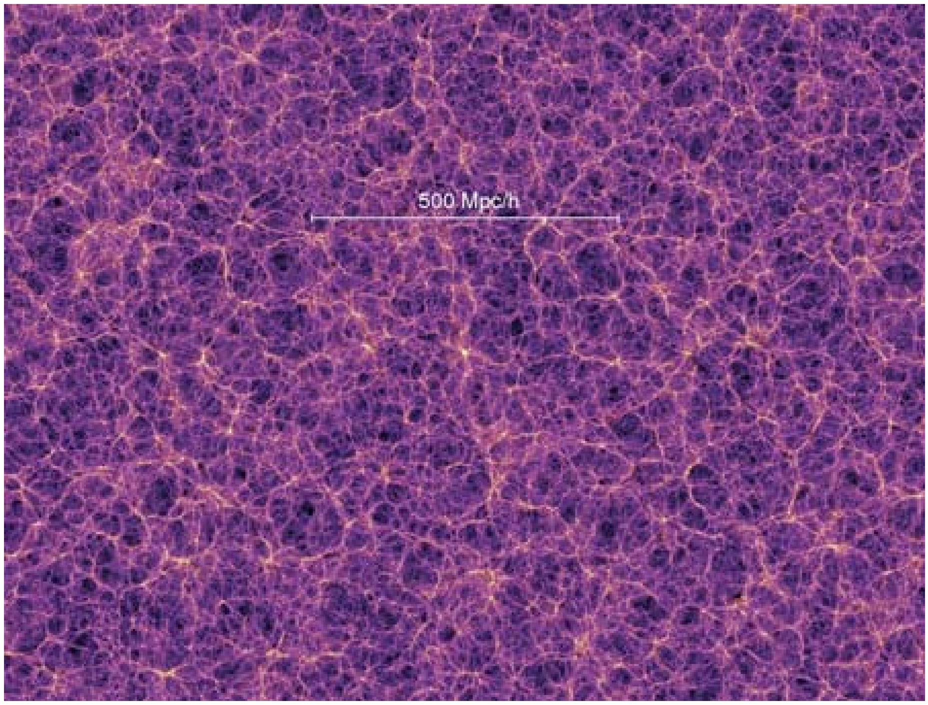
What were the first objects to light up the universe and when did they do it?



[Caption -: Simulations based on the standard cosmological model, as shown here, indicate that on very large distance scales, galaxies should be uniformly distributed. But observations show a clumpier distribution than expected,(The length bar represents about 2.3 billion light years)

Figure 4

[Caption -: Simulations based on the standard cosmological model, as shown here, indicate that on very large distance scales, galaxies should be uniformly distributed. But observations show a clumpier distribution than expected. (The length bar represents about 2.3 billion light years.]

In the modern hierarchical theories of galaxies structure formation, It is considered that rich clusters of galaxies formed at the vertices of a web like distribution of matter, with filaments emanating from them to large distances and with smaller objects forming and draining in along these filaments. The amount of mass contained in structures near the clusters can be comparable to the collapsed mass of the cluster itself. As the lensing kernel is quite broad along the line of sight around cluster lenses with typical red shifts z_l=0.5, structures many mega parsecs away from the cluster are essentially at the same location as the cluster itself, when considering their effect on the cluster's weak lensing signal. When large-scale numerical simulations of structure formation in a Λ-dominated cold dark matter model was used to quantify the effect that large-scale structure near clusters has upon the cluster masses deduced from weak lensing analysis. A correction for the scatter in possible observed lensing masses should be included when interpreting mass functions from weak lensing surveys.

It was in fact Jerome Drexler, an applied armature physicist who hypothesized and discovered the relativistic-baryon dark matter in early part of 2002 and the dark matters was considered to be engaged in galaxy formation. But Drexler's hypothesis of relativistic dark baryons, would imply that the Dark matter cannot clump on galaxy scales since they are relativistic. The alternate hypothesis might be that Relativistic-baryons entered the universe at the time of the Big bang as a radial outward dispersion of very high energy relativistic charged particles, having low entropy. Because of their very low entropy, the big bang could satisfy the Second Law of Thermodynamics. The initial very high energies of the big-bang relativistic baryons would correspond to the estimated initial temperatures in the current big bang theories. Actually, relativistic-baryon dark matter forms into long large filaments that can create galaxy clusters, galaxies, and stars, but only after those dark matter filaments collide with other similar long large dark matter filaments (http://www.nature.com/nature/journal/v435/n7042/fig_tab/435572a_F1.html what drexler recenly told[2]] New Releases from website from NASA/Harvard, entitled "Motions in nearby galaxy cluster reveal presence of hidden superstructure," regarding Chandra x-ray images of the Fornax cluster makes the significant statement: "Astronomers think that most of the matter in the universe is concentrated in long large filaments of

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dark matter [now called the "cosmic web"] and galaxy clusters are formed where these filaments intersect[/collide]." [2]

http://www.nasa.gov/centers/marshall/news/news/relea ses/2004/04-231.html) according to the 2004 NASA/Harvard/Columbia University team, relativistic-baryon dark matter does not form galaxy clusters or galaxies until after the dark matter filaments intersect/collide. These collisions slow the relativistic protons and helium nuclei and also create pions and muons, which decay into electrons. The created electrons then transform the slowed protons and helium nuclei into hydrogen and helium atoms, the basic ingredients of galaxies and stars. Thus, these remnants of the dark-matter-filament collisions are ideal for forming galaxies, galaxy clusters, and stars.

d) Warm matter in formation of galaxies and cosmic Web?

The most accepted model of cosmology structure formation is so till date CDM model including the dark energy, or from that particle universe evolved as baryons in diffuse intergalactic medium accelerated towards the site of formation of such structures under influence of gravity and shocks and that heats trillions of Kelvin temperature. The question then remains What is that Dark energy? If from dark matter, What is dark matter? It is distinct from Dark energy? How that matter organized and how is cosmic web organized? How galaxies formed in it? Are the dark energy the zero rest mass particles in Higgs fields and photon that was emitted later with formation of stars is condensation of zero mass (mass less particles), Rupak Bhattacharya and Professor Pranab kumar Bhattacharya suggested? Are they missing baryons? Is it possible that the missing baryons may be concentrated into those filamentary cosmic web structures and they are hot intergalactic medium(WHIM)?The distribution of baryons beyond galaxies thus may be described. The majority of the baryons, which represent 4% of the cosmic mass and energy budget, lie far from individual galaxies in the diffuse intergalactic medium (IGM). Many of these baryons may be in a warm phase that can be probed by quasar absorption in the Lyman-α line of hydrogen. The mature field of quasar spectroscopy can diagnose the location, physical state, metallicity, and general geometry of this gas, which is called the "cosmic web." The remainder of the gas is kept very hot by in fall and shocks and is mostly in higher density regions such as filaments, groups and clusters. The hot gas is only detectable via X-rays and the absorption of highly ionized species of heavy elements. The baryons in low density regions of space are excellent tracers of underlying dark matter. The evolution of the cosmic web indicates where to look for the baryons in collapsed objects but the overall inefficiency of galaxy formation has conspired to keep most baryons dark.

Scientists think dark energy is a form of repulsive gravity that now dominates the universe, although they have no clear picture of what it actually is. Understanding the nature of dark energy is one of the biggest problems in science. Possibilities include the cosmological constant, which is equivalent to the energy of empty space. Other possibilities include a modification in general relativity on the largest scales, or a more general physical field. Vikhlinin and his colleagues used Chandra to observe the hot gas in dozens of galaxy clusters, which are the largest collapsed objects in the universe. Some of these clusters are relatively close and others are more than halfway across the universe. increase in mass of the galaxy clusters over time aligns with a universe dominated by dark energy The study strengthens the evidence that dark energy is the cosmological constant. Although it is the leading candidate to explain dark energy, theoretical work suggests it should be about 10 raised to the power of 120 times larger than observed. Therefore, alternatives to general relativity, such as theories involving hidden dimensions, are being explored. These results have consequences for predicting the ultimate fate of the universe. If dark energy is explained by the cosmological constant, the expansion of the universe will continue to accelerate, and the Milky Way and its neighbor galaxy, Andromeda, never will merge with the Virgo cluster. In that case, about a hundred billion years from now, all other galaxies ultimately would disappear from the Milky Way's view and, eventually, the local super clusters of galaxies also would disintegrate.

References Références Referencias

1. J. Richard Bond[*], Lev Kofman[†] & Dmitry Pogosyan How filaments of galaxies are woven into the cosmic web *Nature* 380, 603 - 606 (18 April 1996); doi:10.1038/380603a0; 1996.
2. Jerome Drexler "Relativistic-Baryon Dark Matter Utilizes Cosmic Web Collisions to Create Hydrogen and Helium Atoms Discovering Dark matter Cosmology" in website Jerome Drexler Discovering Dark matter cosmology (http://www.nature.com/nature/journal/v435/n7042/fig_tab/435572a_F1.html