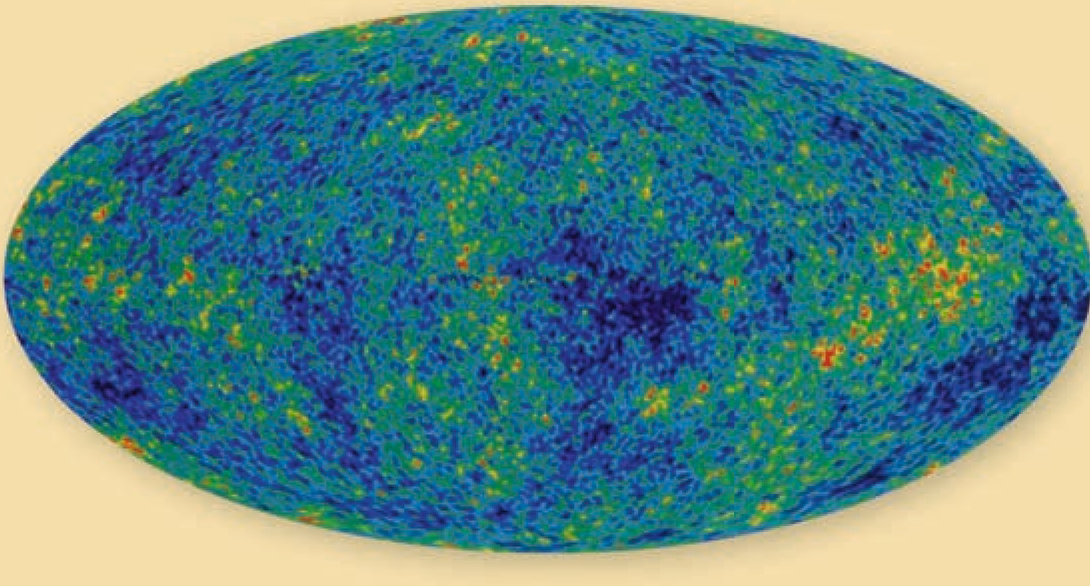
Charalampos D. Matsiras

The Expanding Universe - The Shift of the Light towards the Red Spectrum

A different proven view



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Author's contact details:
Kazazi 31, 55133 Thessaloniki, GREECE
Tel. +30 2310.434.735
e-mail: mmatsira@yahoo.gr

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This book is dedicated to the
memory of my parents

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1. Instead of Preface

In the introduction of this study, I found it useful, instead of preface, like the title of this chapter states, to cite a few excerpts, slightly retouched only in their wording, of some of the renowned books on the same topic, mentioned in the bibliography. The reasons are the following: a. Because they gave me the idea and kept vivid my interest to engage in the study of one of the top cosmological issues, b. Because I have truly been impressed by the bold scientific imagination and the exciting way, in which, the prominent scientists and authors of these studies, express their opinions and arguments.

However, I want to clarify that some of these excerpts do not have the necessary consistency among them, and some others refer to the same topic, but with different wording, specific to the publication they come from. Nevertheless, they constitute a well-assembled, attractively legible, and comprehensible text.

"The Big Bang did not take place in a specific place, but everywhere!"

"The galaxies are not moving, but the space between them grows, and despite that nothing can go faster than the speed of light, space can be dilated at a speed greater than the speed of light."

"The speed of the universe's expansion, during the first fractions of the second is called "inflation". This expansion took place in a speed many times that of the speed of light, and it refers to the "stretch" of the space and not the movement of the matter. The space can expand -stretch out- at an infinite speed."

"The boundaries of the universe expand at the speed of light, but there is no reason for the universe to end within its own boundaries, in other words, in 14 billion light years."

"It is believed that the universe's surface today (cosmological horizon) is about 46 billion light years away."

"The matter curves spacetime and spacetime's curvature dictates how the matter should move. Gravitation is a geometric curvature and energy is a mass."

"At an age of 380,000 years, the Universe was a soup of matter, light, and energy. When its temperature dropped between 5,000 and 3,000C^o, the light managed to escape from that soup."

"If we move with the speed of light, we will turn into a black hole."

"There are stars of a mass smaller than 1/10 of the solar mass -the minimum required matter for a star to be condensed, and for the gravity to give to the star's interior the necessary temperature to kick off its fusion process. Moreover, there are no stars of a mass larger than 50 solar masses ($\leq M_H$), due to the fact that the temperature in their center could reach some thousand million degrees Celsius.

The result would be the radiation pressure would exceed the gravitational one, except in the case of stars of the population III (stars that were formed 13 billion years ago), as well as in some of the extremely rare blue supergiant stars, of a mass 100 to 150 times more than the solar mass, with a surface temperature between 20,000 to 50,000 degrees Celsius, and with an age of 1.7 to 2.1 million years.

"The fusion in stars releases a lot of gluons (less are needed in the new nucleus) that are then transformed into energy, through mesons (pions)."

Cosmic censorship (R. Penrose): "All singularities that emerge from the collapse of stars or other celestial objects are hidden inside black holes. A singularity is a unique point, with infinite matter density, where spacetime's curvature is infinite. At a point like this, the space and the time cease to exist."

According to Bekenstein, a black hole is defined by its mass, its spin, its electric charge, and its size. The entropy of a black hole is the measure of the quantity of the information that looks like it's lost without return, during a star's collapse. The black hole has a limited entropy, and it is in a thermal equilibrium. The boundaries (horizon of events) of a black hole expand when more matter falls into its interior. When two black holes collide and merge, the area of the event horizon of the newly-formed black hole is larger than the sum of the horizons of the merged black holes. The value of the entropy is proportional to the area of the horizon and it cannot exceed ¼ of the area of the surface, in Planck units. The entropy of the black hole is given by Hawking's formula:

$$S = \frac{\pi A K c^3}{4 G \hbar},$$

where A is the area of the horizon of a black hole, K is the Boltzmann constant, G is the gravitational constant, $\hbar$ is the Planck constant and c is the speed of light.

Unruh Effect: In a vacuum, an accelerating observer will perceive a thermal bath of photons, around them, of a temperature proportional to their acceleration. Once they cease to accelerate, then this effect also ceases.

The first law of thermodynamics states that a small change in the entropy of a system is followed by a proportional change in its energy. A similar law links the change of the mass of a black hole with the change of the surface area of its event horizon. If we accept that the surface area of the event horizon is proportional to the entropy of the black hole, then we must accept that the gravity at the surface is proportional to the temperature of the black hole. On this thought, Hawking proved that black holes are hot –release thermal energy– with a surface temperature given by the following formula:

$$T = \frac{\hbar c^3}{8 \pi K G m}$$

This temperature is the product of the quantum influence of the space quanta, which, when they vibrate, produce the thermal energy of a black hole. In addition, due to the fact that the space quanta are identical to the hypothetical gravity quanta, the vibration of the gravity quanta heat up the surface of a black hole and produce its thermal energy. Consequently, the thermal energy of a black hole is a combination of gravitational quanta and thermodynamics.

Our world, thus, is a combination of temporary quanta of space and matter.

Loop quantum gravity (LQG): attempts to combine the Theory of General Relativity and Quantum Mechanics. According to the General Relativity, the vacuum is not a totally inert space, but it has potential. It is a field. According to Quantum Mechanics, every field consists of quanta (small granular structures). Consequently, the space is not continuous -infinitely divisible- but it consists of units of space, called loops, with a size of one millionth of a millionth of the size of the smallest nucleus.

These loops are connected to each other, forming a network, which creates the substance of the Universe. The space quanta are the space itself. Therefore, the space is created from the connection of the gravitational quanta. The quanta of space and matter are in constant interaction.

The verification of the theory of the granular structure of space was based on the study of black holes. The matter cannot collapse into an infinitesimal point because there aren't any infinitesimal points, instead there are space quanta. According to Quantum Mechanics, when the matter density reaches a critical point –it is assumed that the density is 10^{96}gr/cm^3– it exerts an opposing force to gravity, preventing its further collapse.

If we assume that gravitons (particles that mediate the force of gravity) exist, then they will be perceived as space quanta because space is intertwined with gravity. However, gravity is intertwined with spacetime curvature. Gravity forces are exceeded by the quantum fluctuations of space and matter.

Planck star: It is the last stage of the life of a star, where the pressure that is formed by the quantum fluctuations of the spacetime equals the weight of the matter. If the sun would turn into a black hole, it would have a diameter of 1.5km. If, nevertheless, it were to turn into a Planck star, it would have the size of an atom. More pressure on the mass of a Planck star would force it to jump and start expanding at a very fast pace. This would lead to the explosion of a black hole. For an observer inside the black hole, this explosion would have been super quick. For an observer, outside and far from the black hole, that explosion would have been too slow, since the light would need a lot of time to reach the observer. It is likely that certain black holes were formed during the early universe, and some of them seem to explode now. We could observe the emitted signals of the "explosion" in the form of high energy cosmic rays that reach the Earth (their measurement is sometimes achieved with the use of the Cherenkov radiation).

Maybe, the Big Bang was a leap of a preexisting universe, which was previously condensed. In other words, it would have come from a Big Bounce.

Black holes and the initial universe have a common trait. They have a common boundary, beyond which, the gravity is intertwined with quantum effects.

The theoretically smaller black holes will reach the Planck limit. The evaporation of a black hole of Planck length and Planck mass takes place in Planck time (10^{-43} sec). With the evaporation of a black hole, the gravitational energy converts into matter and radiation. Maybe, there are also virtual black holes, which emerge as fluctuations from the vacuum, they absorb a certain type of particles and disappear again in the vacuum, in infinitesimal time.

At the Planck wall (Planck length), time and space cease to exist. There, the time is zero. Beyond the Planck wall (inside the Planck length), time is considered "imaginary". On Planck's scale, all quantum fields are unified into one.

What is the flow of time? Time passing is something internal to the cosmos. It is born in the same cosmos, in the relation between quantum events that form the cosmos, and they are the source of time themselves. Space quanta and matter quanta are in constant interaction.

The difference between the past and the future exists only when there is thermal energy exchange. When there is no exchange (flow) of thermal energy, the future behaves like the past. The time passing is in close relation to time and thermal energy.

Thermodynamics is the probabilistic behavior of thermal energy and temperature. In Quantum Mechanics, the movement of particles takes place randomly (here the Law of Probabilities also holds).

In a thermal electromagnetic field, the electromagnetic waves are vibrating faster, distributing energy randomly. However, what is a thermal gravitational field? The gravitational field is the space itself or better said, it is the spacetime. Therefore, when thermal energy is dispersed throughout the gravitational field, the space and time need to vibrate. However, we still do not know how to describe that. We do not have the appropriate equations that describe the thermal shocks of a thermal spacetime. Therefore, the curvatures of spacetime still continue to express gravity.

In Quantum mechanics, the particle is represented by a wave function, known as the Schrödinger equation, whose measure gives the probability to a particle being in a certain position. The pace at which a wave function is changing from a point to another, demonstrates its speed. Nevertheless, this wave function cannot hold in the interior of a black hole, due to the extreme spacetime's curvature.