Cosmic Matter and the Nonexpanding Universe.

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Abstract.

An increasingly large number of observations consistently reveal the existence of a much larger amount of intergalactic matter than presently accepted. Radio signals coming from directions between galaxies is discussed. An average density of matter in space of about 0.01 atom/cm^3 is derived. It is known that the density of matter is compatible with many reliable observations. These results lead to a nonexpanding cosmological universe.

1. Introduction

The big-bang theory was first proposed by Abbé Georges Lemaître [1]. Later, H. Hubble deduced the related constant, but as reported by Shelton [2]: "***Dr. Hubble never committed himself to the theory of the expanding universe***". Hubble himself in his book states [3]: "***The familiar interpretation of red shifts as velocity shifts very seriously restricts not only the time scale, the age of the universe, but the spatial dimensions as well. On the other hand, the alternative possible interpretation, that red shifts are not velocity shifts, avoids both difficulties . . . .***" Many prestigious scientists like R. A. Millikan agreed with Hubble when he wrote in a letter [4] dated 15 may 1953: "***Personally I should agree with you that this hypothesis (tired light) is more simple and less irrational for all of us***." Another prestigious scientist, Hannes Alfvén, is also challenging the orthodox view of the origin of the universe [1]. Since its origin, the big bang theory has remained an important controversy that is actively discussed in many specialized meetings [5]. Until a satisfactory model of the universe is found, the cosmological model must be reconsidered every time new observations or new considerations are brought in. It is not possible to achieve a rational choice between alternatives models when only one alternative (the big bang) is considered. We will examine here how some observations involving plasma physics in space are compatible with a recent red shift theory. We will see then how the new-tired light mechanism [6] is in agreement with many reliable observations.

II. Considerations on the Red Shift Mechanism.

The big bang theory is now based mainly on three arguments. First, it implies that the red shift of remote galaxies is a velocity red shift. Secondly, it leads to a prediction of abundance of three light isotopes - helium 4, deuterium, and lithium 7 - that apparently agrees with observations. Thirdly, it is claimed that the observed 3 K radiation confirms the big-bang hypothesis because of the belief that it is the cosmic primeval radiation.

A serious study shows the weakness of these arguments. A Doppler interpretation of the red shift is difficult to accept when one realizes that the number of red shift observations that cannot be explained by the Doppler theory is so large, that books [7], describing a long list of non-Doppler red shifts have appeared on the subject. Also, a catalogue containing 780 references [8] of red shifts observations, which are inexplicable by the Doppler effect, has been published under the timid title: "***Untrivial Red Shifts: A Bibliographical Catalogue.***" How can all these observations be ignored?

The second argument related to the distribution of light isotopes in the Universe has been rebutted by Lerner [9]. This author shows that when the contribution of He^4 produced in massive stars due to nuclear reactions, is added to the predicted big bang prediction of helium, nearly twice as much helium is produced as actually exists. Lerner [9] concludes, "***Thus either the blackbody spectrum or the light element predictions of the big bang are clearly wrong.***"

The third argument, related to the 3K-microwave background, is also no longer valid, since it is now seen [10] that the 3K radiation must exist anyway, even if the big bang never happened. This last point is based on the argument that it is a fundamental law of physics that Planck's spectrum, at 3K, must be emitted by any dark matter at that temperature. Since dark matter in the universe is likely at 3K, it emits the observed spectrum and, consequently, there is no need of any other radiation coming from an assumed big bang.

There are several alternatives to the Big bang theory, as clearly illustrated by Ellis [11]. More recently, an alternative [6] to explain the red shift observations, which does not require any new physics, has been presented. In this model [6], the red shift is produced by inelastic collisions of photons on atoms and molecules. Some scientists reject this mechanism because they are not aware that most photon-molecule collisions do not lead to any significant angular dispersion of photons in all directions. We must note here that the words "***dispersed, dispersion, etc.,*** " in this paper are not the specialized (optics) ones describing the variation of propagation speed of light as a function of its frequency. Of course, the Rayleigh-Thomson scattering mechanism exists and makes photons disperse in all directions, but this does not imply that the undeviated (undispersed) photons have not interacted with any molecule. In fact, the probability for the photon to interact with molecules and be transmitted without any noticeable dispersion is more than about 10^9 times larger than for the Rayleigh scattering. This is demonstrated by the following simple argument.

A. Matter-Photon Interactions Without Angular Dispersion.

It is known that the velocity of transmission of the energy (group velocity) of photons is reduced as calculated by the index of refraction of the gas. At atmospheric pressure, one does not easily notice the importance of this non-dispersive transmission of light at a reduced speed of propagation, precisely because almost all photons are transmitted without angular dispersion through the air. For example, at a distance of 100 m, it is an everyday experience that light is transmitted through (calm) air without any noticeable dispersion and does not produce any visible fuzziness (even when observed with a telescope). The index of refraction of air ($\boldsymbol{n}$=1.0003) shows that collisions on air molecules are delayed by as much as 100 times ($\boldsymbol{n}$-1) =3 centimeters during the 100-m trajectory (with respect to the transmission in vacuum). One must realize that the small fraction (0.0003) above the index of refraction $\boldsymbol{n}$ of vacuum does not mean that such a small proportion of photons collide with molecules of the gas. The fraction above 1.0000 of the index of refraction refers to the time delay produced during the interaction of photons on molecules. That delay, as large as 3 cm, can be explained only as being caused by many photon-molecule collisions. That delay is about 1 billion times the size of the Bohr radius. Therefore, one expects that roughly 1 billion collisions be required to produce such a delay. One must conclude that the 3-cm delay, due to the presence of air molecules, proves that photons have interacted with about 1 billion molecules of air ***without any angular dispersion***. Also, since the image produced is not fuzzy, most photons have maintained their initial directions in the trajectory from the source to the observer's eye.

B. Individual Collisions

Even if everyone knows that air is composed of individual molecules, and is not a continuous medium, the index of refraction ***n*** is used to calculate the speed of light. This represents an approximation that assumes perfect homogeneity of the medium. Of course, gaseous matter is not homogenous because matter is concentrated into atoms. That approximation can be avoided if one considers individual collisions of photons on each molecule, but the interaction without angular dispersion remains, of course, ***an observed fact***. In space, where the gas density is lower by more than 20 orders of magnitude, there is about one interaction (with no molecular dispersion) per week. Rayleigh scattering is much less frequent. It is inappropriate here to use a continuous function (such as the index of refraction) to describe light propagation that involves photon-atom interactions. In this last case, the reduced speed of light moving through gases can be explained by a short delay of the photon every time it is interacting with the atom. It is known that the total delay in transmission varies linearly with the gas pressure, multiplied by the distance traveled through the gas. It is therefore proportional to the number of collisions. From that description, one sees that in space, at extremely low pressure, the fundamental transmission mechanism is just the same as at atmospheric pressure. This means that almost all photons will interact with gas molecules without any measurable angular dispersion. This does not seem to have been realized previously. Of course, this observation is compatible with fundamental principles. We must also note that we deal here with hydrogen or other transparent gases (simple molecules) having no spectral features within the bandwidth considered.

C. Inelastic Interactions

The next step is to examine the properties of such collisions. One knows that the photon has momentum and energy. We have just seen above that the collisions produce a delay in the transmission of light: Therefore, there is a finite interval of time during which the photon is absorbed before being re-emitted.

One knows that an atom is polarized when electromagnetic waves move across it. The polarizing field moves the electron (of the atom) away from its normal position. In this polarizing field, this polarized atom acquires (at least a part of) the energy of the electromagnetic wave. The energy given by the photon to the polarized atom appears as an energy given to the electron of the atom to make it reach its new position (as a polarized atom). Since the electromagnetic wave (i.e. the photon) also has momentum, one can see that when the energy of the electromagnetic wave is transmitted to the electron (of the atom), the photon momentum (that cannot vanish) is also transmitted to the electron (of the atom). When the photon momentum is transferred to an electron (of the atom), it necessarily leads to an acceleration of this electron. Therefore, this photon momentum transfer produces the acceleration of the electron (of the atom). Maxwell`s equations show that bremsstrahlung is emitted when an electron is accelerated. This bremsstrahlung represents an energy loss, taking place due to the passage of the polarizing wave. Consequently, bremsstrahlung is emitted due to the passage of electromagnetic radiation and therefore photon-atom collisions are inelastic.

We have seen above that this same phenomenon (polarization of the atom) produces a delay in transmission. After the delay, the transmitted photon is re-emitted in the forward direction (without angular dispersion as demonstrated above).

The results of quantitative calculations of this slightly inelastic non-dispersive scattering have been published [6], [12]. In ordinary conditions, the energy loss per collision [6], [12] is about 10^{-13} of the incident photon. Therefore this phenomenon produces a red shift that follows the same rule as that of the Doppler effect; i.e. Dl/l= constant. It can be calculated that the secondary photon emitted that carries the extra energy has a wavelength of a few thousand km. Since the longest wavelength observed in radio astronomy is 144 m [4], [13], observations cannot detect these secondary long wavelength photons. Furthermore, radio waves having wavelengths thousands of km long, cannot be transmitted [14] in space over great distances because of the interstellar plasma.

The fact that the collisions of photons on atoms are ***never*** perfectly inelastic has been known qualitatively for many years from quantum electrodynamics [15], [16]. It is important to realize that this phenomenon produces a red shift similar and generally indistinguishable from the Doppler effect.

The theoretical prediction [6] of inelastic collisions leading to a red shift is confirmed experimentally in several examples: i.e., the Sun's chromosphere [6], [17], in binary stars [6], and in the K-term [6] (related to the stars in the sun's neighborhood).

In the case of the sun's chromosphere [6], [17], numerous experiments regularly reported during the last 80 years have shown that there is a well-observed red shift on the sun's limb. It is shown [17] that this previously unexplained red shift could now be explained very clearly by the new non-Doppler mechanism.

Calculations [6] show that an average concentration of about 0.01 atom/cm^3 leads to the same cosmic red shift as the one observed and reported as being the Hubble constant. More experimental data given below, will help to determine what fraction (if not all) of this redshift must be attributed to photon collisions on gases in space. The residual, if any, would be caused by a real expansion of the universe. We will see below that the observation of very long radio waves is important for the investigation of that problem.

III. Considerations of Plasma in Space

Due to its extremely low concentration, the average density of interstellar matter has not yet been measured directly. All values are theoretical and model dependent. The value given by the current cosmological model that assumes the big bang gives a characteristic density of about 10^{-8} atom/cm^3. Other models based on particle physics predict different values. For example, it has been reported recently [18] that the standard hot-universe theory predicts a value that is 15 orders of magnitude higher. Models based on one version of supergravity contradict [18] the cosmological model by 10 orders of magnitude. The typical energy density stored in the Polonyi fields brings a contradiction [18] of 15 orders of magnitude, while most of the higher-dimensional Kalusa-Klein theories considered in the early 1980's predict [18]a density larger by 125 orders of magnitude! Finally, no consistent cosmological model [18] based on superstrings has been suggested so far. As seen above, the problem related to the amount of matter in intergalactic space is extremely complex, and the predictions are completely incompatible.

In order to achieve a real measurement of the amount of cosmic matter, one can try to detect radiation emitted by that interstellar matter, or at least detect its interaction with radiation. Is seems that the most sensitive method of detection of that matter (or plasma) might be by looking at very long radio waves. If the gas is ionized, this hydrogen in intergalactic space will emit plasma radiation [4], [13], and very long radio waves are then expected to be issued from that medium.

IV. Detection of Very Long Radio Waves.

Some years ago, a very large radio telescope was designed and built by one of us (G. R.) in order to detect very long radio waves. The instrument was designed to observe at a wavelength of 144 m. It consists of 192 dipoles, mounted in an array 3520 ft. (1.07 km) in diameter covering 223 acres (90 hectares). This makes it one of the world's largest telescopes. During the minimum solar activity in the mid-1960, the southern sky had been mapped at that wavelength. It was found [4], [13], [19] that the appearance of the sky is the inverse of that at shorter wavelengths (i.e. galaxies appear dark on a bright intergalactic background).

This shows that at such a long wavelength, it is possible to detect radiation in the direction of intergalactic space. Furthermore, at that wavelength, the galaxies are no longer transparent and appear as shadows on the illuminated cosmic background. This experiment provides completely new information on intergalactic space.

From these results it is calculated that the density of radiation observed [4], [13], [19] at that wavelength of 144 m corresponds to a plasma temperature of 3.4 ´10^6 K. Since radiation is observed for the first time from a direction in space where there is no resolved galaxy (intergalactic direction), the radio signal detected had to travel across an important part of the universe before reaching us. If one assumes that the radiation is produced by the hot intergalactic plasma, this would require an average plasma density of 0.01 atom per cm^3 [4], [13], [19]. Another assumption is that the radiation is produced by plasma coming from many very remote unresolved galaxies. More data are required at these long wavelengths in order to know the origin of that radiation. More knowledge on the amount of intergalactic matter would be useful to determine the origin of that radiation.

V. Discussion

In order to discover the origin of that radiation observed from an intergalactic direction and the meaning of the non-Doppler red shift mechanism leading to a density of 0.01 atom per cm^3, let us consider other measurements related to intergalactic matter.

a. Intergalactic Cloud

The direct detection of very large amounts of intergalactic matter is of course extremely difficult and has not been very successful in the past. However, during the last decade, some huge molecular clouds have been discovered in the intergalactic space. Recently, the most important discovery appears to have been made by Schneider [20]. Schneider discovered a cloud of HI not associated with any galaxy, being just there by itself. The density reported by Schneider [20] is 10^3 atoms/cm^3. The mass of the cloud is 10^9 solar masses. It is irregular in shape and covers an area 100´200 kpc. This is far larger that the Milky Way which has a diameter of 25 kpc and a thickness of 2 kpc. This irregular cloud appears to be part of a much larger ellipse of similar clouds.

In fact, in order to explain the larger densities reported above, one needs a much larger amount of matter that the one discovered by Schneider [20]. Therefore the nature of the gas to be detected must be different. There are several experimental methods to detect matter in space. Unfortunately, almost all those methods are selective and can detect only one kind of matter. Most of these methods use spectroscopy and measure emitted or absorbed radiation by matter.

b. Determination by Spectroscopic Methods

Emission of radiation is extremely useful to detect matter at high temperature on stars and hot bodies. Unfortunately, most of the universe is too cold. Most of the intergalactic matter does not seem to emit photons. Atomic hydrogen can be detected in emission and absorption at a 21-cm wavelength. Unfortunately, other gases like Helium and H_2 are completely undetectable in that wavelength range. Absorption spectroscopy is also very useful in order to determine some atomic and molecular species.

c. Difficulty of Detecting H_2.

Since H_2 has no permanent dipole moment, it does not readily emit or absorb radiation. For example, it is known that most excited molecules emit photons in about 10^{-8} s. The spontaneous emission of the first rotational state of molecular hydrogen is practically non-existent in space. A transition from the second rotational state is, relatively much more probable but would require about 1000 years. One must reach the sixth state, before the transition time become 1 year. The probability of the absorption of radiation in H_2 is also proportional, and therefore extremely improbable. All these forbidden transitions are such that one cannot hope to detect H_2. Molecular hydrogen can only be detected in the far UV spectrum. It has been observed in some stellar spectra in the UV range. Molecular hydrogen when mixed with other gases also becomes detectable.

d. Detection of the Faraday Effect

Since spectroscopic methods are too selective to prove the absence of some kind of matter in space, one might try to examine another method also related to the interaction of radiation. Using X rays, one has been able to get some rough X-ray density estimates. Another method consists in using the Faraday effect. The Faraday effect is the result of interaction between a magnetic field and light. When polarized radiation travels through matter located in a magnetic field, the plane of polarization of a light wave is rotating through the angle a according to the equation:

$$a=VHL$$

Where H is the magnetic field strength, L is the path length, and V is the constant of proportionality (the Verdet constant).

It is known that some galaxies emit polarized light through the synchrotron mechanism. Because of the Faraday effect, one expects that the plane of polarization will rotate as a function of the galactic magnetic field. The actual detection of the Faraday effect in space is an extraordinary discovery, but it is difficult to use it to make precise quantitative measurements. In practice, both the galactic matter density and galactic magnetic field are inhomogeneous, and one observes the "depolarization" of radiation due to that inhomogeneity. This is called the differential Faraday rotation. In principle, in order to be able to calculate the density of matter in space by that method, it is necessary to know the following.

1) The initial degree of polarization of the radiation at the moment it is generated in the galaxy.

2) The distribution of the intensity of the magnetic field.

3) The degree of homogeneity of the galactic gas density in that direction.

4) The degree of homogeneity of the galactic magnetic field in that direction.

5) The Verdet constant (which is 4×10^{-7} for Helium and 62×10^{-7} for H_2), which is a function of the nature of that matter.

6) All other competing sources of the radio signal, which emit at the same frequency and in the same direction.

If all these six conditions are satisfied simultaneously, one can calculate the density of matter in this region of the intergalactic medium. Using that method, for example, (using estimated values) it has been calculated recently by Strom and Jägers [21], that "There is no evidence for substantial amounts of additional (dark) matter"

e. Detection by Gravitational Forces

The problem of dark matter has been brought up following the observation that stars and all visible matter moving around galaxies do not move according to Kepler's laws but have a constant tangential velocity. That constant velocity is seen easily, and appears very clearly on spectrograms of galaxies [22]. In order to explain that quite unexpected velocity distribution, it has been calculated [22] that there must be some invisible galactic matter in the galaxy so that the gravitational force decreases linearly as the distance from the center of the galaxy. This is possible only if the density of matter in the galaxy decreases as the square of the distance from the nucleus, as mentioned in [22]. This leads to a total integrated mass of the galaxy (within a given radius), which increases linearly with the radius considered.

The density of matter as a function of radius must follow a quadratic decrease very closely in order to take into account the very constant velocity of rotating matter around the galaxy. This assumes that the non-Doppler component of the red shift is small compared with the velocity shift due to galactic rotation. As far out as one can detect, there is not the slightest sign of deviation from that quadratic decreasing density law. This quadratic decrease of the density of matter appears as a very common fundamental property in galaxies. Therefore, at the same time one proves the existence of new matter, one also proves that it is invisible as far out as one can observe luminous objects that belong to that galaxy. Why should we expect any discontinuity of that inverse quadratic density outside the radius of luminous objects? Since the very large amount of matter inside the visible radius could not be detected by any methods other than gravity, why should we be surprised that it remains invisible outside that visible radius, since the density at a larger radius is even lower than inside the visible radius.

From the observations above, we conclude that the total amount of matter in galaxies is much larger that the visible component. The fraction of invisible matter is as much as 90 to 99 percent of the total mass [22]. If there is no discontinuity in the inverse quadratic density law of gases around the nucleus, up to the distance of another neighboring galaxy, a still much larger amount of matter is invisible around the observed galaxies. The average density of matter in space then becomes compatible with the values reported in this paper.

f. Dark Matter from "Voids"

There are a large number of fields of research in astrophysics reporting important mass anomalies; Let us mention another one: The mass anomalies found in the study by Rood [23] of "voids" in space. This author reports that in order to solve these anomalies, one has to accept one of the following assumptions.

l "Galaxies and system of galaxies contain enough dark matter in one of more forms that have so far escaped detection to solve the mass anomaly"

l "Newtonian/general-relativity theory does not apply in extragalactic astronomy".

A choice between these two assumptions must be made.

g. Comments

The largest fraction of gases in space cannot be atomic hydrogen, but possibly can be H_2. Such a large amount of H_2 would be undetectable in the 21-cm radio receivers of radio astronomers. We have seen above how H_2, having no dipole moment, cannot emit any measurable amount of radio-frequency signal, and how it is extremely difficult to detect. Therefore, H_2 is a serious candidate that might form the important component of invisible matter in space.

A word must be said about neutrinos. It can be seen that, in order to explain the stability of the rotation of galaxies by the existence of invisible mass [22], that invisible mass must rotate around the nucleus of the galaxy at the same speed as the visible matter itself. Furthermore, there must be a mechanism to stabilize that rotation when matter moves to different radius. It appears quite unlikely that the invisible mass around galaxies can be neutrinos, since an interacting mechanism is required to stabilize the orbits. Neutrinos have such a small interaction cross-section that such a mechanism does not seem to exist.

One must conclude that the average density of matter reported here appears to be compatible with the amount of matter expected from several reliable observations. The non-velocity interpretation of red shift is in perfect agreement with Hubble's observations [3]. These results lead to a non-expanding model of universe.

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Grote Reber was born in Wheaton Il., USA, on December 22, 1911. He graduated in engineering at the Illinois Institute of Technology, Chicago. After the discovery of the existence of cosmic radio waves by K. Jansky, he was the first to explore this new field. ***In 1937***, he completed the construction of the ***first bowl-shaped radio-wave reflector (9-m in diameter)*** and began to map radio sources in the sky. For about 10 years, ***he was the only scientist working in radio astronomy in the world***. His data showed that the most intense radiation emanates from the center of our galaxy. Later, another radio telescope in Hawaii provided a great improvement in sensitivity at lower frequencies. More recently, using his large radio telescope in Tasmania, he discovered radio sources emitting at 144 m and other new features in the radio map of the sky at that wavelength. Grote Reber died on December 28th 2002.

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