ISSN 2250-3153

Effect of Gravitational Waves on Hydrogen in near-by Universe

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Abstract- This paper attempts to explain the postulate that 80% of light is unaccounted for in the current universe. [1]

It tends to pin the cause of the excess light observed by the Cosmic Origins Spectrograph on Gravitational waves, and how it interacts with the light in the near universe which could further augment the research going in this field and provide an alternate method of detecting these elusive waves that are considered to carry crucial data about the primordial universe and how it came into being.

According to observations made by the Cosmic Origins Spectrograph on board the Hubble Space Telescope which took the first ever image of the Cosmic web found that the universe is still missing 80% of its light in the local universe. [2] Astronomers are completely baffled as they still don't know the reason for this anomaly indicating that our current perceptions of the universe may not be completely true and therefore calls for a careful consideration on the matter.

So from where all this excess light is coming from? The most fascinating possibility is that an exotic new source, not quasars nor galaxies — which are the known sources of light in the universe — is responsible for the missing photons that tantamount to the excess light as observed in the study.

We know that Gravitational waves are a result of accelerating universe and as photons of light responds to this warping relevant in space-time fabric they tend to amplify the photons thereby supporting the results observed. [3]

Index Terms- Gravitational Waves, Hydrogen tendrils, re-ionization, 80% of light missing.

I. INTRODUCTION

Flustered because astrophysicist know that there are only two known sources for light in the universe: quasars, which are fueled by hot gas falling onto supermassive black holes over a million times the mass of the sun, and the hottest young stars and found that these so known sources of light are incompetent to match the findings by the Cosmic Origins Spectrograph which detected that the hydrogen tendrils that fills up the intergalactic space are lightning too much.

According to the paper "When these hydrogen atoms are struck by highly energetic ultraviolet light, they are transformed from electrically neutral atoms to charged ions. The astronomers were surprised when they found far more hydrogen ions than could be explained with the known ultraviolet light in the universe, which comes primarily from quasars. The difference is a stunning 400 p
ercent." [4]

When the hydrogen atoms in deep space are bombarded with photons from around the universe, they are transformed from neutral atoms to ions. The type of light that is energetic enough to turn neutral hydrogen into hydrogen ions is called ionizing photon. Astronomers were stunned when they discovered that there were far more ionized hydrogen than which could be explained by the known sources, an astounding difference of 400 percent. Furthermore we know that almost always all the light from these young stars in galaxies are absorbed by the encompassing cloud of gas and dust which forms a cloak around the galaxies sometimes even feeding them. And the other source, the quasars are far less in number and intensity to create such an effect as to match the results.

1.1. Re-ionization:

Shortly after the Big Bang the universe was ionized due to which ordinary matter consisting of hydrogen was stripped apart of its electrons. Gradually the universe cooled down enough for the electron and proton to combine and form neutral hydrogen. This cooled gas goes on to form the first stars in the universe, but it is a rather painstakingly long process with many factors coming into considerations like what was the temperature, pressure of the gas, how rapidly this accretion disk was rotating, its angular velocity and so on. And therefore some time of the order of millions of years of magnitude must have elapsed before the first stars came into existence, implying that during this period the hydrogen remained intact.

Astronomers agree that the universe became fully re-ionized roughly 1 billion years after the Big Bang. About 200 million years after the birth of the cosmos, ultraviolet (UV) radiation from stars began to split neutral hydrogen into electrons and protons. It took another 800 million years to complete the process everywhere. This epoch of re-ionization marked the last major change to gas in the universe, and it remains ionized today, over 12 billion years later. [1]

And still strange enough this aberration occurs in only near-by and relatively well studied cosmos. When we point our telescopes to faraway galaxies i.e. billions of light years away everything seems to add up. A tacit implication is that the light needed to ionize hydrogen works in the early universe but comes apart locally.

1.2 Dark Matter

A previous possible explanation for this abstruse phenomenon came in light when scientists predicted dark matter culpable. The extra light is hypothesized to be given away when dark Matter — which is generally said to be at the peripherals of the galaxies and constitutes almost 27 percent of the universe—

decays to give out that extra supply of energy required for the observations to hold true. [5]

Dark matter is said to consist of WIMP (weakly interacting massive particles) which are said to be their own pseudo particle. Therefore when they come in contact they annihilate to produce gamma rays and additionally if they are unstable they could decay into standard model particle for example an antiprotons or positrons emanating from region of areas with high dark energy density. The detection of such a signal though is not a conclusive evidence for dark matter, as the production of gamma rays from other sources is not fully understood. [6]. And therefore we turn to gravitational waves that might provide another perspective for this phenomenon.

1.3. Gravitational Waves

Albert Einstein predicted the existence of gravitational waves in 1916 as part of the theory of general relativity. In Einstein's theory "Space and time are aspects of a single measurable reality called space-time. Matter and energy are two expressions of a single material. We can think of space-time as a fabric; the presence of large amounts of mass or energy distorts space-time – in essence causing the fabric to warp – and we observe this warping as gravity". [6] [7]. A more massive moving object will produce more powerful waves, and objects that move very quickly will produce more waves over a certain time period. When large masses move suddenly, a region of the space-time curvature ripples outward, spreading as waves in much the way as ripples on the surface of an agitated pond. When two dense objects such as neutron stars or black holes orbit each other, space-time is stirred by their motion and gravitational energy ripples throughout the universe. [6]

II. Finding

We know that the universe is expanding at an accelerated rate, in formal terms, this means that the cosmic scale factor, given by

$$p(t) = p_o(t) * a(t)$$

has a positive second derivative, which follows directly from Newton's law of motion.

where,
p(t): is the position of an object at any given time
$p_o(t)$: is the current position of the object, and
a(t): the scale factor corresponding to p(t), which explains how close or how far objects are in space.

Now since space is expanding there definitely ought to be a greater presence of Gravitational waves which follows implicitly from general relativity. We also know that photons are affected by gravitational fields not because photons have mass, but because gravitational fields (in particular, strong gravitational fields,) change the shape of space-time. The photons are responding to the curvature in space-time, not directly to the gravitational field.

To understand that why there is a sudden increase in light in the local vicinity of our own and nearby galaxies, we need to understand that gravitational waves are a by-product of the expanding universe i.e. greater the expansion the more packed and stronger these waves tend to be; and the universe is expanding at a relatively more accelerated rate in the local universe. However the orders of magnitude of how strong it is, is still on the very faint side and therefore it is very difficult to detect gravitational waves. But on other side Gravitational waves can travel over large cosmological distances without being damped and can pass through other matter, unlike radio waves which are easy to detect but gets scattered when travelling over large distances.

From a recent paper published in the New Journal of Physics, Niclas Westerberg, et al., from institutions in the UK and Italy scientists carried out an experiment where-in they tried to simulate space-time in lab using thin graphene sheets and illuminating it with intense short laser beams thus producing the equivalence of periodic expansion and contraction of space-time and can be likened to Gravitational waves. They also predicted through calculations that these gravitational waves may amplify electromagnetic radiation, producing large numbers of photons that can potentially be detected. [3]. If correct boundary conditions are available Gravitational waves can give rise to emission of photons.

The amplification observed is a kind of non-linear amplification where-in light of variable wavelength is emitted by optical parametric amplification process and is an attribute of some crystals. The input light beam of frequency w_s is divided non-linearly into two light beams such that $w_s=w_1+w_2$, where w_1 and w_2 are the two output light beams. These two lower-frequency beams are called the "signal" and "idler". [8] . The two output beams are comparatively weaker and more dispersed as compared to the input beam and to overcome this optical parametric amplification (OPA) is employed, wherein the input is w_s and w_1. The OPA distributes energy such that energy from w_s is given to w_1 hence amplifying it and also creates a new beam with frequency such that $w_s=w_1+w_2$.

This new amplified beam that is obtained interacts with the hydrogen tendrils to create the observed result. However since the graphene sheet is wavelength thick only the oscillation does not occur inside the medium as in traditional parametric amplification but is rather the oscillation of the medium itself. Such parametric amplification are examples of the dynamic Casimir effect, in which photons are produced due to an accelerated or suddenly changing medium, which is analogous to accelerating space-time continuum.

III. Conclusion

This reasons all points to that probably gravitational waves can hold key to the excessive light found in the nearby cosmos i.e. this can explain why there is more light at relatively smaller astronomical distances relative to us. They tend to stir up the space-time continuum in periodic expansion and contraction and thus provides the necessary conditions for the photons of light to amplify and cause the excess of ionization of the hydrogen tendrils that floats the intergalactic space. Further due to rapid expansion of the universe that is accelerating at a faster rate for

greater values of the scale factor and the shift in the light due to Doppler shift explains as to why this this excess light is found only in the near-by cosmos.

Furthermore according to the paper in which the results were published, it can open up completely new avenues to detect gravitational waves, whose finding would help us to know more about how our present day universe came into existent. It can offer a fundamentally very different perspective to pursue with greater diligence Gravitational Wave Astronomy that can help to decipher some of the greatest secrets of the universe.

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