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A Plausible Implication of the Universe Accelerated Expansion on Extragalactic Radio Source Luminosity

O. L. Ubah [a*] and J. C. Ezeugo [a]

[a] *Nnamdi Azikiwe University, Awka, Nigeria.*

Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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Short Research Article

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ABSTRACT

In this paper, statistical method of analysis was used to determine the variation of radio luminosity with cosmic epoch. Two different types of radio sources were used, radio-loud quasars and radio galaxies. They were used differently in order to ascertain consistency (if any) in their results. The results of the linear regression analyses obtained shows that the luminosity of extragalactic radio sources has an inverse power law function with the scale factor of the universe according to the relation, $L \sim a^{-n}$. The implication of this is that since the universe scale factor is time-dependent, the relation suggests that accelerated expansion of the universe causes diminution of radio source luminosity. This result suggestively indicates that extragalactic radio sources are more luminous at an earlier epoch than at a later epoch.

Keywords: Luminosity; quasars; galaxies; redshift; cosmic dilation; cosmic epoch; scale factor.

**Corresponding author: E-mail: Ubahlevi@gmail.com;*

1. INTRODUCTION

The success of the currently accepted cosmological model certainly implies that we live in an expanding universe [1,2]. This idea of cosmic dilation (or universe expansion) given birth by Einstein's theory of relativity gave rise to the ideas of length contraction and cosmic time dilation. Time dilation (the stretching of time by a factor of $(1 + z)$ is a fundamental property of an expanding universe, and an early work done by Goldhaber et al. [3] which involved measuring the light waves width of a sample of distant supernovae covering a wide range of redshift provided convincing evidence for the presence of cosmological time dilation [1]. Hence, time dilation and its experimental confirmation is commonly perceived as one of the pillars of relativity theory [4].

The cosmos is a vast space extending beyond the confines of the Milky Way galaxy (our home galaxy), filled with different kinds of radio objects. Some of these radio objects located beyond the confines of the Milky Way galaxy (usually known as Extra Galactic Radio sources (EGRS) [5]) serve as engine room for the generation and release of huge amounts of power and energy into the vast cosmic space. These energies most often are released through radio and optical radiations coming from jets generated by these cosmic engines [6]. The jets travel to very large distances on the order of thousands of kilo parsecs over a long time frame in millions of years within the intergalactic space dissipating energy and momentum into the intergalactic medium through which they travel while also maintaining their structural coherency [6]. Due to their high collimation effects, the jets are not easily destroyed and consequently, their life span last for thousands of years while giving out huge amounts of energies in the form of radio and optical radiations. Their large distances from us and the effects of cosmic expansion of the universe makes it difficult for photons released to reach us in time, thus resulting in a time dilated luminosity of the radio sources [7]. In this paper, we use statistical method of analysis to investigate how cosmic dilation affects the luminosity of distant radio sources.

2. MATERIALS AND METHODS

The analyses are based on combined samples from Nilson 1998 [8] compilations. It comprises of 235 quasars and 411 radio galaxies totaling 646 radio source samples. This means that two different types of extragalactic radio sources are used – they are radio-loud quasars and radio galaxies. These two classes of objects are used individually in the regression analyses in order to ascertain consistency (if any) in their results. A linear regression analysis was carried out between the luminosity and the redshift parameters of each radio source and the results of these analyses shown in the figures below.

3. RESULTS

The figures below shows the relation between radio luminosity L and redshift z for the two different radio sources; quasars and radio galaxies. From the figures, it can be seen that there is a strong correlation between luminosity and redshift. It can also be observed that both radio source types give similar correlation values for the luminosity/redshift relation.

For the galaxies, linear regression analysis yield

$$\mathrm{Log}_{10}\,\mathrm{L} = 1.63 + \log(1+\mathrm{Z})^{0.07} \qquad (1)$$

With correlation coefficient given as, $r_G = 0.822$

For the quasars, we obtain

$$\mathrm{Log}_{10}\,\mathrm{L} = 1.64 + \log(1+\mathrm{Z})^{0.04} \qquad (2)$$

With correlation coefficient given as, $r_Q = 0.823$

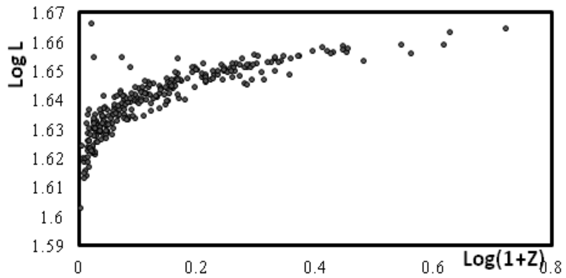

Fig. 1. Scatter plot for source observed luminosities against redshifts (Radio galaxies)

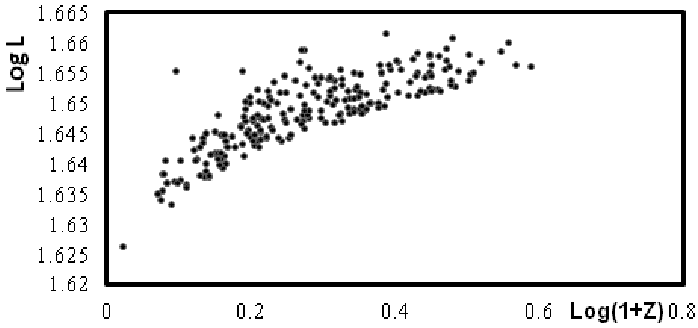

Fig. 2. Scatter plot for source observed luminosities against redshifts (Radio-loud quasars)

Simplifying and generalizing the above equations (1&2) yields

$$L \sim (Z+1)^{n} \quad (3)$$

Where the index whose value is 0.04 for quasars and 0.07 for radio galaxies respectively are the slopes. These results are in line with those obtained by Ezeugo [9], Ubachukwu and Ogwo [10], Kapahi [11], Hawkins [1]. The similarity in their regressional trends (results of the analysis appear almost similar) supports quasar/galaxy unification scheme. In this scheme both sources are seen as similar sources but seen in different angles of observations.

Moreover, from the work of Ubah & Ezeugo [6], Condon & Matthews, [12], we have that

$$a^{-1} = (1+z) \quad (4)$$

Here, a is the scale factor of the universe

Thus, combining the last two equations, gives

$$L \sim a^{-n} \quad (5)$$

Hence, equation (5) shows that the luminosity of a radio source has an inverse power-law function with the scale factor of the universe.

4. DISCUSSION

The correlation coefficients for the two types of radio sources appear to be exact indicating effects of a variation parameter that is independent of the radio source type. This similarity in behaviour in the $L - z$ plane has been attributed to strong luminosity selection effects which usually characterize bright flux density-limited samples [9-11].

Further analysis on the linear regression of the $L - z$ plane shows that the luminosity of the radio sources has an inverse power law function with the scale factor of the universe according to the relation $L \sim a^{-n}$. The implication of this is that since the universe scale factor is time-dependent (i.e. it is not constant in every epoch), the relation suggests that accelerated expansion of the universe brings about diminution effects on the radio source luminosity. Therefore, extragalactic radio sources appear to shine brighter at earlier epoch than at subsequent epochs. This is in consonance with what is obtainable in the literature, e.g. Hawkins [1].

5. CONCLUSION

We have used linear regression analysis to obtain a relation that may connect extragalactic radio source luminosity and the universe scale factor. The result plausibly implies that since the universe scale factor is a function of time, the accelerated expansion of the universe initiates diminution of extragalactic radio source luminosity. Therefore, extragalactic radio sources may appear brighter at earlier epoch than at later epochs. This result is in consonance with results obtained by [1,9-13].

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Hawkins MRS. On time dilation in quasar light curves. Monthly Notices of the Royal Astronomical Society. 2010;405(3): 1940-1946.
   Available: Https://doi.org/10.111/j.1365-2966.2010.16581

2. Riess AG. The expansion of the Universe is faster than expected. Nat Rev Phys 2. 2010;10–12. Avaiable:https://doi.org/10.1038/s42254-019-0137-0
3. Goldhaberet al. Timescale stretch parameterization of type 1a supernova B-Band Light Curves; 2001.
4. Roman Tomarchitz. Cosmic time dilation; the clock paradox revisited, chaos, Solitons & Fractals. Elsevier, ISSN= 0960-0779. 2004;20(4):713-717. Available:https://doi.or/10.1016/j.chaos.2003.09.016
5. Ezeugo JC. On size evolution / radiated power of extragalactic Radio Sources and implications. International Astronomy and Astrophysics Research Journal. Article no IAARJ. 80372. 2022; 4(1):1-5.
6. Ubah OL, Ezeugo JC. Relativistic Jet Propagation: Its Evolution and Linear Size Cosmic Dilation. International Astronomy and Astrophysics Research Journal. Article no. IAARJ. 708272021; 3(3):1-6.
7. Gaskell CM, Koratkar AP, Kwon TY, Liang Y, Scott JH, Wysota A. Optical variability of quasars as a function of luminosity and redshift. Bulletin of American Astronomical Society. 1987;19:1074.
8. Nilson K. Kinematical models of double radio sources and the unified scheme, Monthly notices of Royal Astronomical Society. 1998;132:31-37.
9. Ezeugo JC. Luminosity selection effects on the linear size evolution with cosmic epoch of compact steep spectrum sources. Journal of Basic Physical Research. 2019;9(1):57-64.
10. Ubachukwu AA, Ogwo JN. Luminosity selection effects and linear size evolution in the Quasar/Galaxy unification scheme, Australian Journal of Physics. 1998;51: 143 – 51.
11. Kapahi VK. Redshift and luminosity dependence of the linear sizes of powerful radio galaxies. The astronomical Journal. 1989;97:1-9.
12. Condon JJ, Matthews AM. Cosmology for Astronomers. Astronomical Society of the Pacific. 2018;130:073001.
13. Ubachukwu AA, Ogwo JN. Redshift and luminosity dependence of linear size of compact steep spectrum sources and the quasar/galaxy unification scheme. Australian Journal of Physics. 1999;52: 141-146.

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