Journal of Theoretics

A Simple Calculation of a Possible Variation in the Speed of Light

Author: Ioannis Iraklis Haranas

York University
Department of Physics and Astronomy
128 Petrie Science Building
4700 Keele Street North
Toronto, Ontario, Canada M3J-1P3

YHaranas@yahoo.com

ABSTRACT
The idea of a possible variable light cosmology was recently investigated by certain authors. In our brief note an estimate for a possible variation in the speed of light can be calculated if fundamental relations of cosmology are used along with a plausible definition of the speed of light.

Keywords: speed of light, cosmology, theory, Dirac, Gamow, Mach.

INTRODUCTION
Paul Dirac was the first to talk about a possible time-dependence in the fundamental physical constants.1 He also expressed the idea that the dimensionless quantities which characterize the structure of our universe in the present era are, interestingly enough, of the same magnitude.[2] He stated that gravitational constant (G) should be varying inversely with time. Later on, Gamow suggested that the elementary charge e^2 could be increasing with time.[3]

In the grand scheme of things, the variability of the physical constants could also be a consequence of Mach's principle, according to which the laws of physics should be determined by the contents of the universe.[4] If that is the case, we assume that the laws of physics in the cosmological arena could also depend on quantities like the deceleration parameter q_o, average density p, Hubble's constant H_o, or the expansion rate of the universe $\frac{dR(t)}{dt}$.

In the study of our universe the theory of relativity plays a very important role. It is important because of the following postulates: 1) the laws of nature are the same in all inertial frames; 2) the speed of light is the same in all inertia frames. Looking at the second postulate, we can surmise that it does not exclude the possibility that the speed of light c varies with time. It is true that the value of c has been confirmed by many experiments, but these experiments have only been performed within a very small part of the space-time manifold. Let us not forget that the dimensions of the universe are much greater than terrestrial, primarily because the radius of the universe R_U is 10^{28} cm, and its age t_U is about 10^{17} sec. It is still not certain that the theory of relativity is valid in this much larger range space-time.[5] To study the evolution of the universe, we need general relativity, in which the speed of light c is present in the field equations. If the speed of light could be changing, albeit slowly, with time, then some kind of measurable effect would eventually show up, and this change could also affect the structure and evolution of the universe. Even though the effects of a changing the value of c may be too small to measure in a time-interval in the order of a year, the integrated effect over billions of years could make an investigation of the effect quite interesting.

CALCULATION OF THE RATE OF CHANGE IN c
In starting our simple-minded calculation of a possible variation in the speed of light, we must emphasize that our basic assumption is that the expansion-rate $\frac{dR(t)}{dt}$ of the radius of the universe R(t) at any time t is equal to the speed of light c(t) at that same time:

$$c(t) = \frac{dR(t)}{dt} \qquad \textbf{(1)}$$

It should be noted that R(t) is not some kind of a physical length, but can be thought of as universal length of space itself, and its present expansion-rate will be written as $\frac{dR(t_o)}{dt}$ = c_o. The value of the expansion-rate depends on quantities such deceleration parameter q_o. The value of q_o is not certain, but observation shows that $q_o > 0$, which implies that the expansion of the universe is slowing down.[6] In other words, on the basis of our major assumption, light might have been traveling faster than at its present value.[7] Some suggest a past value of 10^{10}c.[8]

Let us now proceed with the calculation of the change-rate. First, let us define Hubble's constant in the present era t_o:

$$H_0 = \frac{\dot{R}(t_0)}{R(t_0)} \qquad (2)$$

and the deceleration parameter in the present era q_o:

$$q_0 = -\frac{\ddot{R}(t_0)\,R(t_0)}{\dot{R}(t_0)^2} \qquad (3)$$

Now, if we combine (1), (2), and (3), then we can write (3) as follows:

$$q_0 = -\frac{dc_0}{dt}\frac{1}{c_0 H_0} \qquad (4)$$

By choosing values $c_o = 3.0\text{x}10^{10}$ cm/sec, $q_o = 1.0$, $H_0 = 1.77\text{x}10\text{-}18\ \text{sec}^{-1}$, Dt = 1 year = $3.15\text{x}10^7$ sec we obtain:

$$\Delta c = -c(t_o)q_o H_o \Delta t = (1.77\times10^{-18})(3\times10^{10})(3.15\times10^{7}) = -1.674\ \text{cm sec}^{-1} \qquad (5)$$

which is the decrease in the speed of light in one year's time. The result implies that the speed of light is decreasing at the present time. In the future, if we have better estimates for the parameters, q_o, and H_0, then a better estimate can also be obtained for Dc.

The change-rate just calculated is relatively small indeed, and it should not effect cosmology and relativity within the domain of space-time in our vicinity. After all, it could be more of a special relativistic effect than a gravitational one.[7] We could also mention that the idea of a cosmological model in terms of a variable speed of light might be new and daring, but a time-dependent value of c could go a long way towards solving some of the modern cosmological problems such as flatness, isotropy, horizons, cosmological constant, homogeneity, etcetera.[7,10] A time-dependent value of c would also affect calculation of black-hole size and evaporation.[9]

CONCLUSIONS

Given recent discussions of the possibility of a time-dependent value of the speed of light[7,8,9,10] we have presented a calculation to estimate the rate of change. The calculation has been carried out on the assumption that the speed of light at any time is equal to the rate of change of the radius of an expanding universe.

ACKNOWLEDGMENTS

I would like to thank Dr: William Lonc of the Astronomy and Physics Department at Saint Mary's University, Halifax, Nova Scotia for useful discussions during the preparation of this little paper.

REFERENCES

1. P. A. Dirac, Proc. R. Soc. A 165, 199, 1938.
2. Idem, Nature, 139, 323, 1937
3. G. Gamow, Phys. Rev. Letters, 19, 759, 1967.
4. D. W. Sciama, Mon. Notes Royal, Astronomical, Soc. 113, 34, 1953.
5. S. Weinberg, Gravitation and Cosmology, John Wiley & Sons, New York, 1972.
6. J. V. Peach, Astrophys. J. 159, 753, 1970.
7. A. Albrecht and J. Magueijo, Phys., Rev., D 59, 1999.
8. V. S. Troiskii, Astrophysics and Space Science 139, 1987, 389-411.
9. J. Barrow, Phys. Rev. D 59, 1999.
10. M. A. Clayton, J. W. Moffat Physics Letters B, 460, 1999, 263-270.

[Journal Home Page](http://www.journaloftheoretics.com)

email: mail@journaloftheoretics.com