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QUADRATIC RED SHIFT LAW AND THE NON-ARCHIMEDEAN UNIVERSE

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The quadratic law of the cosmic red-shift proposed recently by Segal et al. and Troitskii et al. is explained in a static non-Archimedean Universe by the "compression" of the radial distance metric. The metric is compressed according to the universal mapping function $\nu(x) = \tanh x$.

1. Introduction

The widely accepted standard cosmology is based on the notion that the space- time metric at an earlier epoch (about 20 billion years ago) was singular. All the matter and the energy of the Universe was concentrated in single infinitesimal point. The experimental proof for this physically absurd but widely accepted notion is suppose to have come from the Hubble's law which states that the red shift of distant galaxies is proportional to the distance from the observer. The linear law, first published in 1929 by Hubble was culmination of a decade of earlier research by a number of workers like Slipher, Wirtz and Lundmark on the subject of the cosmic red shift. Later work by Hubble and Humason [1] in 1939 seems to have confirmed the linear law. This resulted in its wide acceptance though there were reservations expressed by Zwicky [2] on account of use of bright galaxy cluster samples. Apart from the simplicity, the major impetus for the acceptance of the linear law came from the fact that it seemed to confirm some earlier theoretical concepts about expanding Universe by Friedman, Lemaitre and De-Sitter. Later work by Gamow on remanent cosmic radiation and element abundance and recent work by Penrose and Hawking on gravitational singularities seems to have nailed the issue in favour of the linear law and the expanding Universe.

In spite of these brilliant successes, there were always nagging doubts about the validity of the linear law. In particular Chip Arp and co-workers [3] have been pointing out for some time (apparently without much success) that the red shift from quasars and other large scale structures show an anomalous behaviour which cannot be explained by the linear law. In fact, based on extensive investigations, Segal et al. [4] and Troitskii and his co-workers [5] have recently shown that the quadratic law $z\alpha R^2$ (z is the red shift and R is the distance of the object) is a better fit to the available data on cosmic red shift than the linear $z\alpha R$.

If this law is true, then there must be serious reconsiderations about expanding Universe and standard cosmology. There is no way in which the quadratic law can be accommodated in it. To explain this law Segal et al. have resorted to chronometrical cosmology [4] while Troitskii has attributed it to gravitational effects. Very recently [6] we have explained the cosmic red shift in a static Universe starting from a very general principle which states that "magnitude of all the physical quantities in the Universe is bounded from above". The red shift arises due to radial compression of the metric in a Universe of finite extent. In this paper we show how these notions can be used to explain the quadratic law of the red shift.

2. Non-Archimedean algebra

As stated earlier we start from very general principle which states that the magnitude of physical quantities is finite. Now, ordinary algebra and mathematics which is based on the Archimedean axiom that "there is no largest number" is unsuited to deal with such quantities. As we have recently shown in a series of papers [7-12], internally consistent, alternate

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algebras based on the notion of a "largest number" can be constructed. These algebras which are called "Non-Archimedean" (NA) algebras are most suited to deal with physical quantities whose magnitudes are bounded from above. In this section we describe some basic rules of NA which will be used later in the discussion.

Let us begin by declaring M to be the "largest" number. Our first task, then, is to construct an internally consistent number system and an algebra for such number which will respect the axiom that M is the largest number. That is, no operation of this algebra or mathematical operations based on it will ever result in a number greater than M. As has been shown [11], such a number field can be obtained from the ordinary unbounded number field by a mapping function $\nu(x)$ and its inverse $\tau(x)$ with following properties [12]:

$$\nu(0) = \tau(0) = 0; \quad \tau(\pm\infty) = M; \quad \tau(\pm M) = \pm\infty. \tag{2.1}$$

Further, the four basic operation for the new numbers are given by

$$x \overset{\circ}{+} y = \nu[\tau(x) + \tau(y)], x \overset{\circ}{-} y = \nu[\tau(x) - \tau(y)] \tag{2.2}$$

$$x \circ y = \nu[\tau(x) \times \tau(y)], x \overset{\circ}{\circ} y = \nu[\tau(x)/\tau(y)] \tag{2.3}$$

Thus once $\nu(x)$ and $\tau(x)$ satisfying eq. (2.1) are specified, then the corresponding set of basic operations and the entire mathematical structure based on them is determined. It should be noted that because of isomorphism the NA algebras are as consistent as the usual Archimedean algebra.

What, then is thus universal mapping function $\nu(x)$ according to which all physical quantities are to be manipulated? Clearly mathematical considerations alone cannot uniquely specify $\nu(x)$. This function is to be fixed by the appeal to the experimental observations. The most suitable observation for this is that of the cosmic red shift which we discuss in the next section.

Cosmic red shift

To discuss this, we consider a spherically symmetric, at and static Universe of radius R_0. In this Universe the distance between two points A and B is bounded from above, i.e. $R \leq R_0$. Because of this, the radial distance metric is "compressed" as one travels outwards from the point of observation towards horizon (Fig. 1a). This "compressed" metric is to be obtained by mapping all the points on the radius of an ∞ sphere to the radius of a finite sphere R_0 using mapping function $\nu(R)$ (which is yet to be determined). Our discussion of the red shift will be based on two principles. (a) cosmological principle - which states that the Universe looks identical from all vantage points. Thus if B is the observation point (Fig. 1b) then the Universe looks identical with a sphere of radius R_0 redrawn around B. (b) Universe locally is Archimedean i.e. $\nu(R) \simeq R$ for $R \ll R_0$.

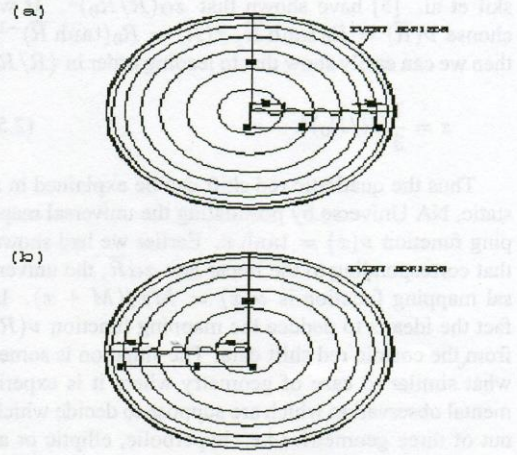

Fig. 1. *a) Non-Archimedean Universe as seen from point A.The event horizon is the outermost boundary. The light from B is redshifted when received at A. b) The same Universe as seen from point B. The light from A is redshifted when received at B.*

Thus NA effect will be apparent only when the magnitudes are close to their upper bounds i.e. $R \leq R_0$. One such object is the radiation from the distant objects. Clearly, one can see that the light emitted by a star at B will be red shifted when observed at A (Fig. 1a). Similarly, light emitted by a star at A will be red shifted when observed at B (Fig. 1b). Thus the phenomenon of red shift is a NA effect in a static Universe. The function $\nu(R)$ can be related to the red shift z as follows. Let the light be emitted at time $t = 0$ from B and observed at $t = t_2$ when received at A. If the distance between A and B is R then $R/R_0 = \nu(ct_2/R_0)$, where c is the velocity of light. Thus the light is received at A at time $t_2 = \frac{R_0}{c}\tau(\overline{R})$, $\overline{R} = R/R_0$ and the wavelength of the radiation mea-

sured at A is $\lambda_2 = ct_2/n$ where n is the number of wavelength between A and B. On the other hand, if the Universe was infinite, then the light would have been received at time $t_1 = R/c$ and the wavelength would have been $\lambda_1 = ct_1/n$. Thus the red shift $z = (\lambda_2 - \lambda_1)/\lambda_1$ is given by

$$z = \frac{\tau(\overline{R})}{\overline{R}} - 1. \tag{2.4}$$

Now extensive work by Segal et al. [4] and Troitskii et al. [5] have shown that $z\alpha(R/R_0)^2$. If we choose $\nu(\overline{R}) = R_0 \tanh \overline{R}$, $\tau(\overline{R}) = R_0(\tanh \overline{R})^{-1}$, then we can easily show that to leading order in (R/R_0)

$$z = \frac{1}{3}(R/R_0)^2. \tag{2.5}$$

Thus the quadratic red shift can be explained in a static, NA Universe by postulating the universal mapping function $\nu(x) = \tanh x$. Earlier we had shown that corresponding to the linear law $z\alpha\overline{R}$, the universal mapping function is $\nu(x) = Mx/(M + x)$. In fact the idea is to deduce the mapping function $\nu(R)$ from the cosmic red shift data. The situation is somewhat similar to case of geometry where it is experimental observation which are suppose to decide which out of three geometries i.e. hyperbolic, elliptic or at is applicable to the Universe. It should be noted that as in De-setter's Universe, the boundary R_0 in the NA Universe is the "event horizon" and the red shift $z \to \infty$ and $R \to R_0$, that is the light will take infinitely long time to go from $R = 0$ to $R = R_0$. To see this, the distance R covered by the light in time t is $R = R_0 \tanh(ct/R_0)$, thus $t \to \infty$ as $R \to R_0$. Also in this Universe all the points within the metric are equidistant from the event horizon i.e. $R_0 \overset{\circ}{-} R = R_0$ for all R.

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КВАДРАТИЧНЫЙ ЗАКОН КРАСНОГО СМЕЩЕНИЯ И НЕАРХИМЕДОВА ВСЕЛЕННАЯ

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Квадратичный закон космологического красного смещения, предложенный недавно Сегалом, Троицким и др., объясняется в статической неархимедовой Вселенной как сокращение радиального расстояния. Оно сокращается согласно универсальному закону: $\nu(x) = \operatorname{th} x$.

КВАДРАТИЧНИЙ ЗАКОН ЧЕРВОНОГО ЗМІЩЕННЯ ТА НЕАРХІМЕДІВ ВСЕСВІТ

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Квадратичний закон космологічного червоного зміщення, запропонований нещодавно Сегалом, Троїцьким та ін., пояснюється у статичному неархімедовому Всесвіті як скорочення радіальної відстані. Вона скорочується згідно із універсальним законом: $\nu(x) = \operatorname{th} x$.