The Pioneer satellites anomaly is a natural constant

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Abstract

It is believed that the Pioneer satellites anomaly could be resolved by the orbit determination programs (ODP) if some particular elements of the satellite that were omitted or rejected as non applicable were taken into account. This is not the case and up to now, not a single proposition has been able to resolve the anomalous acceleration that plagued those satellites. We show that the Pioneer anomaly is in fact a natural and universal constant also remarked as an apparent numerical coincidence.

Contents

1 Introduction

N umerous studies about the Pioneer satellites anomaly have been published and this anomaly became an enigma after the incapacity to find it a rational explication. The two most recent documents making a complete review and analysis of the numerous proposals are those of "J.D. Anderson, P.A. Laing, E.L. Lau, A.S. Liu, M.M. Nieto and S.G. Turyshev, April 2002" [1] and of "S.G. Turyshev and V.T. Toth, August 2010" [2]. Clearly detected by 1987, announced at a 1993 Conference Proceedings [3] and since the first reference to its presence in a 1994 scientific publication [4], it initiated numerous proposals and publications. Most of them concluded to an inertial effect, that is the presence of elements not taken into account by the satellite navigation softwares, translated as a force causing an acceleration of the satellite. The most frequent element suggested as a cause is of thermal nature. This is an error since the power available on the satellite decreases with time while the anomaly stays constant. It is astonishing that most studies always make reference to the Pioneer anomaly as a physical acceleration of the satellite instead of referring to the observed fact of a constant drift of the Doppler signal.

R ecently, thinking differently, Allan Joel Anderson [5] looks for an unknown influence on the electromagnetic signal, that is on the communication link with the satellite. This effect, he calls "Cosmic redshift", is based on the hypothesis of an expanding universe according to the FLRW (Friedman, Lemaître, Robertson, Walker) model. He considers that the Hubble constant "H_o" represents the rate of change of the wavelength of the photons by unit of time. This explication cannot hold because an expanding universe always increases the wavelength or the redshift contrarily to what is observed, a blue shift. But this proposal has the value of pointing attention to a cause acting on the electromagnetic signal itself.

I t has also been pointed out the presence of very small cyclic variations of the drifting Doppler radio signal [2]. The analysis showed half day, daily, half annual and annual periodicity where the day is the sidereal one [6]. Those cyclic variations become smaller as the distance to the satellite increase. Isn't this a clear indication of a distance dependency on the light ray length between the satellite and the listening earth stations ?

2 Models

T here are two cosmological models supporting an interaction with an electromagnetic signal and able to change its wavelength and able to explain the drifting of the Doppler signal. There is the expansionist model also known as the Big Bang and the transformation model. According to both models, the observed wavelength vary as a function of the travelled distance by the electromagnetic wave or, equivalently, as a function of the redshift.

2.1 The expansionist model

L et us consider the geometrical space, as isotropic and expanding. Any distance "d", between any fixed and non moving point, remains proportional during expansion. This is described by a time function "$a(t)$" which acts as a multiplier on all dimensions. However, even if those dimensions change with time, isotropic space implies that relative values of the rate of change will be the same everywhere that is

$$\dot{a}(t)/a(t) = constant \tag{2.1}$$

Considering the distance "d", the wavelength "λ", and the frequency "f", their relative rate of change are

$$\dot{a}/a = \dot{d}/d = \dot{\lambda}/\lambda = -\dot{f}/f \tag{2.2}$$

In this universe we consider that Galaxies don't have intrinsic speed, they move due to the expansion of the universe. Hubble's law link their speed "v" to their distance "d" by the Hubble constant "H_o" as

$$v = H_o d \tag{2.3}$$

In such world, Hubble constant can be related to expansion and to wavelength as

$$H_o = v/d = \dot{d}/d = \dot{\lambda}/\lambda \tag{2.4}$$

Using the redshift definition and with some mathematics we get

$$\mathbb{Z} = (\lambda - \lambda_o)/\lambda_o \tag{2.5}$$

$$\lambda = \lambda_o(\mathbb{Z}+1) \tag{2.6}$$

$$\dot{\lambda} = \lambda_o\dot{\mathbb{Z}} \tag{2.7}$$

$$\dot{\lambda}/\lambda = \dot{\mathbb{Z}}/(\mathbb{Z}+1) \tag{2.8}$$

$$H_o = \dot{\lambda}/\lambda = -\dot{f}/f = \dot{\mathbb{Z}}/(\mathbb{Z}+1) \tag{2.9}$$

Wavelength emitted by galactic sources are at a later time always longer. Consequently frequencies are always smaller.

2.2 The transformation model

G osselin [7] considers that the photons transforms naturally without any interaction with other elements of the universe, this being an intrinsic property. Then on their journey, the photon's energy lowers while their number increase. This transformation lasts until their wavelength reach the cosmic microwave background (CMB) where it stops. This transformation works inversely for photons whose wavelength is longer than the CMB one. In this model, the Hubble constant comes out naturally where it has a logarithmic form instead of the classic one $d = c/H_o \cdot \mathbb{Z}$. It is written as

$$d = \pm c/H_o \cdot ln(\mathbb{Z}+1) \tag{2.10}$$

This double situation is taken into account by the fact that the cosmic shift is negative and greater than -1 when wavelength are longer than the CMB wavelength and positive on the contrary. Some mathematics where the variables are the time "t", the distance "d", the Hubble constant "H_o", the vacuum speed of light "c", the cosmic shift "$\mathbb{Z}$", the wavelength "λ" at the frequency "f" brings

$$d = \pm c/H_o \cdot ln(\mathbb{Z}+1) \tag{2.11}$$
$$\mathbb{Z} = exp(\pm H_o d/c) - 1 \tag{2.12}$$
$$\dot{\mathbb{Z}} = \pm H_o(\mathbb{Z}+1) \tag{2.13}$$
$$H_o = \pm\dot{\mathbb{Z}}/(\mathbb{Z}+1) \tag{2.14}$$
$$\lambda = \lambda_o exp(\pm H_o d/c) \tag{2.15}$$
$$\dot{\lambda} = \pm\lambda H_o \tag{2.16}$$
$$f = f_o exp(\pm(-H_o d/c)) \tag{2.17}$$
$$\dot{f} = \pm(-f H_o) \tag{2.18}$$
$$H_o = \pm\dot{\lambda}/\lambda = \pm(-\dot{f}/f) = \pm\dot{\mathbb{Z}}/(\mathbb{Z}+1) \tag{2.19}$$

2.3 Comparison

T hese two models come to the same equation except for the negative sign. The expansionist model predicts a constant increase of the wavelength or a frequency decrease. The transformation model shows two solutions depending on the length of the wavelength compared to length of the cosmic microwave background. Larger, there is a decrease and shorter, there is an increase as for the expansionist model. The negative sign and the negative value of the cosmic shift make the difference.

3 The Doppler effect

L et us consider a source at rest sending a wave of frequency "f_s" toward an observer also at rest who measure it as an observed frequency "f_o". If that source moves toward this observer, always at rest, with a constant speed "v_s", this last one would see a different frequency because of the Doppler effect. "c" being the signal speed in the media, the observed frequency is

$$f_o = f_s \cdot c/(c - v_s) \tag{3.1}$$

$$f_s/f_o = 1 - v_s/c \tag{3.2}$$

$$(f_s - f_o)/f_o = -v_s/c \tag{3.3}$$

$$\Delta f/f_o = v_s/c \tag{3.4}$$

If the source were to quickly accelerate during a short time interval "Δt", it would reach the speed "v_s" and be submitted to an acceleration "$a_s = v_s/\Delta t$". The signal of this source now moving at constant speed will be observed at a new frequency as given by equation (3.1). Then equation (3.4)is written as

$$\Delta f/f_o = a_s \Delta t/c \tag{3.5}$$

$$a_s/c = (\Delta f/\Delta t)/f_o \tag{3.6}$$

$$a_s/c = \dot{f}/f_o \tag{3.7}$$

Without consideration for the sign, the second term of equation (3.7) is the Hubble constant as per equation (2.9) for the expansionist model or equation (2.19) for the transformation model. Using "a_P" for the Pioneer acceleration instead of "a_s" we have

$$a_P = cH_o \tag{3.8}$$

Here we have the product of two natural constants of the universe. Then we can say that the satellite acceleration is an invariant. Using the value determined by Gosselin [7] for the Hubble constant $H_o = 2,731934 \cdot 10^{-18}\ s^{-1}$, we find for the value of the universal virtual satellite acceleration

$$a_P = 8,19 \cdot 10^{-10}\ m\ s^{-2} \tag{3.9}$$

which is close to the Pioneer anomalous acceleration $8,74 \pm 1,33 \cdot 10^{-10}\ m\ s^{-2}$. This explains the strange numerical coincidence between the speed of light, the Hubble constant and the Pioneer anomaly. There isn't any magic there, no mystery. This is an erroneous association of a non existing inertial force with a cosmological phenomena, a substitution based on the fact that two different interpretations, an inertial and a cosmological one, both leading to the same Doppler effect.

4 Analysis

A s we have shown, both models, expansion or transformation, lead to the same mathematical expression for the Hubble constant, exception being made of the sign. Both models predict the same cosmic redshift as long as the wavelength of the signal is longer than the CMB one. For the expansion model, there is no limit to this evolution of the wavelength. For the transformation model, this evolution stops at the CMB wavelength. And conversely, longer wavelengths evolve toward this CMB wavelength. And it is exactly the situation in which the satellites evolve. The frequency of the signal used between the satellite and the earth stations is lower than the CMB one. This is why with increasing distance the drift of the Doppler signal is toward the blue (shorter wavelength or higher frequency). It is impossible for the expansion model to cope with this fact because it always predicts an increase of the wavelength. Since the satellite is moving at a constant speed "v_P", we write "$d = v_P\ t$" into equation (2.12) and take its derivative against time

$$\mathbb{Z} = exp(-\ H_o\ v_P\ t/c) - 1 \tag{4.1}$$

$$\dot{\mathbb{Z}} = -\ (\mathbb{Z}+1)\ (H_o/c)\ v_P \tag{4.2}$$

Then it is clear that the Doppler drift is proportional to the satellite distance from the observer. It shall be noted that "$\mathbb{Z}$" is a negative quantity that becomes more negative as the satellite goes farther from the observer.

C onsidering what has been said, it shall be of interest to make a reanalysis the satellites data. The parameters of interest are the line of sight distance between the satellite and the earth stations, the satellite speed as determined by the Doppler redshift and the Doppler redshift drift. Graphing those against time and, the Doppler redshift drift against distance, shall show clearly the Hubble constant as well as the small fluctuations due to the earth movement. The important change of the Doppler drift when a satellite encounters a planet (flyby) is explained by an abrupt change of the satellite direction causing an important modification to the line of sight distance.

5 Conclusion

We showed that the Pioneer anomalous acceleration is a non existing phenomena but simply an erroneous interpretation of the Doppler signal drift. According to the Gosselin [7] model, this is in fact caused by the long distance transformation of the electromagnetic signal used for the communications with the satellite. We also showed that the value of this false acceleration is a universal constant and the same for any satellite. We call it the virtual Pioneer acceleration.

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