Less Mundane Explanation of Pioneer Anomaly from Q-Relativity

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There have been various explanations of Pioneer blueshift anomaly in the past few years; nonetheless no explanation has been offered from the viewpoint of Q-relativity physics. In the present paper it is argued that Pioneer anomalous blueshift may be caused by Pioneer spacecraft experiencing angular shift induced by similar Q-relativity effect which may also affect Jupiter satellites. By taking into consideration "aether drift" effect, the proposed method as described herein could explain Pioneer blueshift anomaly within ∼0.26% error range, which speaks for itself. Another new proposition of redshift quantization is also proposed from gravitational Bohr-radius which is consistent with Bohr-Sommerfeld quantization. Further observation is of course recommended in order to refute or verify this proposition.

1 Introduction

In the past few years, it is becoming well-known that Pioneer spacecraft has exhibited an anomalous Doppler frequency blueshifting phenomenon which cannot be explained from conventional theories, including General Relativity [1, 4]. Despite the nature of such anomalous blueshift remains unknown, some people began to argue that a post-einsteinian gravitation theory may be in sight, which may be considered as further generalisation of pseudo-Riemannian metric of general relativity theory.

Nonetheless, at this point one may ask: Why do we require a generalization of pseudo-Riemannian tensor, instead of using "patch-work" as usual to modify general relativity theory? A possible answer is: sometimes too much path-work doesn't add up. For instance, let us begin with a thought-experiment which forms the theoretical motivation behind General Relativity, an elevator was put in free-falling motion [8a]. The passenger inside the elevator will not feel any gravitational pull, which then it is interpreted as formal analogue that "inertial acceleration equals to gravitational acceleration" (Equivalence Principle). More recent experiments (after Eötvös) suggest, however, that this principle is only applicable at certain conditions.

Further problem may arise if we ask: what if the elevator also experiences lateral rotation around its vertical axis? Does it mean that the inertial acceleration will be slightly higher or lower than gravitational pull? Similarly we observe that a disc rotating at high speed will exert out-of-plane field resemble an acceleration field. All of this seems to indicate that the thought-experiment which forms the basis of General Relativity is only applicable for some limited conditions, in particular the $F = m\frac{dv}{dt}$ part (because General Relativity is strictly related to Newtonian potential), but it may not be able to represent the rotational aspects of gravitational phenomena. Einstein himself apparently recognizes this limitation [8a, p.61]:

> "...all bodies of reference K' should be given preference in this sense, and they should be exactly equivalent to K for the formation of natural laws, provided that they are in a state of *uniform rectilinear and non-rotary motion* with respect to K." (Italic by Einstein).

Therefore, it shall be clear that the restriction of *non-rotary motion* remains a limitation for all considerations by relativity theory, albeit the *uniform rectilinear* part has been relaxed by general relativity theory.

After further thought, it becomes apparent that it is required to consider a new kind of metric which may be able to represent the rotational aspects of gravitation phenomena, and by doing so extends the domain of validity of general relativity theory.

In this regard, the present paper will discuss the aforementioned Pioneer blueshift anomaly from the viewpoint of Q-relativity physics, which has been proposed by Yefremov [2] in order to bring into application the quaternion number. Despite the use of quaternion number in physical theories is very scarce in recent years — apart of Pauli matrix — it has been argued elsewhere that using quaternion number one could expect to unify all known equations in Quantum Mechanics into the same framework, in particular via the known isomorphism between Dirac equation and Maxwell equations [5].

Another problem that was often neglected in most treatises on Pioneer spacecraft anomaly is the plausible role of aether drift effect [6]. Here it can be shown that taking this effect into consideration along with the aforementioned Q-relativity satellite's apparent shift could yield numerical prediction of Pioneer blueshift within ∼0.26% error range, which speaks for itself.

We also suggest a new kind of Doppler frequency shift which can be predicted using Nottale-type gravitational Bohr-radius, by taking into consideration varying G parameter as described by Moffat [7]. To our knowledge this proposition of new type of redshift corresponding to gravitational Bohr-radius has never been considered before elsewhere.

Further observation is of course recommended in order to verify or refute the propositions outlined herein.

2 Some novel aspects of Q-relativity physics. Pioneer blueshift anomaly

In this section, first we will review some basic concepts of quaternion number and then discuss its implications to quaternion relativity (Q-relativity) physics [2]. Then we discuss Yefremov's calculation of satellite time-shift which may be observed by precise measurement [3]. We however introduce a new interpretation here that such a satellite Q-timeshift is already observed in the form of Pioneer spacecraft blueshift anomaly.

Quaternion number belongs to the group of "very good" algebras: of real, complex, quaternion, and octonion [2]. While Cayley also proposed new terms such as quantic, it is less known than the above group. Quaternion number can be viewed as an extension of Cauchy imaginary plane to become [2]:

$$Q \equiv a + bi + cj + dk\,, \tag{1}$$

where a, b, c, d are real numbers, and i, j, k are imaginary quaternion units. These Q-units can be represented either via 2×2 matrices or 4×4 matrices [2].

It is interesting to note here that there is quaternionic multiplication rule which acquires compact form:

$$1q_k = q_k 1 = q_k\,, \quad q_j q_k = -\delta_{jk} + \varepsilon_{jkn} q_n\,, \tag{2}$$

where δ_{kn} and ε_{jkn} represent 3-dimensional symbols of Kronecker and Levi-Civita, respectively [2]. Therefore it could be expected that Q-algebra may have neat link with pseudo-Riemannian metric used by General Relativity. Interestingly, it has been argued in this regard that such Q-units can be generalised to become Finsler geometry, in particular with Berwald-Moor metric. It also can be shown that Finsler-Berwald-Moor metric is equivalent with pseudo-Riemannian metric, and an expression of Newtonian potential can be found for this metric [2a].

It may also be worth noting here that in 3D space Q-connectivity has clear geometrical and physical treatment as movable Q-basis with behaviour of Cartan 3-frame [2].

It is also possible to write the dynamics equations of Classical Mechanics for an inertial observer in constant Q-basis. $SO(3, R)$-invariance of two vectors allow to represent these dynamics equations in Q-vector form [2]:

$$m\frac{d^2}{dt^2}\left(x_k q_k\right) = F_k q_k\,. \tag{3}$$

Because of antisymmetry of the connection (generalised angular velocity) the dynamics equations can be written in vector components, by conventional vector notation [2]:

$$m\left(\vec{a} + 2\vec{\Omega}\times\vec{v} + \dot{\vec{\Omega}}\times\vec{r} + \vec{\Omega}\times\left(\vec{\Omega}\times\vec{r}\right)\right) = \vec{F}\,. \tag{4}$$

Therefore, from equation (4) one recognizes known types of classical acceleration, i.e. linear, coriolis, angular, centripetal. Meanwhile it is known that General Relativity introduces Newton potential as *rigid* requirement [2a, 6b]. In other words, we can expect — using Q-relativity — to predict new effects that cannot be explained with General Relativity.

From this viewpoint one may consider a generalisation of Minkowski metric into biquaternion form [2]:

$$dz = \left(dx_k + i dt_k\right) q_k\,, \tag{5}$$

with some novel properties, i.e.:

- temporal interval is defined by imaginary vector;
- space-time of the model appears to have six dimensions (6D);
- vector of the displacement of the particle and vector of corresponding time change must always be normal to each other, or:

$$dx_k dt_k = 0\,. \tag{6}$$

It is perhaps quite interesting to note here that Einstein himself apparently once considered similar approach, by proposing tensors with Riemannian metric with Hermitian symmetry [8]. Nonetheless, there is difference with Q-relativity described above, because in Einstein's generalised Riemannian metric it has 8-dimensions, rather than 3d-space and 3d-imaginary time.

One particularly interesting feature of this new Q-relativity (or rotational relativity) is that there is universal character of motion of the bodies (including non-inertial motions), which can be described in unified manner (Hestenes also considers Classical Mechanics from similar spinor language). For instance advanced perihelion of planets can be described in term of such rotational precession [2].

Inspired by this new Q-relativity physics, it can be argued that there should be anomalous effect in planets' satellite motion. In this regard, Yefremov argues that there should be a deviation of the planetary satellite position, due to discrepancy between calculated and observed from the Earth motion magnitudes characterizing cyclic processes on this planet or near it. He proposes [2]:

$$\Delta\varphi \approx \frac{\omega V_e V_p}{c^2}\,t\,, \tag{7}$$

or

$$\Delta\varphi' \approx -\frac{\omega V_e V_p}{c^2}\,t'. \tag{8}$$

Therefore, given a satellite orbit radius r, its position shift is found in units of length $\Delta l = r\,\Delta\varphi$. His calculation

Satellites	Cycle frequency ω, 1/s	Angular shift $\Delta\varphi$, ″/100 yrs	Linear shift Δl, km/100 yrs	Linear size a, km
Phobos (Mars)	0.00023	18.2	54	20
Deimos (Mars)	0.00006	4.6	34	12
Metis (Jupiter)	0.00025	**10.6**	431	40
Adrastea (Jupiter)	0.00024	**10.5**	429	20
Amalthea (Jupiter)	0.00015	6.3	361	189

Table 1: The following table gives values of the effect for five fast satellites of Mars and Jupiter. Orbital linear velocities are: of the Earth $V_E = 29.8$ km/s, of Mars $V_P = 24.1$ km/s, of Jupiter $V_P = 13.1$ km/s; the value of the light velocity is $c = 299\,793$ km/s; observation period is chosen 100 years. Courtesy of A. Yefremov, 2006 [3].

for satellites of Mars and Jupiter is given in Table 1. Nonetheless he gave no indication as to how to observe this anomalous effect.

In this regard, we introduce here an alternative interpretation of the aforementioned Q-satellite time-shift effect by Yefremov, i.e. this effect actually has similar effect with Pioneer spacecraft blueshift anomaly. It is known that Pioneer spacecraft exhibits this anomalous Doppler frequency while entering Jupiter orbit [1, 4], therefore one may argue that this effect is caused by Jupiter planetary gravitational effect, which also may cause similar effect to its satellites.

Despite the apparent contradiction with Yefremov's own intention, one could find that the aforementioned Q-satellite time-shift could yield a natural explanation of Pioneer spacecraft blueshift anomaly. In this regard, Taylor [9] argues that there is possibility of a mundane explanation of anomalous blueshift of Pioneer anomaly (5.99×10^{-9} Hz/sec). The all-angle formulae for relativistic Doppler shift is given by [9a, p.34]:

$$v' = v_0\,\gamma\,\frac{(1-\beta\cos\phi)}{\sqrt{1-\beta^2}}\,, \tag{9}$$

where $\beta = v/c$. By neglecting the $\sqrt{1-\beta^2}$ term because of low velocity, one gets the standard expression:

$$v' = v_0\,\gamma\,(1-\beta\cos\phi)\,. \tag{9a}$$

The derivative with respect to ϕ is:

$$\frac{dv'}{d\phi} = v_0\,\gamma\,\beta\sin\phi\,, \tag{10}$$

where $\frac{dv'}{d\phi} = 5.99\times10^{-9}$ Hz/sec, i.e. the observed Pioneer anomaly. Introducing this value into equation (10), one gets requirement of an effect to explain Pioneer anomaly:

$$d\phi = \frac{\arcsin\,(5.99\times10^{-9}\ \text{Hz})}{v_0\,\gamma\,\beta} = 1.4\times10^{-12}\ \text{deg/sec}. \tag{11}$$

Therefore, we can conclude that to explain 5.99×10^{-9} Hz/sec blueshift anomaly, it is required to find a shift of emission angle at the order 1.4×10^{-12} degree/sec only (or around 15.894″ per 100 years).

Interestingly this angular shift can be explained with the same order of magnitude from the viewpoint of Q-satellite angular shift (see Table 1), in particular for Jupiter's Adrastea (10.5″ per 100 years). There is however, a large discrepancy at the order of 50% from the expected angular shift.

It is proposed here that such discrepancy between Q-satellite angular shift and expected angular shift required to explain Pioneer anomaly can be reduced if we take into consideration the "aether drift" effect [6]. Interestingly we can use experimental result of Thorndike [6, p.9], saying that the aether drift effect implies a residual apparent Earth velocity is $v_{obs} = 15 \pm 4$ km/sec. Therefore the effective V_e in equation (8) becomes:

$$V_{e.eff} = v_{obs} + V_e = 44.8\ \text{km/sec}. \tag{12}$$

Using this improved value for Earth velocity in equation (8), one will get larger values than Table 1, which for Adrastea satellite yields:

$$\Delta\varphi_{obs} = \frac{\omega V_{e.eff} V_p}{c^2}\,t = \frac{V_{e.eff}}{V_e}\,\Delta\varphi = 15.935''/100\ \text{yrs}. \tag{13}$$

Using this improved prediction, the discrepancy with required angular shift only (15.894″ per 100 years) becomes $\sim$ 0.26%, which speaks for itself. Therefore one may conclude that this less mundane explanation of Pioneer blueshift anomaly with Q-relativity may deserve further consideration.

3 A new type of redshift from gravitational Bohr radius. Possible observation in solar system.

In preceding paper [10, 11] we argued in favour of an alternative interpretation of Tifft redshift quantization from the viewpoint of quantized distance between galaxies. A method can be proposed as further test of this proposition both at solar system scale or galaxies scale, by using the known quantized Tifft redshift [14, 15, 16]:

$$\delta r \approx \frac{c}{H}\,\delta z\,. \tag{14}$$

In this regards, we use gravitational Bohr radius equation:

$$r_n = n^2\,\frac{GM}{v_0^2}\,. \tag{15}$$

Inserting equation (15) into (14), then one gets quantized redshift expected from gravitational Bohr radius:

$$z_n = \frac{H}{c} n^2 \frac{GM}{v_0^2} \tag{16}$$

which can be observed either in solar system scale or galaxies scale. To our present knowledge, this effect has never been described elsewhere before.

Therefore, it is recommended to observe such an accelerated Doppler-freequency shift, which for big jovian planets this effect may be detected. It is also worth noting here that according to equation (16), this new Doppler shift is quantized.

At this point one may also take into consideration a proposition by Moffat, regarding modification of Newtonian acceleration law to become [7]:

$$a(r) = -\frac{G_\infty M}{r^2} + K\frac{\exp(-\mu_\phi r)}{r^2}(1+\mu_\phi r) \tag{17}$$

where

$$G_\infty = G\left[1+\sqrt{\frac{M_0}{M}}\,\right]. \tag{17a}$$

Therefore equation (16) may be rewritten to become:

$$z_n \approx \frac{H}{c} n^2 \frac{GM}{v_0^2}\left[1+\sqrt{\frac{M_0}{M}}\,\right] \approx \chi\,\frac{H}{c} n^2 \frac{GM}{v_0^2} \tag{18}$$

where n is integer (1, 2, 3, ...) and:

$$\chi = \left[1+\sqrt{\frac{M_0}{M}}\,\right]. \tag{18a}$$

To use the above equations, one may start by using Bell's suggestion that there is fundamental redshift $z = 0.62$ which is typical for various galaxies and quasars [14]. Assuming we can use equation (16), then by setting $n = 1$, we can expect to predict the mass of quasar centre or galaxy centre. Then the result can be used to compute back how time-variation parameter affects redshift pattern in equation (18). In solar system scale, time-varying radius may be observed in the form of changing Astronomical Unit [4].

This proposition, however, deserves further theoretical considerations. Further observation is also recommended in order to verify and explore further this proposition.

4 Concluding remarks

In the present paper it is argued that Pioneer anomalous blueshift may be caused by Pioneer spacecraft experiencing angular shift induced by similar Q-relativity effect which may also affect Jupiter satellites. By taking into consideration aether drift effect, the proposed method as described herein could predict Pioneer blueshift within ∼0.26% error range, which speaks for itself. Further observation is of course recommended in order to refute or verify this proposition.

Another new proposition of redshift quantization is also proposed from gravitational Bohr-radius which is consistent with Bohr-Sommerfeld quantization. It is recommended to conduct further observation in order to verify and also to explore various implications of our propositions as described herein.

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References

1. Anderson J.D., Campbell J.K., & Nieto M.M. arXiv: astro-ph/ 0608087; [1a] Nieto M.M. & Anderson J.D. arXiv: gr-qc/0507052.
2. Yefremov A. *Hypercomplex Numbers in Geometry and Physics*, 2004, v. 1(1), 105; [2a] Pavlov D. G. arXiv: math-ph/ 0609009.
3. Yefremov A. Private communication, October 2006. Email: a.yefremov@rudn.ru.
4. Laemmerzahl C. & Dittus H. Clocks and gravity, from quantum to cosmos. UCLA, 2006, http://www.physics.ucla.edu/ quantum_to_cosmos/q2c06/Laemmerzahl.pdf
5. Christianto V. *EJTP*, 2006, v. 3, No. 12, http://www.ejtp.com.
6. Consoli M. arXiv: physics/0306094, p. 9; [6a] Consoli M. *et al.* arXiv: gr-qc/0306105; [6b] arXiv: hep-ph/0109215.
7. Moffat J. arXiv: astro-ph/0602607.
8. Einstein A. *Ann. Math.*, 1945, v. 46; [8a] Einstein A. Relativity: the special and general theory. Crown Trade Paperback, New York, 1951, pp. 61, 66–70.
9. Taylor S. arXiv: physics/0603074; [9a] Engelhardt W. *Apeiron*, 2003, v. 10, No. 4, 34.
10. Smarandache F. & Christianto V. *Progress in Physics*, 2006, v. 4, 27–31.
11. Smarandache F. & Christianto V. *Progress in Physics*, 2006, v. 4, 37–40.
12. Smarandache F. & Christianto V. *Progress in Physics*, 2006, v. 2, 63–67.
13. Fischer U. arXiv: cond-mat/9907457; [13a] arXiv: cond-mat/ 0004339.
14. Bell M.B. arXiv: astro-ph/0111123; [14a] Bell M.B. arXiv: astro-ph/0305112; [14b] Bell M.B. arXiv: astro-ph/0305060.
15. Humphreys R. *TJ Archive*, v. 16, http://answersingenesis.org.
16. Múnera H. *Apeiron*, 1998, v. 5, No. 3–4.
17. Zurek W. (ed.) *Proc. Euroconference in Formation and Interaction of Topological Defects*, Plenum, 1995; arXiv: cond-mat/9502119.
18. Volovik G. arXiv: cond-mat/0507454.