Frequency shift caused by gravitation, Doppler and aberration

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ABSTRACT

This paper describes a frequency shift by the difference in particle speed and gravitational potential. The frequency of light source is offset by the increase in motion energy and the clock delay, and that Doppler shift is a synthesis of the classical Doppler shift and the aberrational Doppler shift. And the translational movement of longitudinal direction without aberration is only the primary Doppler shift occurs. Gravitational frequency shift by difference of height is changing the frequency of the light source, and is changing the wave speed and wavelength of the photon. As an example the Flyby anomalies explain that the difference of centrifugal force potential appears to the frequency shift and ranging data.

INTRODUCTION

My previous research [1] involved representing energies (gravitational mass, inertial mass, and Planck's constant) of different particle speeds as an equivalence for quantum ($Mc=\Delta m\Delta w=hf/c$). In addition, $E=Mc^2$ (kinetic energy is changed to mass) does not indicate that the total energy change is always proportional to particle speed. Therefore, "energy representation of a mathematical action," and "energy change of a physical interaction" are not similar. The actual physical phenomenon should distinguish between these actions.

METHODOLOGY

The wave speed and total energy of the object to be resting at the invariant system is

$$c=w_0=f_0\lambda_0, \tag{1}$$
$$E_0=M_0c^2. \tag{2}$$

The clock delay is offset by the difference of motion energy:

A state that has added the motion energy from the (Eq.1,2) is

$$w=(c^2-v^2)^{1/2}, \tag{3}$$
$$E=(c/w)E_0. \tag{4}$$

When represent the energy quantum, it is

$$hf=(c/w)hf_0, \tag{5}$$

The light source from a motion object → Doppler shift viewed from the invariant system is

$$f_D=(w/c)f(1-[v\cdot\sin\theta/c]^2)^{1/2}/(1-v\cdot\cos\theta/c)=f_0(1-[v\cdot\sin\theta/c]^2)^{1/2}/(1-v\cdot\cos\theta/c), \quad (6)$$

$$\lambda_D=\lambda_0(1-v\cdot\cos\theta/c)/(1-[v\cdot\sin\theta/c]^2)^{1/2}. \quad (7)$$

The frequency of light source is offset by the increase in motion energy and the clock delay, and that Doppler shift is a synthesis of the classical Doppler shift and the aberrational Doppler shift.

Fig.1 is representing the difference between the Doppler shifts of relativity.

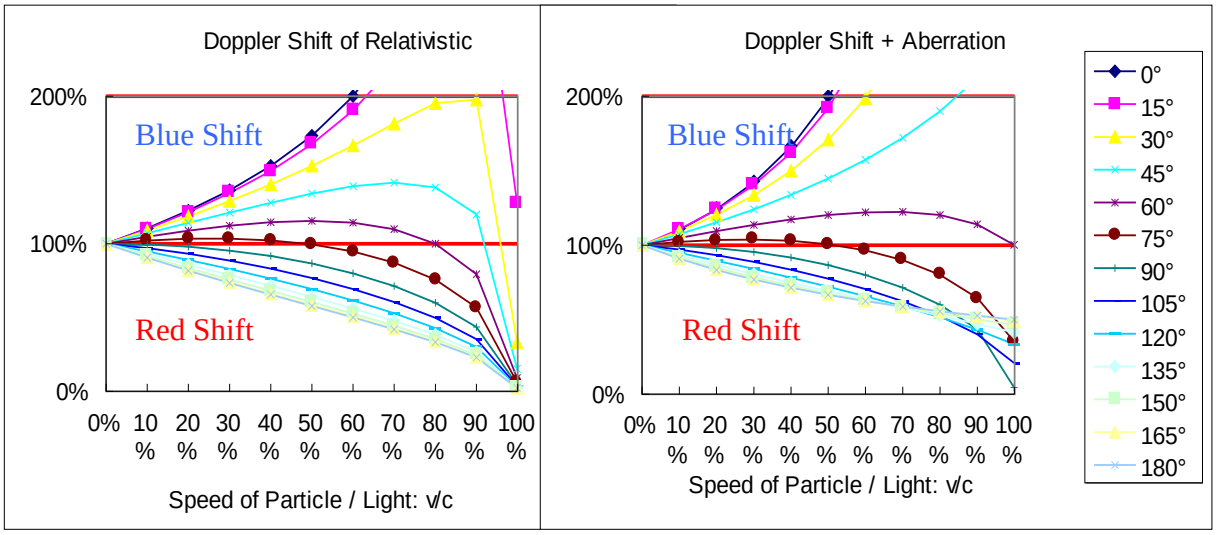

FIG.1: Comparison of the Doppler shift of this paper and the relativity: A Doppler shift of this paper is the same as almost the relativity at a relative speed (v/c<30%) of low-speed range or the transverse relative angle (θ=90°). That aberration Doppler shift is smaller toward the longitudinal relative angle. It will have only the primary Doppler shift at the relative angle (θ=0°,180°). On the other hand, the transverse Doppler shift of Relativistic occurs with the relative speed, and the relative angle is not involved, and the frequency will be shifted as disappear at the speed of light.

These are supported by the following.

a) The space-time from Noether's theorem there is a translational invariance and time invariance [5].
b) In Inverse photo-electric effect [6], the frequency of photons emitted from the moving electron is increased.
c) In Inverse Compton scattering [7], when electrons and photons in the relative motion collide, electron motion energy are transferred to the energy of the photon.

Gravitational frequency shift by the difference of gravitational potential:

A state that has lost the gravitational potential energy from the (Eq.1,2) is

$$w_L=(c^2-2GM/r)^{1/2}, \quad (8)$$

$$E_L=(w_L/c)E_0. \quad (9)$$

When represent the energy quantum, it is

$$hf_L=(w_L/c)hf_0. \quad (10)$$

A state that has added the gravitational potential energy from the (Eq.8,9) is

$$w_H=(c^2-2GM/[r+h])^{1/2}, \quad (11)$$
$$E_H=(w_H/c)E_0. \quad (12)$$

When represent the energy quantum, it is

$$hf_H=(w_H/c)hf_0. \quad (13)$$

Light emitted from the object to be still at an altitude $(r+h)$ → Gravitational blue-shift when viewed from the observer of the altitude (r) is

$$\lambda_0>\lambda_L=w_L/f_H. \quad (14)$$

Light emitted from the object to be still at an altitude (r) → Gravitational red-shift when viewed from the observer of the altitude $(r+h)$ is

$$\lambda_0<\lambda_H=w_H/f_L. \quad (15)$$

Gravitational red (blue) shift by the height difference $(r<r+h<\infty)$ is changing the frequency $(f_L<f_H<f_0)$ of the light source, and it is changing the wave speed $(w_L<w_H<w_0)$ and wavelength $(\lambda_L<\lambda_0<\lambda_H)$ of the photon. These are supported by the following observations fact.

a) The difference between the progresses of clocks is not related to the propagation of photons [2].
b) The photon does not change the propagation speed by the difference in the energy (frequency) [3].
c) Strong gravitational field than observer delay the arrival time of the photons pass through [4].

RESULTS AND DISCUSSION

They are summarized that the frequency shift of the light source is caused by the difference in the gravitational potential in Table 1 and Fig.2. It does not occur the frequency shift of the light source if the gravitational potential is the same. And the translational movement of longitudinal direction without aberration is only the primary Doppler shift occurs. The rotational motion like Mossbauer rotor experiment [8,9,10,11] will occur the red-shift in both directions by the aberration.

TABLE 1: Frequency shift caused by gravitation, Doppler and aberration

Viewing Source from Observer	Gravitational Blue Shift	Gravitational Red Shift	Doppler Shift	Doppler Shift	Aberrational Red Shift	Aberrational Red Shift
Total Energy	↑	↓	↑	↓	↑	↓
Particle Speed	–	–	↑	↓	↑	↓
Wave Speed	↑	↓	↓	↑	↓	↑
Gravitational Potential	↓	↑	–	–	–	–

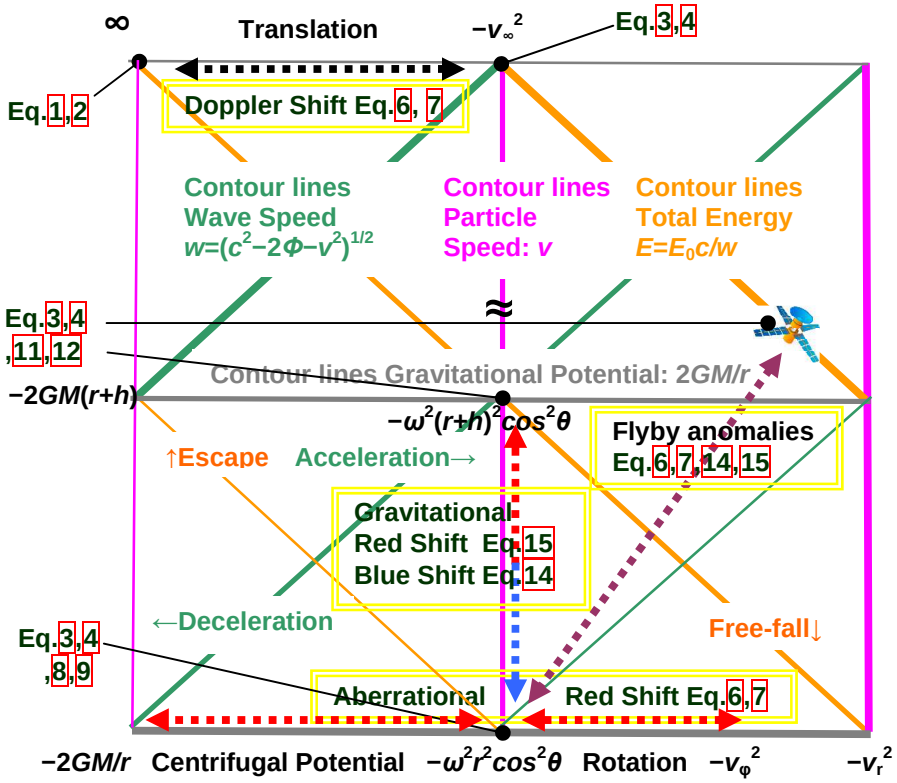

FIG.2: The frequency shift with the four-dimensional contour lines for the particle speed (Y-axis), the gravitational potential (X-axis), the total energy (＼Clinoaxis) and the wave speed (／Clinoaxis).

In the case of Flyby anomalies [12]:

The apparent speed of the low estimate ($v_\infty'^2=v^2-2GM/r$) [13] on the free-fall spacecraft (Eq.3,4,11,12) from infinity (Eq.1,2) appears to the speed increment of apparent. The real speed of infinity viewed from the observer in the delayed clock by centrifugal force potential (Eq.3,4,8,9) is

$$v_\infty=(c/w)v_\infty'=v_\infty' c/(c^2-\omega^2r^2\cdot\cos^2\theta)^{1/2}. \quad (16)$$

The speed increment at infinity of empirical formula [13] appear, it is

$$\Delta v_\infty = 2(\cos\delta_i - \cos\delta_o) v_\infty' \omega r/c. \quad (17)$$

Table 2 summarizes that there is no difference in the speed increment at infinity of Eq.(16,17) by the difference of the observing latitude.

TABLE 2: Comparison from the NASA Deep Space Network (DSN) view and the Equatorial view of empirical formula:

Quantity / Spacecraft	Galileo I	Galileo II	NEAR	Cassini	Rosetta-I	Messenger
Apparent speed at infinity: v_∞' (m/s)	8.949E+03	8.877E+03	6.851E+03	1.601E+04	3.863E+03	4.056E+03
Speed increment at infinity: Δv_∞ (m/s)	3.920E-03	-4.600E-03	1.346E-02	-2.000E-03	1.820E-03	2.000E-05
Incoming: δ_i (deg)	-12.52	-34.26	-20.76	-12.92	-2.81	31.44
Outgoing: δ_o (deg)	-34.15	-4.87	-71.96	-4.99	-34.29	-31.92
Empirical formula: E×$v_\infty'\omega r/c$ (m/s)	4.128E-03	-4.680E-03	1.329E-02	-1.069E-03	2.069E-03	5.537E-05
E: $2(\cos\delta_i - \cos\delta_o)$	2.973E-01	-3.398E-01	1.251E+00	-4.305E-02	3.452E-01	8.799E-03
DSN GOLDSTONE G: $\Delta v_\infty \cos(35°)$ (m/s)	3.211E-03	-3.768E-03	1.103E-02	-1.638E-03	1.491E-03	1.638E-05
G/$v_\infty'/(1-w^2/c^2)^{1/2}$	2.823E-01	-3.340E-01	1.266E+00	-8.052E-02	3.037E-01	3.178E-03
DSN MADRID M: $\Delta v_\infty \cos(40°)$ (m/s)	3.003E-03	-3.524E-03	1.031E-02	-1.532E-03	1.394E-03	1.532E-05
M/$v_\infty'/(1-w^2/c^2)^{1/2}$	2.823E-01	-3.340E-01	1.266E+00	-8.052E-02	3.037E-01	3.178E-03

Physical quantity of light-blue and green background was brought [13],
ω: 7.292 115 ×10^{-5} (rad/s) is the angular frequency of the Earth, r: 6,378 km is the Earth radius.

It is supporting the relationship of the frequency shift with the four-dimensional contour lines of Fig.2.

CONCLUSION

This paper has been described a frequency shift with the difference in particle speed and gravitational potential. If we do not use the absolute stationary coordinate, we had been lost the guarantee of the same inertial system. However, it can be regarded as the same inertial system if there is no occurrence of a frequency shift. Therefore, knowing the exact frequency shift of each phenomenon is important.

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