Red shifts of photons and massive particles

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Abstract

The existence of space motion background is proposed in Space Motion Theory. Here, the mechanism of red shifts is concluded into a formula: $1+z=(E_c/E_c^{'})(E_i{}^q{}_r/E_i{}^q{}_s)$, where z represents the value of a red shift; $E_c/E_c^{'}$, named photonic red shift, signifies the ratio of E_c the energy of the photon before going through the distribution of the sender or the recipient to $E_c^{'}$ the energy of the photon after going through that; $E_i{}^q{}_r/E_i{}^q{}_s$, named massive-particle red shift, means the absolute-energy quantity ratio of the recipient to the sender. Furthermore, according to energy conservation and momentum conservation, the mechanism of photonic red shifts is deduced. The analyses herein verify the existence of space motion background mathematically.

Keywords: Space motion background; Energy velocity; Space Motion Theory

1 Introduction

Space Motion Theory indicates the existence of space motion background [1], which may help understand the motion of photons more deeply.

According to Space Motion Theory, every particle has its distribution energy spread over the universe. The motion of a particle is relative to its space motion background, which is composed of the sum of the distributions of other particles in the universe and free vacuum energy. If a particle is on or close to a celestial body with great mass and low rotation speed, its space motion background is mainly provided by the particles of the celestial body and can be approximately regarded as static to the ground of the celestial body.

A photon generation is at the inside of the sender a particle, a celestial body, a galaxy, or a greater structure. Although the valid range of the distribution of a particle is very small, at the beginning, the photon is in the range. Then the photon will leave the distribution of the particle into the space motion background of the particle the distribution of the higher system. And then leaves the distribution of the higher system into the space background of the higher system; and so on. However, herein, the sender and the recipient are analyzed in the common space motion background.

When the photon leaves the sender, because the sender is static in its distribution, the photon leaves static system. When the photon leaves the distribution of the sender, it leaves a moving system (assuming the sender moves in the space motion background). In such a progress, the energy of the photon will change to conform to energy conservation and momentum conservation.

In this research, I will only analyze the four cases that the vector of the energy velocity of the photon is in the same direction and in the opposite direction of the vector of the energy velocity of the sender and the recipient, but will not analyze the situations that there is an angle between them. The results of the cases multiplied by the cosines are the approximate values of red shifts because $\gamma^2(c+v)/c=c/(c-v)$ is nonlinear and $\gamma^2(c+v\cos\theta)/c\neq c/(c-v\cos\theta)$, where γ is Lorentz factor; $\gamma=(1-v^2/c^2)^{-1/2}$. The physical meaning corresponding to this inequality is the $\cos\theta$ changes after the photon leaves the distribution.

2 Photonic red shifts and massive-particle red shifts

The red-shift phenomena that are induced by photonic energy changes are named photonic red-shift phenomena, or photonic red shifts; the red-shift phenomena that are induced by the absolute-energy quantity difference between the recipient and the sender are named massive-particle red-shift phenomena, or massive-particle red shifts.

A red shift is the product of the photonic red shift and the massive-particle red shift, which can be expressed as:

$$1+z=(E_c/E_c^{'})(E_i{}^q{}_r/E_i{}^q{}_s) \qquad (1)$$

Where z represents the value of a red shift; $E_c/E_c^{'}$ is the photonic red shift; E_c is the energy of the photon before going through the distributions of the sender or the recipient and $E_c^{'}$ is the energy of the photon after going through the distributions; $E_i{}^q{}_r/E_i{}^q{}_s$ is the massive-particle red shift, which is the ratio of the absolute energy of a standard object, such as an 1kg weight, at the recipient to that of the same standard object at the sender.

3 The mechanism of photonic red shifts

A photon generates from the inside of the sender a particle or object, and then it will go through the distribution of the sender and get into the space motion background of the sender.

In Space Motion Theory, absolute energy: $E_i=Mc^2$; the local momentum (relative momentum): $p=Mv$, where v is the energy velocity.

The first case: when a photon with an absolute mass M_{cs} leaves a sender with an absolute mass M_s ($M_s>>M_{cs}$) and the energy velocity of the photon is just in the opposite direction of the energy velocity of the sender:

Before the photon going through the distribution of the sender, momentum conservation:

$$M_{cs}c=M_s\Delta v_s=M_s^{'}\Delta v_s \qquad (2.1)$$

where Δv_s is the little change of the energy velocity of the sender (v_s).

After the photon going through the distribution, Energy conservation:

$$M_s+M_{cs}=M_s^{'}+M_{cs}^{'} \qquad (3.1)$$

where M_s is the mass of the sender before the photon going through the distribution of the sender; $M_s^{'}$ is the mass of the sender after the photon going through the distribution; M_{cs} is the mass of the photon before it going through the distribution; $M_{cs}^{'}$ is the mass of the photon after it going through the distribution.

According to Space Motion Theory, the velocity Δv is measured by the time and length of the sender but the velocity v is measured by the time and length of the space background. And, the sum of Δv and v is measured by the quantities of the space background. The velocity Δv measured by the space background is $\Delta vL_v^q/T^q=\Delta v/\gamma^2$ [1], where γ is Lorentz factor; $\gamma=(1-v^2/c^2)^{-1/2}$.

Therefore, the sum of v_s and Δv_s is $v_s+\Delta v_s/\gamma_s^2$.

After the photon going through the distribution, momentum conservation:

$$M_sv_s+M_{cs}v_s=M_s^{'}(v_s+\Delta v_s/\gamma_s^2)-M_{cs}^{'}c \qquad (4.1)$$

Combine (2.1), (3.1) and (4.1). $M_{cs}c=M_{cs}^{'}\gamma_s^2(c+v_s)$; $M_{cs}/M_{cs}^{'}=\gamma_s^2(c+v_s)/c$.

Therefore, $E_{cs}/E_{cs}^{'}=M_{cs}/M_{cs}^{'}=\gamma_s^2(c+v_s)/c=c/(c-v_s)$, which is a red shift.

The second case: when a photon leaves a sender in the same direction of the energy velocity of the sender:

(2.1) and (3.1) is the same with this case. The situation of (4.1) is:

$$M_sv_s+M_{cs}v_s=M_s^{'}(v_s-\Delta v_s/\gamma_s^2)+M_{cs}^{'}c \qquad (4.2)$$

Therefore, $E_{cs}/E_{cs}^{'}=\gamma_s^2(c-v_s)/c=c/(c+v_s)$, which is a blue shift.

$M_{cs}^{'}=M_{cr}$, where M_{cr} is the mass of the photon before it going through the distribution of a recipient. And, $M_{cr}^{'}$ is the mass of the photon after it going through the distribution; M_r is the mass of the recipient before the photon going through the distribution; $M_r^{'}$ is the mass of the recipient after the photon going through the distribution.

The third case: when a photon with an absolute mass M_{cr} reaches a recipient with an absolute mass M_r ($M_r>>M_{cr}$) and the energy velocity of the photon is just in the same direction of the energy velocity of the recipient:

The situation of (2.1) is:

$$M_{cr}^{'}c=M_r^{'}\Delta v_r=M_r\Delta v_r \quad (2.2)$$

The situation of (3.1) is:

$$M_r+M_{cr}=M_r^{'}+M_{cr}^{'} \quad (3.2)$$

The situation of (4.1) is:

$$M_rv_r+M_{cr}c=(M_r^{'}+M_{cr}^{'})(v_r+\Delta v_r/\gamma_r^2) \quad (4.3)$$

Therefore, $E_{cr}/E_{cr}^{'}=c/[\gamma_r^2(c-v_r)]=(c+v_r)/c$, which is a red shift.

The fourth case: when a photon reaches a recipient in the opposite direction of the energy velocity of the recipient:

(2.2) and (3.2) is the same with this case. The situation of (4.3) is:

$$M_rv_r-M_{cr}c=(M_r^{'}+M_{cr}^{'})(v_r-\Delta v_r/\gamma_r^2) \quad (4.4)$$

Therefore, $E_{cr}/E_{cr}^{'}=c/[\gamma_r^2(c+v_r)]=(c-v_r)/c$, which is a blue shift.

$1+z=(E_i{}^q{}_r/E_i{}^q{}_s)(E_c/E_c^{'})=(E_i{}^q{}_r/E_i{}^q{}_s)(E_{cs}/E_{cs}^{'})(E_{cr}/E_{cr}^{'})$.

A complete red shift can be expressed as Formula 5:

Formula 5.1 (the pair of the first case and the third case):

$$1+z=(E_i{}^q{}_r/E_i{}^q{}_s)(c+v_r)/(c-v_s)=(E_i{}^q{}_r/E_i{}^q{}_s)\gamma_s^2(c+v_s)/[\gamma_r^2(c-v_r)]=(E_s{}^q{}_r/E_s{}^q{}_s)(c+v_s)/(c-v_r) \quad (5.1)$$

Formula 5.2 (the pair of the first case and the fourth case):

$$1+z=(E_i{}^q{}_r/E_i{}^q{}_s)(c-v_r)/(c-v_s)=(E_i{}^q{}_r/E_i{}^q{}_s)\gamma_s^2(c+v_s)/[\gamma_r^2(c+v_r)]=(E_s{}^q{}_r/E_s{}^q{}_s)(c+v_s)/(c+v_r) \quad (5.2)$$

Formula 5.3 (the pair of the second case and the third case):

$$1+z=(E_i{}^q{}_r/E_i{}^q{}_s)(c+v_r)/(c+v_s)=(E_i{}^q{}_r/E_i{}^q{}_s)\gamma_s{}^2(c-v_s)/[\gamma_r{}^2(c-v_r)]=(E_s{}^q{}_r/E_s{}^q{}_s)(c-v_s)/(c-v_r) \quad (5.3)$$

Formula 5.4 (the pair of the second case and the fourth case):

$$1+z=(E_i{}^q{}_r/E_i{}^q{}_s)(c-v_r)/(c+v_s)=(E_i{}^q{}_r/E_i{}^q{}_s)\gamma_s{}^2(c-v_s)/[\gamma_r{}^2(c+v_r)]=(E_s{}^q{}_r/E_s{}^q{}_s)(c-v_s)/(c+v_r) \quad (5.4)$$

Where $E_s{}^q{}_r$ is the quantity ratio of the internal energy at the recipient; $E_s{}^q{}_s$ is the quantity ratio of the internal energy at the sender; $E_s{}^q/E_i{}^q=(E_s/e)/(E_i/e)=E_s/E_i=1/\gamma^2$.

4 $\pm\Delta v/\gamma^2$ and $c/(c\pm v_s)$ and $(c\pm v_r)/c$ accord with $E_i=\gamma E_0$

According to Special Relativity and Space Motion Theory, $E_i=\gamma E_0$, where E_0 is static in the space background and E_i represents the energy of the sender or the recipient.

E_i varies with v. A micro variance of E_i dE_i equals $E_0(d\gamma/dv)dv$.

$$dE_{is}=E_{0s}[d(1-v_s{}^2/c^2)^{-1/2}/dv_s]dv_s=E_{0s}(-1/2)\gamma_s{}^3(-2v_s/c^2)dv_s=E_{is}(\gamma_s{}^2v_s/c^2)dv_s \quad (6.1)$$

$$dE_{ir}=E_{0r}[d(1-v_r{}^2/c^2)^{-1/2}/dv_r]dv_r=E_{0r}(-1/2)\gamma_r{}^3(-2v_r/c^2)dv_r=E_{ir}(\gamma_r{}^2v_r/c^2)dv_r \quad (6.2)$$

In the first case, $E_{is}=E_{cs}c/\Delta v_s$ and $dv_s=\Delta v_s/\gamma_s{}^2$. Bringing them into (6.1), it can be obtained that:

$$dE_{is}=E_{cs}v_s/c \quad (7.1)$$

(It should be noticed that $v+\Delta v/\gamma^2$ is formed when the photon just leaves the massive particle but is not an energy velocity then, because the massive particle and the photon are still in a common distribution; after the photon leaves the distribution of the massive particle, $v+\Delta v/\gamma^2$ is the energy velocity of the massive particle.)

In the second case, $E_{is}=E_{cs}c/\Delta v_s$ and $dv_s=-\Delta v_s/\gamma_s{}^2$. Bringing them into (6.1), it can be obtained that:

$$dE_{is}=-E_{cs}v_s/c \quad (7.2)$$

In the third case, $E_{ir}=E_{ir}{}'=E_{cr}{}'c/\Delta v_r$ and $dv_r=\Delta v_r/\gamma_r{}^2$. Bringing them into (6.2), it can be obtained that:

$$dE_{ir}=E_{cr}{}'v_r/c \quad (7.3)$$

In the fourth case, $E_{ir}=E_{ir}{}'=E_{cr}{}'c/\Delta v_r$ and $dv_r=-\Delta v_r/\gamma_r{}^2$. Bringing them into (6.2), it can be obtained that:

$$dE_{ir}=-E_{cr}{}'v_r/c \quad (7.4)$$

While,

According to the result of the photonic red shifts of the first case $E_{cs}/E_{cs}{}^{'}=c/(c-v_s)$,

$dE_{is}=E_{is}{}^{'}-E_{is}=E_{cs}-E_{cs}{}^{'}=E_{cs}[1-(c-v_s)/c]=E_{cs}v_s/c$ (8.1)

According to the result of the photonic red shifts of the second case $E_{cs}/E_{cs}{}^{'}=c/(c+v_s)$,

$dE_{is}=E_{is}{}^{'}-E_{is}=E_{cs}-E_{cs}{}^{'}=E_{cs}[1-(c+v_s)/c]=-E_{cs}v_s/c$ (8.2)

According to the result of the photonic red shifts of the third case $E_{cr}/E_{cr}{}^{'}=(c+v_r)/c$,

$dE_{ir}=E_{ir}{}^{'}-E_{ir}=E_{cr}-E_{cr}{}^{'}=E_{cr}{}^{'}[(c+v_r)/c-1]=E_{cr}{}^{'}v_r/c$ (8.3)

According to the result of the photonic red shifts of the fourth case $E_{cr}/E_{cr}{}^{'}=(c-v_r)/c$,

$dE_{ir}=E_{ir}{}^{'}-E_{ir}=E_{cr}-E_{cr}{}^{'}=E_{cr}{}^{'}[(c-v_r)/c-1]=-E_{cr}{}^{'}v_r/c$ (8.4)

The results of (7.1-7.4) and (8.1-8.4) are the same and deduced from different prerequisites, which suggests the prerequisites $E_i=\gamma E_0$, $\pm\Delta v/\gamma^2$, and $c/(c\pm v_s)$ and $(c\pm v_r)/c$ are consistent.

5 Formula 5 is consistent with the previous Doppler red-shift formulae

Doppler red-shift phenomena involve photonic red shifts and massive-particle red shifts.

The previous Doppler red-shift formulae were concluded from experiments, and they are $1+z=1+\vec{v}/c$ in low speed and, according to the Ives-Stilwell experiment in 1938, $1+z=(1+\vec{v}/c)\gamma$ in high speed. The corresponding expression of this theory for $\vec{v}$ is $\overrightarrow{v_{rs}}$. $\vec{v}=\overrightarrow{v_{rs}}=\pm v$; when the sender and the recipient directly get farther, $\vec{v}=v$ while when the sender and the recipient directly get closer, $\vec{v}=-v$.

In low speed:

$E_s{}^q{}_r/E_s{}^q{}_s\approx 1$.

In the condition of Formula 5.1: $\vec{v}=v=v_s+v_r$.

In the condition of Formula 5.2: $\vec{v}=v=v_s-v_r$ (when $v_s>v_r$) and $\vec{v}=-v=-(v_r-v_s)=v_s-v_r$ (when $v_s<v_r$); therefore, $\vec{v}=v_s-v_r$.

In the condition of Formula 5.3: $\vec{v}=v=v_r-v_s$ (when $v_r>v_s$) and $\vec{v}=-v=-(v_s-v_r)=v_r-v_s$ (when $v_r<v_s$); therefore, $\vec{v}=v_r-v_s$.

In the condition of Formula 5.4: $\vec{v}=-v=-(v_s+v_r)=-v_s-v_r$.

Formula 5.1: $1+z=(E_s{}^q{}_r/E_s{}^q{}_s)(c+v_s)/(c-v_r)\approx(c+v_s+v_r)/c=1+\vec{v}/c$

Formula 5.2: $1+z=(E_s{}^q{}_r/E_s{}^q{}_s)(c+v_s)/(c+v_r)\approx(c+v_s-v_r)/c=1+\vec{v}/c$

Formula 5.3: $1+z=(E_s{}^q{}_r/E_s{}^q{}_s)(c-v_s)/(c-v_r)\approx(c-v_s+v_r)/c=1+\vec{v}/c$

Formula 5.4: $1+z=(E_s{}^q{}_r/E_s{}^q{}_s)(c-v_s)/(c+v_r)\approx(c-v_s-v_r)/c=1+\vec{v}/c$

Therefore, Formula 5 accords with the formula $1+z=1+\vec{v}/c$.

In high speed and in the condition that the sender is in high speed but the recipient is in low speed:

$E_s{}^q{}_r/E_s{}^q{}_s=(E_0{}^q/\gamma_r)/(E_0{}^q/\gamma_s)\approx\gamma_s\approx\gamma$.

In the condition of Formula 5.1: $\vec{v}=v=v_s+v_r\approx v_s$.

In the condition of Formula 5.2: $\vec{v}=v=v_s-v_r\approx v_s$.

In the condition of Formula 5.3: $\vec{v}=-v=-(v_s-v_r)\approx-v_s$.

In the condition of Formula 5.4: $\vec{v}=-v=-(v_s+v_r)\approx-v_s$.

Formula 5.1: $1+z=(E_s{}^q{}_r/E_s{}^q{}_s)(c+v_s)/(c-v_r)\approx\gamma_s(c+v_s)/c\approx(1+\vec{v}/c)\gamma$;

Formula 5.2: $1+z=(E_s{}^q{}_r/E_s{}^q{}_s)(c+v_s)/(c+v_r)\approx\gamma_s(c+v_s)/c\approx(1+\vec{v}/c)\gamma$;

Formula 5.3: $1+z=(E_s{}^q{}_r/E_s{}^q{}_s)(c-v_s)/(c-v_r)\approx\gamma_s(c-v_s)/c\approx(1+\vec{v}/c)\gamma$;

Formula 5.4: $1+z=(E_s{}^q{}_r/E_s{}^q{}_s)(c-v_s)/(c+v_r)\approx\gamma_s(c-v_s)/c\approx(1+\vec{v}/c)\gamma$.

Therefore, Formula 5 accords with $1+z=(1+\vec{v}/c)\gamma$.

In high speed and in the condition that the recipient is in high speed but the sender is in low speed:

$E_i{}^q{}_r/E_i{}^q{}_s=\gamma_r E_0{}^q/(\gamma_s E_0{}^q)\approx\gamma_r\approx\gamma$.

In the condition of Formula 5.1: $\vec{v}=v=v_r+v_s\approx v_r$.

In the condition of Formula 5.2: $\vec{v}=-v=-(v_r-v_s)\approx-v_r$.

In the condition of Formula 5.3: $\vec{v}=v=v_r-v_s\approx v_r$.

In the condition of Formula 5.4: $\vec{v}$=-v=-(v_r+v_s)≈-v_r.

Formula 5.1: $1+z=(E_i{}^q{}_r/E_i{}^q{}_s)(c+v_r)/(c-v_s)\approx\gamma_r(c+v_r)/c\approx(1+\vec{v}/c)\gamma$;

Formula 5.2: $1+z=(E_i{}^q{}_r/E_i{}^q{}_s)(c-v_r)/(c-v_s)\approx\gamma_r(c-v_r)/c\approx(1+\vec{v}/c)\gamma$;

Formula 5.3: $1+z=(E_i{}^q{}_r/E_i{}^q{}_s)(c+v_r)/(c+v_s)\approx\gamma_r(c+v_r)/c\approx(1+\vec{v}/c)\gamma$;

Formula 5.4: $1+z=(E_i{}^q{}_r/E_i{}^q{}_s)(c-v_r)/(c+v_s)\approx\gamma_r(c-v_r)/c\approx(1+\vec{v}/c)\gamma$.

Therefore, in this situation, Formula 5 also accords with $1+z=(1+\vec{v}/c)\gamma$.

If the recipient and the sender are all in high speed, only the pair of the first case and the third case is deduced as the following.

Formula 5.1: $1+z=(E_s{}^q{}_r/E_s{}^q{}_s)(c+v_s)/(c-v_r)=(\gamma_s/\gamma_r)(c+v_s)/(c-v_r)$ while the previous Doppler red-shift formula: $1+z=(1+\vec{v}/c)\gamma=(1+v/c)\gamma=[(c+v)/(c-v)]^{1/2}$.

According to Formula 5.1:

$$1+z=(\gamma_s/\gamma_r)(c+v_s)/(c-v_r)=\{[(c+v_s)(c+v_r)]/[(c-v_s)(c-v_r)]\}^{1/2} \tag{9}$$

According to the Doppler red-shift formula:

$$1+z=[(c+v)/(c-v)]^{1/2}=\{[c+(v_s+v_r)/(1+v_sv_r/c^2)]/[c-(v_s+v_r)/(1+v_sv_r/c^2)]\}^{1/2} \tag{10}$$

where v equals $(v_s+v_r)/(1+v_sv_r/c^2)$, which is according to the theorem of the addition of the velocities in Relativity: $W=(v+w)/(1+vw/c^2)$.

By calculation, (9)=(10).

Data availability

All data generated or analyzed in this study are included in the published article (and its supplementary information files).

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Author contributions

Wenjing Qu is the sole authors of this manuscript. The author declares that he is responsible for all aspects of the manuscript.

Declaration of Competing Interest

The author declares no competing interests.

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