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Electromagnetic Wave Functions of CMB and Schwarzschild Space-Time

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Abstract: *In the general relativity theory, we find electro-magnetic wave functions of Cosmic Microwave Background and Schwarzschild space-time. Specially, this article is that electromagnetic wave equations are treated by gauge fixing equations in Robertson-Walker space-time and Schwarzschild space-time.*

Keywords: *General relativity theory, Electro-magnetic wave equations; Electromagnetic wave functions; Cosmic Microwave Background; Schwarzschild space-time*

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INTRODUCTION

In the general relativity theory, our article's aim is that we find electro-magnetic wave equations and functions by gauge fixing equations in Robertson-Walker space-time and Schwarzschild space-time.

At first, Electro-magnetic field equations are in general relativity theory

$$F^{\mu\upsilon}{}_{;\upsilon} = \frac{4\pi}{c} j^{\mu} \tag{1}$$

$$F_{\mu\upsilon;\lambda} + F_{\upsilon\lambda;\mu} + F_{\lambda\mu;\upsilon} = 0 \tag{2}$$

The electro-magnetic field is

$$F_{\mu\upsilon} = A_{\upsilon;\mu} - A_{\mu;\upsilon} = \frac{\partial A_{\upsilon}}{\partial x^{\mu}} - \frac{\partial A_{\mu}}{\partial x^{\upsilon}} \tag{3}$$

The gauge fixing equation in general relativity theory

$$A^{\mu}{}_{;\mu} = \frac{\partial A^{\mu}}{\partial x^{\mu}} + \Gamma^{\mu}{}_{\mu\rho} A^{\rho}$$

$$\to \partial_{\mu}(A^{\mu} + g^{\mu\upsilon}\partial_{\upsilon}\Lambda) + \Gamma^{\mu}{}_{\mu\rho}(A^{\rho} + \partial^{\rho}\Lambda)$$

$$= \partial_{\mu}(A^{\mu} + g^{\mu\upsilon}\partial_{\upsilon}\Lambda) + \Gamma^{\mu}{}_{\mu\rho}(A^{\rho} + g^{\rho\sigma}\partial_{\sigma}\Lambda) \tag{4}$$

1. ELECTRO-MAGNETIC WAVE EQUATION IN ROBERTSON-WALKER SPACE-TIME

Because the gauge fixing equation is the electro-magnetic wave equation, the electro-magnetic wave equation is in Robertson-Walker space-time.

The Robertson-Walker solution is

$$d\tau^2 = dt^2 - \frac{1}{c^2}\Omega^2(t)\,[\frac{dr^2}{1-kr^2} + r^2 d\Omega^2] \tag{5}$$

In this time, 2-dimensional solution is

$$d\Omega = 0$$

$$d\tau^2 = dt^2 - \frac{1}{c^2}\Omega^2(t)\frac{dr^2}{1-kr^2} \tag{6}$$

The gauge fixing equation is in 2-dimensional solution

$$\partial_\mu (A^\mu + g^{\mu\upsilon}\partial_\upsilon \Lambda) + \Gamma^\mu{}_{\mu\rho}(A^\rho + g^{\rho\rho}\partial_\rho \Lambda)$$

$$= \partial_\mu A^\mu + \Gamma^1{}_{10}A^0 + \Gamma^1{}_{11}A^1 + \partial_\mu g^{\mu\upsilon}\partial_\upsilon \Lambda + g^{\mu\upsilon}\partial_\mu\partial_\upsilon \Lambda + \Gamma^1{}_{10}g^{00}\frac{1}{c}\frac{\partial \Lambda}{\partial t} + \Gamma^1{}_{11}g^{11}\frac{\partial \Lambda}{\partial r} \tag{7}$$

Hence, we can find electro-magnetic wave equation in 2-dimentional Robertson-Walker space-time.

$$\partial_\mu g^{\mu\upsilon}\partial_\upsilon(\sin\Phi) + g^{\mu\upsilon}\partial_\mu\partial_\upsilon(\sin\Phi) + \Gamma^1{}_{10}g^{00}\frac{1}{c}\frac{\partial}{\partial t}(\sin\Phi) + \Gamma^1{}_{11}g^{11}\frac{\partial}{\partial r}(\sin\Phi)$$

$$= [\frac{-2kr}{\Omega^2(t)}\frac{\partial}{\partial r} - \frac{1}{c^2}\frac{\partial^2}{\partial t^2} + \frac{1-kr^2}{\Omega^2(t)}\frac{\partial^2}{\partial r^2} - \frac{\dot{\Omega}}{c\Omega}\frac{1}{c}\frac{\partial}{\partial t} + \frac{kr}{\Omega^2(t)}\frac{\partial}{\partial r}]\sin\Phi = 0$$

$$\Gamma^1{}_{10} = \frac{\dot{\Omega}}{c\Omega} \quad , \quad \Gamma^1{}_{11} = \frac{kr}{1-kr^2} \tag{8}$$

In this time, we can think the shape of electro-magnetic wave function from 2-dimetional Robertson-Walker space-time. In this case, light is

$$d\tau^2 = dt^2 - \frac{1}{c^2}\Omega^2(t)\frac{dr^2}{1-kr^2} = 0$$

$$\int \frac{dt}{\Omega(t)} = \frac{1}{c}\int \frac{dr}{\sqrt{1-kr^2}} \tag{9}$$

Hence, electro-magnetic wave function is in 2-dimetional Robertson-Walker space-time-

$$\vec{E} = \vec{E}_0 \sin\Phi, \vec{B} = \vec{B}_0 \sin\Phi$$

$$\Phi = \omega_0[\int \frac{dt}{\Omega(t)} - \frac{1}{c}\int \frac{dr}{\sqrt{1-kr^2}}]$$

i) $k = 1, \Phi = \omega_0[\int \frac{dt}{\Omega(t)} - \frac{1}{c}\sin^{-1} r]$

ii) $k = 0, \Phi = \omega_0[\int \frac{dt}{\Omega(t)} - \frac{1}{c} r]$

iii) $k = -1, \Phi = \omega_0[\int \frac{dt}{\Omega(t)} - \frac{1}{c}\sinh^{-1} r]$ (10)

The electro-magnetic wave equation-Eq(8) is satisfied by the electro-magnetic wave function-Eq(10).

2. ELECTRO-MAGNETIC WAVE EQUATION IN SCHWARZSCHILD SPACE-TIME

Because the gauge fixing equation is the electro-magnetic wave equation, the electro-magnetic wave equation is in Schwarzschild space-time.

The Schwarzschild solution is

$$d\tau^2 = (1 - \frac{2GM}{rc^2})dt^2 - \frac{1}{c^2}[\frac{dr^2}{1 - \frac{2GM}{rc^2}} + r^2 d\Omega^2] \tag{11}$$

In this time, 2-dimensional solution is

$$d\Omega = 0$$

$$d\tau^2 = (1 - \frac{2GM}{rc^2})dt^2 - \frac{1}{c^2}\frac{dr^2}{1 - \frac{2GM}{rc^2}} \tag{12}$$

The gauge fixing equation is in 2-dimensional solution

$$\partial_\mu (A^\mu + g^{\mu\upsilon}\partial_\upsilon \Lambda) + \Gamma^\mu{}_{\mu\rho}(A^\rho + g^{\rho\rho}\partial_\rho \Lambda)$$

$$= \partial_\mu A^\mu + \Gamma^0{}_{01}A^1 + \Gamma^1{}_{11}A^1 + \partial_\mu g^{\mu\upsilon}\partial_\upsilon \Lambda + g^{\mu\upsilon}\partial_\mu \partial_\upsilon \Lambda + \Gamma^0{}_{01}g^{11}\frac{\partial \Lambda}{\partial r} + \Gamma^1{}_{11}g^{11}\frac{\partial \Lambda}{\partial r}$$

$$= \partial_\mu A^\mu + \partial_\mu g^{\mu\upsilon}\partial_\upsilon \Lambda + g^{\mu\upsilon}\partial_\mu \partial_\upsilon \Lambda$$

$$\Gamma^0{}_{01} = \frac{GM}{r^2c^2}\frac{1}{1 - \frac{2GM}{rc^2}} \quad , \quad \Gamma^1{}_{11} = -\frac{GM}{r^2c^2}\frac{1}{1 - \frac{2GM}{rc^2}} \tag{13}$$

Hence, we can find electro-magnetic wave equation in 2-dimentional Schwarzschild space-time.

$$\partial_\mu g^{\mu\upsilon}\partial_\upsilon (\sin\Phi) + g^{\mu\upsilon}\partial_\mu \partial_\upsilon (\sin\Phi)$$

$$= [\frac{2GM}{r^2c^2}\frac{\partial}{\partial r} - \frac{1}{1 - \frac{2GM}{rc^2}}\frac{1}{c^2}\frac{\partial^2}{\partial t^2} + (1 - \frac{2GM}{rc^2})\frac{\partial^2}{\partial r^2}]\sin\Phi = 0 \tag{14}$$

In this time, we can think the shape of electro-magnetic wave function from 2-dimetional Schwarzschild space-time. In this case, light is

$$d\tau^2 = (1 - \frac{2GM}{rc^2})dt^2 - \frac{1}{c^2}\frac{dr^2}{1 - \frac{2GM}{rc^2}} = 0$$

$$t = \frac{1}{c}\int \frac{dr}{1 - \frac{2GM}{rc^2}} = \frac{r}{c} + \frac{2GM}{c^3}\ln| r - \frac{2GM}{c^2}| \tag{15}$$

Hence, electro-magnetic wave function is in 2-dimetional Schwarzschild space-time-

$$\vec{E} = \vec{E}_0 \sin\Phi, \vec{B} = \vec{B}_0 \sin\Phi$$

$$\Phi = \omega_0 [t - \frac{r}{c} - \frac{2GM}{c^3}\ln| r - \frac{2GM}{c^2}] \tag{16}$$

The electro-magnetic wave equation-Eq(14) is satisfied by the electro-magnetic wave function-Eq(16).

3. CONCLUSION

We find the electro-magnetic wave (CMB) equation and function in Robertson-Walker space-time. We find the electro-magnetic wave equation and function in Schwarzschild space-time.

REFERENCES

[1] S.Yi, “Electromagnetic Field Equation and Lorentz Gauge in Rindler space-time”, The African review of physics,**11,**33(2016)-INSPIRE-HEP

[2] S.Yi, “Electromagnetic Wave Function and Equation, Lorentz Force in Rindler space-time”, International Journal of Advanced Research in Physical Science,**5,9**(2018)

[3] S. Weinberg, Gravitation and Cosmology(John wiley & Sons,Inc,1972)

[4] W. Rindler, Am.J.Phys.**34**.1174(1966)

[5] P. Bergman, Introduction to the Theory of Relativity (Dover Pub. Co.,Inc., New York,1976),Chapter V

[6] C. Misner, K, Thorne and J. Wheeler, Gravitation(W.H.Freedman & Co.,1973)

[7] S. Hawking and G. Ellis, The Large Scale Structure of Space-Time(Cam-bridge University Press,1973)

[8] R. Adler, M. Bazin and M. Schiffer, Introduction to General Relativity(McGraw-Hill,Inc.,1965)

[9] A. Miller, Albert Einstein’s Special Theory of Relativity(Addison-Wesley Publishing Co., Inc., 1981)

[10] W. Rindler, Special Relativity(2nd ed., Oliver and Boyd, Edinburg,1966)

[11] Massimo Pauri, Michele Vallisner, "Marzke-Wheeler coordinates for accelerated observers in special relativity":Arxiv:gr-qc/0006095(2000)

[12] A. Einstein, “Zur Elektrodynamik bewegter K¨orper”, Annalen der Physik. 17:891(1905)

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