# Electro-Magnetic Field Equation and Wave Function in Rindler spacetime

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**ABSTRACT**

In the general relativity theory, we find the electro-magnetic field transformation and the electro-magnetic field equation (Maxwell equation) in Rindler spacetime. We find the electro-magnetic wave equation and the electro-magnetic wave function in Rindler space-time. Specially, this article say the uniqueness of the accelerated frame because the accelerated frame can treat electro-magnetic field equation.

## 1. Introduction

In the general relativity theory, our article's aim is that we find the electro-magnetic field equation in Rindler space-time.

The Rindler coordinate is

$$ct = (\frac{c^2}{a_0} + \xi^1)\sinh(\frac{a_0\xi^0}{c})$$

$$x = (\frac{c^2}{a_0} + \xi^1)\cosh(\frac{a_0\xi^0}{c}) - \frac{c^2}{a_0} \quad , y = \xi^2, z = \xi^3 \tag{1}$$

In this time, the tetrad $e^a{}_\mu$ is

$$d\tau^2 = dt^2 - \frac{1}{c^2}[dx^2 + dy^2 + dz^2]$$

$$= -\frac{1}{c^2}\eta_{ab}\frac{\partial x^a}{\partial \xi^\mu}\frac{\partial x^b}{\partial \xi^\nu}d\xi^\mu d\xi^\nu$$

$$= -\frac{1}{c^2}\eta_{ab}e^a{}_\mu e^b{}_\nu d\xi^\mu d\xi^\nu = -\frac{1}{c^2}g_{\mu\nu}d\xi^\mu d\xi^\nu \quad , \quad e^a{}_\mu = \frac{\partial x^a}{\partial \xi^\mu} \tag{2}$$

$$e^\alpha{}_0(\xi^0) = \frac{\partial x^\alpha}{c\partial\xi^0} = ((1+\frac{a_0}{c^2}\xi^1)\cosh(\frac{a_0\xi^0}{c}), (1+\frac{a_0}{c^2}\xi^1)\sinh(\frac{a_0\xi^0}{c}), 0, 0) \tag{3}$$

About $y$-axis's and $z$-axis's orientation

$$e^\alpha{}_2(\xi^0) = \frac{\partial x^\alpha}{\partial\xi^2} = (0,0,1,0) \quad , \quad e^\alpha{}_3(\xi^0) = \frac{\partial x^\alpha}{\partial\xi^3} = (0,0,0,1) \tag{4}$$

The other unit vector $e^\alpha{}_1(\xi^0)$ is

$$e^\alpha{}_1(\xi^0) = \frac{\partial x^\alpha}{\partial\xi^1} = (\sinh(\frac{a_0\xi^0}{c}), \cosh(\frac{a_0\xi^0}{c}), 0, 0) \tag{5}$$

Therefore,

$$cdt = c\cosh(\frac{a_0\xi^0}{c})d\xi^0(1+\frac{a_0}{c^2}\xi^1) + \sinh(\frac{a_0\xi^0}{c})d\xi^1$$

$$= c\cosh(\frac{a_0\xi^0}{c})d\hat{\xi}^0 + \sinh(\frac{a_0\xi^0}{c})d\hat{\xi}^1$$

$$dx = c\sinh(\frac{a_0\xi^0}{c})d\xi^0(1+\frac{a_0}{c^2}\xi^1) + \cosh(\frac{a_0\xi^0}{c})d\xi^1$$

$$= c\sinh(\frac{a_0\xi^0}{c})d\hat{\xi}^0 + \cosh(\frac{a_0\xi^0}{c})d\hat{\xi}^1, dy = d\xi^2 = d\hat{\xi}^2, \ dz = d\xi^3 = d\hat{\xi}^3 \quad (6)$$

The vector transformation is

$$V'^\mu = \frac{\partial x'^\mu}{\partial x^\alpha}V^\alpha, \qquad U'_\mu = \frac{\partial x^\alpha}{\partial x'^\mu}U_\alpha \qquad\qquad (7)$$

Therefore, the transformation of the electro-magnetic 4-vector potential $(\phi, \vec{A}) = A^\alpha$ is

$$A^\alpha = \frac{\partial x^\alpha}{\partial x'^\mu}A'^\mu = \frac{\partial x^\alpha}{\partial \xi^\mu}A_\xi{}^\mu = e^\alpha{}_\mu A_\xi{}^\mu \ , \ e^\alpha{}_\mu = \frac{\partial x^\alpha}{\partial \xi^\mu}$$

$$dx^\alpha = \frac{\partial x^\alpha}{\partial x'^\mu}dx'^\mu = \frac{\partial x^\alpha}{\partial \xi^\mu}d\xi^\mu = e^\alpha{}_\mu d\xi^\mu \ , e^\alpha{}_\mu = \frac{\partial x^\alpha}{\partial \xi^\mu} \qquad (8)$$

Hence, the transformation of the electro-magnetic 4-vector potential $(\phi, \vec{A})$ in inertial frame and the

eletro-magnetic 4-vector potential $(\phi_\xi, \vec{A}_\xi)$ in uniformly accelerated frame is

$$(\frac{1}{c^2}\frac{\partial^2}{\partial t^2} - \nabla^2)\phi = 4\pi\rho$$

$$(\frac{1}{c^2}\frac{\partial^2}{\partial t^2} - \nabla^2)\vec{A} = \frac{4\pi}{c}\vec{j}$$

$$\text{4-vector } (c\rho, \vec{j}) = \rho_0\frac{dx^\alpha}{d\tau}$$

$$\phi = \cosh(\frac{a_0\xi^0}{c})(1 + \frac{a_0}{c^2}\xi^1)\phi_\xi + \sinh(\frac{a_0\xi^0}{c})A_{\xi^1}$$

$$= \cosh(\frac{a_0\xi^0}{c})\hat{\phi}_\xi + \sinh(\frac{a_0\xi^0}{c})\hat{A}_{\xi^1}$$

$$A_x = \sinh(\frac{a_0\xi^0}{c})(1 + \frac{a_0}{c^2}\xi^1)\phi_\xi + \cosh(\frac{a_0\xi^0}{c})A_{\xi^1}$$

$$= \sinh(\frac{a_0\xi^0}{c})\hat{\phi}_\xi + \cosh(\frac{a_0\xi^0}{c})\hat{A}_{\xi^1}$$

$$A_y = A_{\xi^2} = \hat{A}_{\xi^2}, A_z = A_{\xi^3} = \hat{A}_{\xi^3} \qquad (9)$$

$$g = \begin{pmatrix} -(1+\dfrac{a_0\xi^1}{c^2})^2 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}, \eta = \begin{pmatrix} -1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

$$e^a{}_\mu e_b{}^\mu = \delta^a{}_b \;,\; e^a{}_\mu e_a{}^\upsilon = \delta_\mu{}^\upsilon$$

$$e^a{}_\mu e^b{}_\upsilon \eta_{ab} = g_{\mu\upsilon} \;\rightarrow\; A^T \eta A = g$$

$$e_a{}^\mu e_b{}^\upsilon g_{\mu\upsilon} = \eta_{ab} \rightarrow (A^T)^{-1} g A^{-1} = (A^T)^{-1} A^T \eta A A^{-1} = \eta$$

$$e^a{}_\mu = \eta^{ab} g_{\mu\upsilon} e_b{}^\upsilon \rightarrow \eta^{-1}(A^T)^{-1} A^T \eta A = A = \eta^{-1}(A^T)^{-1} g \tag{10}$$

$$\begin{pmatrix} cdt \\ dx \\ dy \\ dz \end{pmatrix} = \begin{pmatrix} \cosh(\dfrac{a_0\xi^0}{c})(1+\dfrac{a_0\xi^1}{c^2}) & \sinh(\dfrac{a_0\xi^0}{c}) & 0 & 0 \\ \sinh(\dfrac{a_0\xi^0}{c})(1+\dfrac{a_0\xi^1}{c^2}) & \cosh(\dfrac{a_0\xi^0}{c}) & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} cd\xi^0 \\ d\xi^1 \\ d\xi^2 \\ d\xi^3 \end{pmatrix}$$

$$= A \begin{pmatrix} cd\xi^0 \\ d\xi^1 \\ d\xi^2 \\ d\xi^3 \end{pmatrix}$$

$$= \begin{pmatrix} \cosh(\dfrac{a_0\xi^0}{c}) & \sinh(\dfrac{a_0\xi^0}{c}) & 0 & 0 \\ \sinh(\dfrac{a_0\xi^0}{c}) & \cosh(\dfrac{a_0\xi^0}{c}) & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} cd\hat{\xi}^0 \\ d\hat{\xi}^1 \\ d\hat{\xi}^2 \\ d\hat{\xi}^3 \end{pmatrix}$$

$$\tag{11}$$

$$e_\mu{}^\alpha = \frac{\partial \xi^\alpha}{\partial x^\mu} = A^{-1} = \begin{pmatrix} \dfrac{c\partial \xi^0}{c\partial t} & \dfrac{c\partial \xi^0}{\partial x} & \dfrac{c\partial \xi^0}{\partial y} & \dfrac{c\partial \xi^0}{\partial z} \\[2mm] \dfrac{\partial \xi^1}{c\partial t} & \dfrac{\partial \xi^1}{\partial x} & \dfrac{\partial \xi^1}{\partial y} & \dfrac{\partial \xi^1}{\partial z} \\[2mm] \dfrac{\partial \xi^2}{c\partial t} & \dfrac{\partial \xi^2}{\partial x} & \dfrac{\partial \xi^2}{\partial y} & \dfrac{\partial \xi^2}{\partial z} \\[2mm] \dfrac{\partial \xi^3}{c\partial t} & \dfrac{\partial \xi^3}{\partial x} & \dfrac{\partial \xi^3}{\partial y} & \dfrac{\partial \xi^3}{\partial z} \end{pmatrix}$$

$$= \begin{pmatrix} \dfrac{\cosh(\dfrac{a_0 \xi^0}{c})}{(1+\dfrac{a_0 \xi^1}{c^2})} & -\dfrac{\sinh(\dfrac{a_0 \xi^0}{c})}{(1+\dfrac{a_0 \xi^1}{c^2})} & 0 & 0 \\[4mm] -\sinh(\dfrac{a_0 \xi^0}{c}) & \cosh(\dfrac{a_0 \xi^0}{c}) & 0 & 0 \\[2mm] 0 & 0 & 1 & 0 \\[1mm] 0 & 0 & 0 & 1 \end{pmatrix} \qquad (12)$$

$$\begin{pmatrix} \dfrac{1}{c}\dfrac{\partial}{\partial t} \\[2mm] \dfrac{\partial}{\partial x} \\[2mm] \dfrac{\partial}{\partial y} \\[2mm] \dfrac{\partial}{\partial z} \end{pmatrix} = (A^{-1})^T \begin{pmatrix} \dfrac{1}{c}\dfrac{\partial}{\partial \xi^0} \\[2mm] \dfrac{\partial}{\partial \xi^1} \\[2mm] \dfrac{\partial}{\partial \xi^2} \\[2mm] \dfrac{\partial}{\partial \xi^3} \end{pmatrix} = (A^T)^{-1} \begin{pmatrix} \dfrac{1}{c}\dfrac{\partial}{\partial \xi^0} \\[2mm] \dfrac{\partial}{\partial \xi^1} \\[2mm] \dfrac{\partial}{\partial \xi^2} \\[2mm] \dfrac{\partial}{\partial \xi^3} \end{pmatrix}$$

$$= \begin{pmatrix} \dfrac{\cosh(\dfrac{a_0 \xi^0}{c})}{(1+\dfrac{a_0 \xi^1}{c^2})} & -\sinh(\dfrac{a_0 \xi^0}{c}) & 0 & 0 \\[4mm] -\dfrac{\sinh(\dfrac{a_0 \xi^0}{c})}{(1+\dfrac{a_0 \xi^1}{c^2})} & \cosh(\dfrac{a_0 \xi^0}{c}) & 0 & 0 \\[4mm] 0 & 0 & 1 & 0 \\[1mm] 0 & 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} \dfrac{1}{c}\dfrac{\partial}{\partial \xi^0} \\[2mm] \dfrac{\partial}{\partial \xi^1} \\[2mm] \dfrac{\partial}{\partial \xi^2} \\[2mm] \dfrac{\partial}{\partial \xi^3} \end{pmatrix}$$

$$= \begin{pmatrix} \cosh(\frac{a_0\xi^0}{c}) & -\sinh(\frac{a_0\xi^0}{c}) & 0 & 0 \\ -\sinh(\frac{a_0\xi^0}{c}) & \cosh(\frac{a_0\xi^0}{c}) & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} \frac{1}{c}\frac{\partial}{\partial\hat{\xi}^0} \\ \frac{\partial}{\partial\hat{\xi}^1} \\ \frac{\partial}{\partial\hat{\xi}^2} \\ \frac{\partial}{\partial\hat{\xi}^3} \end{pmatrix} \tag{13}$$

$$\frac{1}{c}\frac{\partial}{\partial t} = \frac{c\partial\xi^0}{c\partial t}\frac{1}{c}\frac{\partial}{\partial\xi^0} + \frac{\partial\xi^1}{c\partial t}\frac{\partial}{\partial\xi^1}$$

$$= \frac{\cosh(\frac{a_0\xi^0}{c})}{(1+\frac{a_0\xi^1}{c^2})}\frac{\partial}{c\partial\xi^0} - \sinh(\frac{a_0\xi^0}{c})\frac{\partial}{\partial\xi^1}$$

$$= \cosh(\frac{a_0}{c}\xi^0)\frac{\partial}{c\partial\hat{\xi}^0} - \sinh(\frac{a_0\xi^0}{c})\frac{\partial}{\partial\hat{\xi}^1}$$

$$\frac{\partial}{\partial x} = \frac{c\partial\xi^0}{\partial x}\frac{1}{c}\frac{\partial}{\partial\xi^0} + \frac{\partial\xi^1}{\partial x}\frac{\partial}{\partial\xi^1}$$

$$= -\frac{\sinh(\frac{a_0\xi^0}{c})}{(1+\frac{a_0\xi^1}{c^2})}\frac{\partial}{c\partial\xi^0} + \cosh(\frac{a_0\xi^0}{c})\frac{\partial}{\partial\xi^1}$$

$$= -\sinh(\frac{a_0\xi^0}{c})\frac{\partial}{c\partial\hat{\xi}^0} + \cosh(\frac{a_0\xi^0}{c})\frac{\partial}{\partial\hat{\xi}^1}$$

$$\frac{\partial}{\partial y} = \frac{\partial}{\partial\xi^2} = \frac{\partial}{\partial\hat{\xi}^2}, \frac{\partial}{\partial z} = \frac{\partial}{\partial\xi^3} = \frac{\partial}{\partial\hat{\xi}^3}$$

$$\frac{1}{c^2}\frac{\partial^2}{\partial t^2} - \nabla^2 = \frac{1}{c^2(1+\frac{a_0}{c^2}\xi^1)^2}(\frac{\partial}{\partial\xi^0})^2 - \nabla_\xi^2 = \frac{1}{c^2}(\frac{\partial}{\partial\hat{\xi}^0})^2 - \nabla_{\hat{\xi}}^2$$

$$\vec{\nabla} = (\frac{\partial}{\partial x}, \frac{\partial}{\partial y}, \frac{\partial}{\partial z}), \quad \vec{\nabla}_\xi = (\frac{\partial}{\partial\xi^1}, \frac{\partial}{\partial\xi^2}, \frac{\partial}{\partial\xi^3}), \quad \vec{\nabla}_{\hat{\xi}} = (\frac{\partial}{\partial\hat{\xi}^1}, \frac{\partial}{\partial\hat{\xi}^2}, \frac{\partial}{\partial\hat{\xi}^3})$$

$$\tag{14}$$

## 2. Electro-magnetic Field in the Rindler space-time

The electro-magnetic field $(\vec{E}, \vec{B})$ is in the inertial frame,

$$\vec{E} = -\vec{\nabla}\phi - \frac{\partial \vec{A}}{c\partial t}, \vec{B} = \vec{\nabla} \times \vec{A} \tag{15}$$

$$E_x = -\frac{\partial \phi}{\partial x} - \frac{\partial A_x}{c\partial t}$$

$$= -[-\frac{\sinh(\frac{a_0\xi^0}{c})}{(1+\frac{a_0\xi^1}{c^2})}\frac{\partial}{c\partial \xi^0} + \cosh(\frac{a_0\xi^0}{c})\frac{\partial}{\partial \xi^1}] \cdot [\cosh(\frac{a_0\xi^0}{c})(1+\frac{a_0\xi^1}{c^2})\phi_\xi + \sinh(\frac{a_0\xi^0}{c})A_{\xi^1}]$$

$$-[\frac{\cosh(\frac{a_0\xi^0}{c})}{(1+\frac{a_0\xi^1}{c^2})}\frac{\partial}{c\partial \xi^0} - \sinh(\frac{a_0\xi^0}{c})\frac{\partial}{\partial \xi^1}] \cdot [\sinh(\frac{a_0\xi^0}{c})(1+\frac{a_0\xi^1}{c^2})\phi_\xi + \cosh(\frac{a_0\xi^0}{c})A_{\xi^1}]$$

$$= -\frac{1}{(1+\frac{a_0}{c^2}\xi^1)}\frac{\partial A_{\xi^1}}{c\partial \xi^0} - (1+\frac{a_0\xi^1}{c^2})\frac{\partial \phi_\xi}{\partial \xi^1} - 2\phi_\xi\frac{a_0}{c^2}$$

$$= -\frac{1}{(1+\frac{a_0\xi^1}{c^2})}\frac{\partial}{\partial \xi^1}[(1+\frac{a_0}{c^2}\xi^1)^2\phi_\xi] - \frac{1}{(1+\frac{a_0\xi^1}{c^2})}\frac{\partial A_{\xi^1}}{c\partial \xi^0}$$

$$= -\frac{1}{(1+\frac{a_0\xi^1}{c^2})}\frac{\partial}{\partial \hat{\xi}^1}[(1+\frac{a_0}{c^2}\xi^1)\hat{\phi}_\xi] - \frac{\partial \hat{A}_{\xi^1}}{c\partial \hat{\xi}^0} \tag{16}$$

$$E_y = -\frac{\partial \phi}{\partial y} - \frac{\partial A_y}{c\partial t} = -\frac{\partial}{\partial \xi^2}[\cosh(\frac{a_0\xi^0}{c})(1+\frac{a_0}{c^2}\xi^1)\phi_\xi + \sinh(\frac{a_0\xi^0}{c})A_{\xi^1}]$$

$$-[\frac{\cosh(\frac{a_0\xi^0}{c})}{(1+\frac{a_0\xi^1}{c^2})}\frac{\partial}{c\partial \xi^0} - \sinh(\frac{a_0\xi^0}{c})\frac{\partial}{\partial \xi^1}]A_{\xi^2}$$

$$= -(1+\frac{a_0\xi^1}{c^2})\cosh(\frac{a_0\xi^0}{c})\frac{\partial \phi_\xi}{\partial \xi^2} - \frac{1}{(1+\frac{a_0\xi^1}{c^2})}\cosh(\frac{a_0\xi^0}{c})\frac{\partial A_{\xi^2}}{c\partial \xi^0}$$

$$+ \sinh(\frac{a_0}{c}\xi^0)[\frac{\partial A_{\xi^2}}{\partial \xi^1} - \frac{\partial A_{\xi^1}}{\partial \xi^2}]$$

$$= \cosh(\frac{a_0}{c}\xi^0)[-\frac{1}{(1+\frac{a_0}{c^2}\xi^1)}\frac{\partial}{\partial\xi^2}[\phi_\xi(1+\frac{a_0\xi^1}{c^2})^2]-\frac{1}{(1+\frac{a_0\xi^1}{c^2})}\frac{\partial A_{\xi^2}}{c\partial\xi^0}]$$

$$+\sinh(\frac{a_0}{c}\xi^0)[\frac{\partial A_{\xi^2}}{\partial\xi^1}-\frac{\partial A_{\xi^1}}{\partial\xi^2}]$$

$$= \cosh(\frac{a_0}{c}\xi^0)[-\frac{1}{(1+\frac{a_0}{c^2}\xi^1)}\frac{\partial}{\partial\hat{\xi}^2}[\hat{\phi}_\xi(1+\frac{a_0\xi^1}{c^2})]-\frac{\partial\hat{A}_{\xi^2}}{c\partial\hat{\xi}^0}]$$

$$+\sinh(\frac{a_0}{c}\xi^0)[\frac{\partial\hat{A}_{\xi^2}}{\partial\hat{\xi}^1}-\frac{\partial\hat{A}_{\xi^1}}{\partial\hat{\xi}^2}] \qquad (17)$$

$$E_z = -\frac{\partial\phi}{\partial z}-\frac{\partial A_z}{c\partial t}=-\frac{\partial}{\partial\xi^3}[\cosh(\frac{a_0\xi^0}{c})(1+\frac{a_0}{c^2}\xi^1)\phi_\xi+\sinh(\frac{a_0\xi^0}{c})A_{\xi^1}]$$

$$-[\frac{\cosh(\frac{a_0\xi^0}{c})}{(1+\frac{a_0\xi^1}{c^2})}\frac{\partial}{c\partial\xi^0}-\sinh(\frac{a_0\xi^0}{c})\frac{\partial}{\partial\xi^1}]A_{\xi^3}$$

$$= -(1+\frac{a_0\xi^1}{c^2})\cosh(\frac{a_0\xi^0}{c})\frac{\partial\phi_\xi}{\partial\xi^3}-\frac{1}{(1+\frac{a_0\xi^1}{c^2})}\cosh(\frac{a_0\xi^0}{c})\frac{\partial A_{\xi^3}}{c\partial\xi^0}$$

$$+\sinh(\frac{a_0}{c}\xi^0)[\frac{\partial A_{\xi^3}}{\partial\xi^1}-\frac{\partial A_{\xi^1}}{\partial\xi^3}]$$

$$= \cosh(\frac{a_0}{c}\xi^0)[-\frac{1}{(1+\frac{a_0}{c^2}\xi^1)}\frac{\partial}{\partial\xi^3}[\phi_\xi(1+\frac{a_0\xi^1}{c^2})^2]-\frac{1}{(1+\frac{a_0\xi^1}{c^2})}\frac{\partial A_{\xi^3}}{c\partial\xi^0}]$$

$$+\sinh(\frac{a_0}{c}\xi^0)[\frac{\partial A_{\xi^3}}{\partial\xi^1}-\frac{\partial A_{\xi^1}}{\partial\xi^3}]$$

$$= \cosh(\frac{a_0}{c}\xi^0)[-\frac{1}{(1+\frac{a_0}{c^2}\xi^1)}\frac{\partial}{\partial\hat{\xi}^3}[\hat{\phi}_\xi(1+\frac{a_0\xi^1}{c^2})]-\frac{\partial\hat{A}_{\xi^3}}{c\partial\hat{\xi}^0}]$$

$$+ \sinh(\frac{a_0}{c}\xi^0)\left[\frac{\partial \hat{A}_{\xi^3}}{\partial \hat{\xi}^1} - \frac{\partial \hat{A}_{\xi^1}}{\partial \hat{\xi}^3}\right] \tag{18}$$

$$B_x = \frac{\partial A_z}{\partial y} - \frac{\partial A_y}{\partial z} = \frac{\partial A_{\xi^3}}{\partial \xi^2} - \frac{\partial A_{\xi^2}}{\partial \xi^3} = \frac{\partial \hat{A}_{\xi^3}}{\partial \hat{\xi}^2} - \frac{\partial \hat{A}_{\xi^2}}{\partial \hat{\xi}^3} \tag{19}$$

$$B_y = \frac{\partial A_x}{\partial z} - \frac{\partial A_z}{\partial x} = \frac{\partial A_x}{\partial \xi^3} - \frac{\partial A_{\xi^3}}{\partial x}$$

$$= \frac{\partial}{\partial \xi^3}\left[\sinh(\frac{a_0\xi^0}{c})(1+\frac{a_0}{c^2}\xi^1)\phi_\xi + \cosh(\frac{a_0\xi^0}{c})A_{\xi^1}\right]$$

$$- \left[-\frac{\sinh(\frac{a_0\xi^0}{c})}{(1+\frac{a_0\xi^1}{c^2})}\frac{\partial}{c\partial \xi^0} + \cosh(\frac{a_0\xi^0}{c})\frac{\partial}{\partial \xi^1}\right]A_{\xi^3}$$

$$= \cosh(\frac{a_0}{c}\xi^0)\left[\frac{\partial A_{\xi^1}}{\partial \xi^3} - \frac{\partial A_{\xi^3}}{\partial \xi^1}\right]$$

$$- \sinh(\frac{a_0}{c}\xi^0)\left[-\frac{1}{(1+\frac{a_0}{c^2}\xi^1)}\frac{\partial}{\partial \xi^3}\left[\phi_\xi(1+\frac{a_0\xi^1}{c^2})^2\right] - \frac{1}{(1+\frac{a_0\xi^1}{c^2})}\frac{\partial A_{\xi^3}}{c\partial \xi^0}\right]$$

$$= \cosh(\frac{a_0}{c}\xi^0)\left[\frac{\partial \hat{A}_{\xi^1}}{\partial \hat{\xi}^3} - \frac{\partial \hat{A}_{\xi^3}}{\partial \hat{\xi}^1}\right]$$

$$- \sinh(\frac{a_0}{c}\xi^0)\left[-\frac{1}{(1+\frac{a_0}{c^2}\xi^1)}\frac{\partial}{\partial \hat{\xi}^3}\left[\hat{\phi}_\xi(1+\frac{a_0\xi^1}{c^2})\right] - \frac{\partial \hat{A}_{\xi^3}}{c\partial \hat{\xi}^0}\right] \tag{20}$$

$$B_z = \frac{\partial A_y}{\partial x} - \frac{\partial A_x}{\partial y} = \frac{\partial A_{\xi^2}}{\partial x} - \frac{\partial A_x}{\partial \xi^2}$$

$$= \left[-\frac{\sinh(\frac{a_0\xi^0}{c})}{(1+\frac{a_0\xi^1}{c^2})}\frac{\partial}{c\partial \xi^0} + \cosh(\frac{a_0\xi^0}{c})\frac{\partial}{\partial \xi^1}\right]A_{\xi^3}$$

$$-\frac{\partial}{\partial \xi^2}\left[\sinh\left(\frac{a_0 \xi^0}{c}\right)\left(1+\frac{a_0}{c^2}\xi^1\right)\phi_\xi + \cosh\left(\frac{a_0 \xi^0}{c}\right)A_{\xi^1}\right]$$

$$= \cosh\left(\frac{a_0}{c}\xi^0\right)\left[\frac{\partial A_{\xi^2}}{\partial \xi^1} - \frac{\partial A_{\xi^1}}{\partial \xi^2}\right]$$

$$+ \sinh\left(\frac{a_0}{c}\xi^0\right)\left[-\frac{1}{\left(1+\frac{a_0}{c^2}\xi^1\right)}\frac{\partial}{\partial \xi^2}\left[\phi_\xi\left(1+\frac{a_0 \xi^1}{c^2}\right)^2\right] - \frac{1}{\left(1+\frac{a_0 \xi^1}{c^2}\right)}\frac{\partial A_{\xi^2}}{c\partial \xi^0}\right]$$

$$= \cosh\left(\frac{a_0}{c}\xi^0\right)\left[\frac{\partial \hat{A}_{\xi^2}}{\partial \hat{\xi}^1} - \frac{\partial \hat{A}_{\xi^1}}{\partial \hat{\xi}^2}\right]$$

$$+ \sinh\left(\frac{a_0}{c}\xi^0\right)\left[-\frac{1}{\left(1+\frac{a_0}{c^2}\xi^1\right)}\frac{\partial}{\partial \hat{\xi}^2}\left[\hat{\phi}_\xi\left(1+\frac{a_0 \xi^1}{c^2}\right)\right] - \frac{\partial \hat{A}_{\xi^2}}{c\partial \hat{\xi}^0}\right] \qquad (21)$$

Hence, we can define the electro-magnetic field $(\vec{E}_\xi, \vec{B}_\xi)$ in Rindler spacetime.

$$\vec{E}_\xi = -\frac{1}{\left(1+\frac{a_0 \xi^1}{c^2}\right)}\vec{\nabla}_\xi\left\{\phi_\xi\left(1+\frac{a_0 \xi^1}{c^2}\right)^2\right\} - \frac{1}{\left(1+\frac{a_0 \xi^1}{c^2}\right)}\frac{\partial \vec{A}_\xi}{c\partial \xi^0}$$

$$= -\frac{1}{\left(1+\frac{a_0 \xi^1}{c^2}\right)}\vec{\nabla}_{\hat{\xi}}\left\{\hat{\phi}_\xi\left(1+\frac{a_0 \xi^1}{c^2}\right)\right\} - \frac{\partial \vec{\hat{A}}_\xi}{c\partial \hat{\xi}^0}$$

$$\vec{B}_\xi = \vec{\nabla}_\xi \times \vec{A}_\xi = \vec{\nabla}_{\hat{\xi}} \times \vec{\hat{A}}_\xi$$

In this time, $\vec{\nabla}_\xi = \left(\frac{\partial}{\partial \xi^1}, \frac{\partial}{\partial \xi^2}, \frac{\partial}{\partial \xi^3}\right), \vec{A}_\xi = (A_{\xi^1}, A_{\xi^2}, A_{\xi^3})$

$$\vec{\nabla}_{\hat{\xi}} = \left(\frac{\partial}{\partial \hat{\xi}^1}, \frac{\partial}{\partial \hat{\xi}^2}, \frac{\partial}{\partial \hat{\xi}^3}\right), \vec{\hat{A}}_\xi = (\hat{A}_{\xi^1}, \hat{A}_{\xi^2}, \hat{A}_{\xi^3}) \qquad (22)$$

We obtain the transformation of the electro-magnetic field.

$$E_x = -\frac{1}{\left(1+\frac{a_0 \xi^1}{c^2}\right)}\frac{\partial}{\partial \xi^1}\left\{\phi_\xi\left(1+\frac{a_0 \xi^1}{c^2}\right)^2\right\} - \frac{1}{\left(1+\frac{a_0 \xi^1}{c^2}\right)}\frac{\partial A_{\xi^1}}{c\partial \xi^0}$$

$$= -\frac{1}{(1+\frac{a_0\xi^1}{c^2})} \frac{\partial}{\partial\hat{\xi}^1} \{\hat{\phi}_\xi(1+\frac{a_0\xi^1}{c^2})\} - \frac{\partial\hat{A}_{\xi^1}}{c\partial\hat{\xi}^0} = E_{\xi^1} \quad ,$$

$$E_y = E_{\xi^2} \cosh(\frac{a_0\xi^0}{c}) + B_{\xi^3} \sinh(\frac{a_0\xi^0}{c}),$$

$$E_z = E_{\xi^3} \cosh(\frac{a_0\xi^0}{c}) - B_{\xi^2} \sinh(\frac{a_0\xi^0}{c})$$

$$B_x = B_{\xi^1},$$

$$B_y = B_{\xi^2} \cosh(\frac{a_0\xi^0}{c}) - E_{\xi^3} \sinh(\frac{a_0\xi^0}{c})$$

$$B_z = B_{\xi^3} \cosh(\frac{a_0\xi^0}{c}) + E_{\xi^2} \sinh(\frac{a_0\xi^0}{c}) \tag{23}$$

Hence,

$$E_x = E_{\xi^1}, B_x = B_{\xi^1},$$

$$\begin{pmatrix} E_y \\ B_y \\ E_z \\ B_z \end{pmatrix} = H \begin{pmatrix} E_{\xi^2} \\ B_{\xi^2} \\ E_{\xi^3} \\ B_{\xi^3} \end{pmatrix}$$

$$H = \begin{pmatrix} \cosh(\frac{a_0\xi^0}{c}) & 0 & 0 & \sinh(\frac{a_0\xi^0}{c}) \\ 0 & \cosh(\frac{a_0\xi^0}{c}) & -\sinh(\frac{a_0\xi^0}{c}) & 0 \\ 0 & -\sinh(\frac{a_0\xi^0}{c}) & \cosh(\frac{a_0\xi^0}{c}) & 0 \\ \sinh(\frac{a_0\xi^0}{c}) & 0 & 0 & \cosh(\frac{a_0\xi^0}{c}) \end{pmatrix} \tag{24}$$

The inverse-transformation of the electro-magnetic field is

$$E_{\xi^1} = E_x, B_{\xi^1} = B_x$$

$$
\begin{pmatrix} E_{\xi^2} \\ B_{\xi^2} \\ E_{\xi^3} \\ B_{\xi^3} \end{pmatrix} = H^{-1} \begin{pmatrix} E_y \\ B_y \\ E_z \\ B_z \end{pmatrix}
$$

$$
H^{-1} = \begin{pmatrix} \cosh(\dfrac{a_0\xi^0}{c}) & 0 & 0 & -\sinh(\dfrac{a_0\xi^0}{c}) \\ 0 & \cosh(\dfrac{a_0\xi^0}{c}) & \sinh(\dfrac{a_0\xi^0}{c}) & 0 \\ 0 & \sinh(\dfrac{a_0\xi^0}{c}) & \cosh(\dfrac{a_0\xi^0}{c}) & 0 \\ -\sinh(\dfrac{a_0\xi^0}{c}) & 0 & 0 & \cosh(\dfrac{a_0\xi^0}{c}) \end{pmatrix} \quad (25)
$$

$$
E_{\xi^1} = E_x, \quad B_{\xi^1} = B_x
$$

$$
E_{\xi^2} = E_y \cosh(\frac{a_0\xi^0}{c}) - B_z \sinh(\frac{a_0\xi^0}{c}),
$$

$$
B_{\xi^2} = B_y \cosh(\frac{a_0\xi^0}{c}) + E_z \sinh(\frac{a_0\xi^0}{c})
$$

$$
E_{\xi^3} = E_z \cosh(\frac{a_0\xi^0}{c}) + B_y \sinh(\frac{a_0\xi^0}{c})
$$

$$
B_{\xi^3} = B_z \cosh(\frac{a_0\xi^0}{c}) - E_y \sinh(\frac{a_0\xi^0}{c}) \quad (26)
$$

### 3. Electro-magnetic Field Equation(Maxwell Equation) in the Rindler space-time

Maxwell equation is

$$
\vec{\nabla} \cdot \vec{E} = 4\pi\rho \quad (27\text{-i})
$$

$$
\vec{\nabla} \times \vec{B} = \frac{\partial \vec{E}}{c\partial t} + \frac{4\pi}{c}\vec{j} \quad (27\text{-ii})
$$

$$
\vec{\nabla} \cdot \vec{B} = 0 \quad (27\text{-iii})
$$

$$
\vec{\nabla} \times \vec{E} = -\frac{\partial \vec{B}}{c\partial t} \quad (27\text{-iv})
$$

1. $\vec{\nabla} \cdot \vec{E} = 4\pi\rho$

$$
E_x = E_{\xi^1} \quad ,
$$

$$E_y = E_{\xi^2} \cosh(\frac{a_0\xi^0}{c}) + B_{\xi^3} \sinh(\frac{a_0\xi^0}{c}),$$

$$E_z = E_{\xi^3} \cosh(\frac{a_0\xi^0}{c}) - B_{\xi^2} \sinh(\frac{a_0\xi^0}{c})$$

$$4\pi\rho = \frac{\partial E_x}{\partial x} + \frac{\partial E_y}{\partial y} + \frac{\partial E_z}{\partial z}$$

$$= [-\frac{\sinh(\frac{a_0\xi^0}{c})}{(1+\frac{a_0\xi^1}{c^2})}\frac{\partial}{c\partial\xi^0} + \cosh(\frac{a_0\xi^0}{c})\frac{\partial}{\partial\xi^1}]E_{\xi^1}$$

$$+ \frac{\partial}{\partial\xi^2}[E_{\xi^2} \cosh(\frac{a_0\xi^0}{c}) + B_{\xi^3} \sinh(\frac{a_0\xi^0}{c})]$$

$$+ \frac{\partial}{\partial\xi^3}[E_{\xi^3} \cosh(\frac{a_0\xi^0}{c}) - B_{\xi^2} \sinh(\frac{a_0\xi^0}{c})]$$

$$= \cosh(\frac{a_0}{c}\xi^0)(\vec{\nabla}_\xi \cdot \vec{E}_\xi) + \sinh(\frac{a_0}{c}\xi^0)[\frac{\partial B_{\xi^3}}{\partial\xi^2} - \frac{\partial B_{\xi^2}}{\partial\xi^3} - \frac{1}{(1+\frac{a_0\xi^1}{c^2})}\frac{\partial E_{\xi^1}}{c\partial\xi^0}]$$

$$= \cosh(\frac{a_0}{c}\xi^0)(\vec{\nabla}_\xi \cdot \vec{E}_\xi) + \sinh(\frac{a_0}{c}\xi^0)[\frac{\partial B_{\xi^3}}{\partial\hat{\xi}^2} - \frac{\partial B_{\xi^2}}{\partial\hat{\xi}^3} - \frac{\partial E_{\xi^1}}{c\partial\hat{\xi}^0}] \quad (28)$$

$2. \vec{\nabla} \times \vec{B} = \frac{\partial\vec{E}}{c\partial t} + \frac{4\pi}{c}\vec{j}$

$$B_x = B_{\xi^1}$$

$$B_y = B_{\xi^2} \cosh(\frac{a_0\xi^0}{c}) - E_{\xi^3} \sinh(\frac{a_0\xi^0}{c})$$

$$B_z = B_{\xi^3} \cosh(\frac{a_0\xi^0}{c}) + E_{\xi^2} \sinh(\frac{a_0\xi^0}{c})$$

X-component) $\frac{\partial B_z}{\partial y} - \frac{\partial B_y}{\partial z}$

$$= \frac{\partial}{\partial\xi^2}[B_{\xi^3} \cosh(\frac{a_0\xi^0}{c}) + E_{\xi^2} \sinh(\frac{a_0\xi^0}{c})]$$

$$-\frac{\partial}{\partial\xi^3}\left[B_{\xi^2}\cosh(\frac{a_0\xi^0}{c})-E_{\xi^3}\sinh(\frac{a_0\xi^0}{c})\right]$$

$$=\cosh(\frac{a_0}{c}\xi^0)\left[\frac{\partial B_{\xi^3}}{\partial\xi^2}-\frac{\partial B_{\xi^2}}{\partial\xi^3}\right]+\sinh(\frac{a_0\xi^0}{c})\left[\frac{\partial E_{\xi^2}}{\partial\xi^2}+\frac{\partial E_{\xi^3}}{\partial\xi^3}\right]$$

$$=\frac{\partial E_x}{c\partial t}+\frac{4\pi}{c}j_x$$

$$=\left[\frac{\cosh(\frac{a_0\xi^0}{c})}{(1+\frac{a_0\xi^1}{c^2})}\frac{\partial}{c\partial\xi^0}-\sinh(\frac{a_0\xi^0}{c})\frac{\partial}{\partial\xi^1}\right]E_{\xi^1}+\frac{4\pi}{c}j_x$$

Hence,

$$\frac{4\pi}{c}j_x$$

$$=\sinh(\frac{a_0\xi^0}{c})(\vec{\nabla}_\xi\cdot\vec{E}_\xi)+\cosh(\frac{a_0\xi^0}{c})\left[\frac{\partial B_{\xi^3}}{\partial\xi^2}-\frac{\partial B_{\xi^2}}{\partial\xi^3}-\frac{1}{(1+\frac{a_0\xi^1}{c^2})}\frac{\partial E_{\xi^1}}{c\partial\xi^0}\right]$$

$$=\sinh(\frac{a_0\xi^0}{c})(\vec{\nabla}_{\hat{\xi}}\cdot\vec{E}_\xi)+\cosh(\frac{a_0\xi^0}{c})\left[\frac{\partial B_{\xi^3}}{\partial\hat{\xi}^2}-\frac{\partial B_{\xi^2}}{\partial\hat{\xi}^3}-\frac{\partial E_{\xi^1}}{c\partial\hat{\xi}^0}\right] \quad (29)$$

Y-component) $\dfrac{\partial B_x}{\partial z}-\dfrac{\partial B_z}{\partial x}$

$$=\frac{\partial B_{\xi^1}}{\partial\xi^3}$$

$$-\left[-\frac{\sinh(\frac{a_0\xi^0}{c})}{(1+\frac{a_0\xi^1}{c^2})}\frac{\partial}{c\partial\xi^0}+\cosh(\frac{a_0\xi^0}{c})\frac{\partial}{\partial\xi^1}\right]\cdot\left[B_{\xi^3}\cosh(\frac{a_0\xi^0}{c})+E_{\xi^2}\sinh(\frac{a_0\xi^0}{c})\right]$$

$$=\frac{\partial E_y}{c\partial t}+\frac{4\pi}{c}j_y$$

$$=\left[\frac{\cosh(\frac{a_0\xi^0}{c})}{(1+\frac{a_0\xi^1}{c^2})}\frac{\partial}{c\partial\xi^0}-\sinh(\frac{a_0\xi^0}{c})\frac{\partial}{\partial\xi^1}\right]\cdot\left[E_{\xi^2}\cosh(\frac{a_0\xi^0}{c})+B_{\xi^3}\sinh(\frac{a_0\xi^0}{c})\right]$$

$$+ \frac{4\pi}{c} j_y$$

$$\frac{4\pi}{c} j_y = \frac{\partial B_{\xi^1}}{\partial \xi^3} - \frac{\partial B_{\xi^3}}{\partial \xi^1} - \frac{1}{(1+\frac{a_0}{c^2}\xi^1)} \frac{a_0}{c^2} B_{\xi^3} - \frac{1}{(1+\frac{a_0}{c^2}\xi^1)} \frac{\partial E_{\xi^2}}{c\partial \xi^0}$$

$$= \frac{1}{(1+\frac{a_0}{c^2}\xi^1)} \frac{\partial}{\partial \xi^3} \{B_{\xi^1}(1+\frac{a_0}{c^2}\xi^1)\} - \frac{1}{(1+\frac{a_0}{c^2}\xi^1)} \frac{\partial}{\partial \xi^1} \{B_{\xi^3}(1+\frac{a_0\xi^1}{c^2})\} - \frac{1}{(1+\frac{a_0}{c^2}\xi^1)} \frac{\partial E_{\xi^2}}{c\partial \xi^0}$$

$$= \frac{1}{(1+\frac{a_0}{c^2}\xi^1)} \frac{\partial}{\partial \hat{\xi}^3} \{B_{\xi^1}(1+\frac{a_0}{c^2}\xi^1)\} - \frac{1}{(1+\frac{a_0}{c^2}\xi^1)} \frac{\partial}{\partial \hat{\xi}^1} \{B_{\xi^3}(1+\frac{a_0\xi^1}{c^2})\} - \frac{\partial E_{\xi^2}}{c\partial \hat{\xi}^0}$$

(30)

Z-component) $\frac{\partial B_y}{\partial x} - \frac{\partial B_x}{\partial y}$

$$= [-\frac{\sinh(\frac{a_0\xi^0}{c})}{(1+\frac{a_0\xi^1}{c^2})} \frac{\partial}{c\partial \xi^0} + \cosh(\frac{a_0\xi^0}{c}) \frac{\partial}{\partial \xi^1}] \cdot [B_{\xi^2} \cosh(\frac{a_0\xi^0}{c}) - E_{\xi^3} \sinh(\frac{a_0\xi^0}{c})]$$

$$- \frac{\partial B_{\xi^1}}{\partial \xi^2}$$

$$= \frac{\partial E_z}{c\partial t} + \frac{4\pi}{c} j_z$$

$$= [\frac{\cosh(\frac{a_0\xi^0}{c})}{(1+\frac{a_0\xi^1}{c^2})} \frac{\partial}{c\partial \xi^0} - \sinh(\frac{a_0\xi^0}{c}) \frac{\partial}{\partial \xi^1}] \cdot [E_{\xi^3} \cosh(\frac{a_0\xi^0}{c}) - B_{\xi^2} \sinh(\frac{a_0\xi^0}{c})]$$

$$+ \frac{4\pi}{c} j_z$$

$$\frac{4\pi}{c} j_z = \frac{\partial B_{\xi^2}}{\partial \xi^1} - \frac{\partial B_{\xi^1}}{\partial \xi^2} + \frac{1}{(1+\frac{a_0}{c^2}\xi^1)} \frac{a_0}{c^2} B_{\xi^2} - \frac{1}{(1+\frac{a_0}{c^2}\xi^1)} \frac{\partial E_{\xi^3}}{c\partial \xi^0}$$

$$= \frac{1}{(1+\frac{a_0}{c^2}\xi^1)} \frac{\partial}{\partial \xi^1} \{B_{\xi^2}(1+\frac{a_0}{c^2}\xi^1)\} - \frac{1}{(1+\frac{a_0}{c^2}\xi^1)} \frac{\partial}{\partial \xi^2} \{B_{\xi^1}(1+\frac{a_0\xi^1}{c^2})\} - \frac{1}{(1+\frac{a_0}{c^2}\xi^1)} \frac{\partial E_{\xi^3}}{c\partial \xi^0}$$

$$= \frac{1}{(1+\frac{a_0}{c^2}\xi^1)} \frac{\partial}{\partial\hat{\xi}^1} \{B_{\xi^2}(1+\frac{a_0}{c^2}\xi^1)\} - \frac{1}{(1+\frac{a_0}{c^2}\xi^1)} \frac{\partial}{\partial\hat{\xi}^2} \{B_{\xi^1}(1+\frac{a_0\xi^1}{c^2})\} - \frac{\partial E_{\xi^3}}{c\partial\hat{\xi}^0}$$

(31)

3. $\vec{\nabla}\cdot\vec{B}=0$

$$\vec{\nabla}\cdot\vec{B} = \frac{\partial B_x}{\partial x} + \frac{\partial B_y}{\partial y} + \frac{\partial B_z}{\partial z}$$

$$= [-\frac{\sinh(\frac{a_0\xi^0}{c})}{(1+\frac{a_0\xi^1}{c^2})} \frac{\partial}{c\partial\xi^0} + \cosh(\frac{a_0\xi^0}{c}) \frac{\partial}{\partial\xi^1}]B_{\xi^1}$$

$$+ \frac{\partial}{\partial\xi^2} [B_{\xi^2} \cosh(\frac{a_0\xi^0}{c}) - E_{\xi^3} \sinh(\frac{a_0\xi^0}{c})]$$

$$+ \frac{\partial}{\partial\xi^3} [B_{\xi^3} \cosh(\frac{a_0\xi^0}{c}) + E_{\xi^2} \sinh(\frac{a_0\xi^0}{c})]$$

$$= \cosh(\frac{a_0\xi^0}{c})(\vec{\nabla}_{\hat{\xi}}\cdot\vec{B}_{\xi}) + \sinh(\frac{a_0\xi^0}{c})[-(-\frac{\partial E_{\xi^2}}{\partial\hat{\xi}^3} + \frac{\partial E_{\xi^3}}{\partial\hat{\xi}^2}) - \frac{\partial B_{\xi^1}}{c\partial\hat{\xi}^0}] = 0$$

(32)

4. $\vec{\nabla}\times\vec{E} = -\frac{\partial\vec{B}}{c\partial t}$

$$E_x = E_{\xi^1} \quad ,$$

$$E_y = E_{\xi^2} \cosh(\frac{a_0\xi^0}{c}) + B_{\xi^3} \sinh(\frac{a_0\xi^0}{c}),$$

$$E_z = E_{\xi^3} \cosh(\frac{a_0\xi^0}{c}) - B_{\xi^2} \sinh(\frac{a_0\xi^0}{c})$$

X-component) $\frac{\partial E_z}{\partial y} - \frac{\partial E_y}{\partial z}$

$$= \frac{\partial}{\partial\xi^2} [E_{\xi^3} \cosh(\frac{a_0\xi^0}{c}) - B_{\xi^2} \sinh(\frac{a_0\xi^0}{c})]$$

$$- \frac{\partial}{\partial\xi^3} [E_{\xi^2} \cosh(\frac{a_0\xi^0}{c}) + B_{\xi^3} \sinh(\frac{a_0\xi^0}{c})]$$

$$= \cosh(\frac{a_0}{c}\xi^0)\,[\frac{\partial E_{\xi^3}}{\partial \xi^2} - \frac{\partial E_{\xi^2}}{\partial \xi^3}] - \sinh(\frac{a_0\xi^0}{c})\,[\frac{\partial B_{\xi^2}}{\partial \xi^2} + \frac{\partial B_{\xi^3}}{\partial \xi^3}]$$

$$= -\frac{\partial B_x}{c\partial t}$$

$$= -[\frac{\cosh(\frac{a_0\xi^0}{c})}{(1+\frac{a_0\xi^1}{c^2})}\frac{\partial}{c\partial\xi^0} - \sinh(\frac{a_0\xi^0}{c})\frac{\partial}{\partial\xi^1}]B_{\xi^1}$$

Hence, 
$$-\sinh(\frac{a_0\xi^0}{c})(\vec{\nabla}_\xi\cdot\vec{B}_\xi) + c\,o\,s\,h(\frac{a_0\xi^0}{c})\ [-(\frac{\partial E_{\xi^3}}{\partial\xi^2} - \frac{\partial E_{\xi^2}}{\partial\xi^3}) + \frac{1}{(1+\frac{a_0\xi^1}{c^2})}\frac{\partial B_{\xi^1}}{c\partial\xi^0}]$$

$$= -\sinh(\frac{a_0\xi^0}{c})(\vec{\nabla}_{\hat{\xi}}\cdot\vec{B}_\xi) + \cosh(\frac{a_0\xi^0}{c})[(\frac{\partial E_{\xi^3}}{\partial\hat{\xi}^2} - \frac{\partial E_{\xi^2}}{\partial\hat{\xi}^3}) + \frac{\partial B_{\xi^1}}{c\partial\hat{\xi}^0}] = 0 \quad (33)$$

Y-component) $\dfrac{\partial E_x}{\partial z} - \dfrac{\partial E_z}{\partial x}$

$$= \frac{\partial E_{\xi^1}}{\partial\xi^3}$$

$$-[-\frac{\sinh(\frac{a_0\xi^0}{c})}{(1+\frac{a_0\xi^1}{c^2})}\frac{\partial}{c\partial\xi^0} + \cosh(\frac{a_0\xi^0}{c})\frac{\partial}{\partial\xi^1}]\cdot[E_{\xi^3}\cosh(\frac{a_0\xi^0}{c}) - B_{\xi^2}\sinh(\frac{a_0\xi^0}{c})]$$

$$= -\frac{\partial B_y}{c\partial t}$$

$$= -[\frac{\cosh(\frac{a_0\xi^0}{c})}{(1+\frac{a_0\xi^1}{c^2})}\frac{\partial}{c\partial\xi^0} - \sinh(\frac{a_0\xi^0}{c})\frac{\partial}{\partial\xi^1}]\cdot[B_{\xi^2}\cosh(\frac{a_0\xi^0}{c}) - E_{\xi^3}\sinh(\frac{a_0\xi^0}{c})]$$

$$\frac{\partial E_{\xi^1}}{\partial\xi^3} - \frac{\partial E_{\xi^3}}{\partial\xi^1} - \frac{1}{(1+\frac{a_0}{c^2}\xi^1)}\frac{a_0}{c^2}E_{\xi^3} + \frac{1}{(1+\frac{a_0}{c^2}\xi^1)}\frac{\partial B_{\xi^2}}{c\partial\xi^0}$$

$$= \frac{1}{(1+\frac{a_0}{c^2}\xi^1)} \frac{\partial}{\partial \xi^3} \{E_{\xi^1}(1+\frac{a_0}{c^2}\xi^1)\} - \frac{1}{(1+\frac{a_0}{c^2}\xi^1)} \frac{\partial}{\partial \xi^1} \{E_{\xi^3}(1+\frac{a_0\xi^1}{c^2})\} + \frac{1}{(1+\frac{a_0}{c^2}\xi^1)} \frac{\partial B_{\xi^2}}{c\partial \xi^0}$$

$$= \frac{1}{(1+\frac{a_0}{c^2}\xi^1)} \frac{\partial}{\partial \hat{\xi}^3} \{E_{\xi^1}(1+\frac{a_0}{c^2}\xi^1)\} - \frac{1}{(1+\frac{a_0}{c^2}\xi^1)} \frac{\partial}{\partial \hat{\xi}^1} \{E_{\xi^3}(1+\frac{a_0\xi^1}{c^2})\} + \frac{\partial B_{\xi^2}}{c\partial \hat{\xi}^0} = 0$$

(34)

Z-component) $\dfrac{\partial E_y}{\partial x} - \dfrac{\partial E_x}{\partial y}$

$$= [-\frac{\sinh(\frac{a_0\xi^0}{c})}{(1+\frac{a_0\xi^1}{c^2})} \frac{\partial}{c\partial \xi^0} + \cosh(\frac{a_0\xi^0}{c}) \frac{\partial}{\partial \xi^1}] \cdot [E_{\xi^2} \cosh(\frac{a_0\xi^0}{c}) + B_{\xi^3} \sinh(\frac{a_0\xi^0}{c})]$$

$$- \frac{\partial E_{\xi^1}}{\partial \xi^2}$$

$$= -\frac{\partial B_z}{c\partial t}$$

$$= -[\frac{\cosh(\frac{a_0\xi^0}{c})}{(1+\frac{a_0\xi^1}{c^2})} \frac{\partial}{c\partial \xi^0} - \sinh(\frac{a_0\xi^0}{c}) \frac{\partial}{\partial \xi^1}] \cdot [B_{\xi^3} \cosh(\frac{a_0\xi^0}{c}) + E_{\xi^2} \sinh(\frac{a_0\xi^0}{c})]$$

$$\frac{\partial E_{\xi^2}}{\partial \xi^1} - \frac{\partial E_{\xi^1}}{\partial \xi^2} + \frac{1}{(1+\frac{a_0}{c^2}\xi^1)} \frac{a_0}{c^2} E_{\xi^2} + \frac{1}{(1+\frac{a_0}{c^2}\xi^1)} \frac{\partial B_{\xi^3}}{c\partial \xi^0}$$

$$= \frac{1}{(1+\frac{a_0}{c^2}\xi^1)} \frac{\partial}{\partial \xi^1} \{E_{\xi^2}(1+\frac{a_0}{c^2}\xi^1)\} - \frac{1}{(1+\frac{a_0}{c^2}\xi^1)} \frac{\partial}{\partial \xi^2} \{E_{\xi^1}(1+\frac{a_0\xi^1}{c^2})\} + \frac{1}{(1+\frac{a_0}{c^2}\xi^1)} \frac{\partial B_{\xi^3}}{c\partial \xi^0}$$

$$= \frac{1}{(1+\frac{a_0}{c^2}\xi^1)} \frac{\partial}{\partial \hat{\xi}^1} \{E_{\xi^2}(1+\frac{a_0}{c^2}\xi^1)\} - \frac{1}{(1+\frac{a_0}{c^2}\xi^1)} \frac{\partial}{\partial \hat{\xi}^2} \{E_{\xi^1}(1+\frac{a_0\xi^1}{c^2})\} + \frac{\partial B_{\xi^3}}{c\partial \hat{\xi}^0} = 0$$

(35)

Therefore, we obtain the electro-magnetic field equation by Eq (28)-Eq(35) in Rindler spacetime .

$$\vec{\nabla}_\xi \cdot \vec{E}_\xi = \vec{\nabla}_{\hat{\xi}} \cdot \vec{E}_\xi = 4\pi \rho_\xi (1+\frac{a_0\xi^1}{c^2})$$

(36-i)

$$\frac{1}{(1+\dfrac{a_0\xi^1}{c^2})}\vec{\nabla}_\xi \times \{\vec{B}_\xi(1+\frac{a_0\xi^1}{c^2})\} = \frac{1}{(1+\dfrac{a_0\xi^1}{c^2})}\frac{\partial\vec{E}_\xi}{c\partial\xi^0}+\frac{4\pi}{c}\vec{j}_\xi$$

$$\frac{1}{(1+\dfrac{a_0\xi^1}{c^2})}\vec{\nabla}_{\hat{\xi}} \times \{\vec{B}_\xi(1+\frac{a_0\xi^1}{c^2})\} = \frac{\partial\vec{E}_\xi}{c\partial\hat{\xi}^0}+\frac{4\pi}{c}\vec{j}_\xi \tag{36-ii}$$

$$\vec{\nabla}_\xi \cdot \vec{B}_\xi = \vec{\nabla}_{\hat{\xi}} \cdot \vec{B}_\xi = 0 \tag{36-iii}$$

$$\frac{1}{(1+\dfrac{a_0\xi^1}{c^2})}\vec{\nabla}_\xi \times \{\vec{E}_\xi(1+\frac{a_0\xi^1}{c^2})\} = -\frac{1}{(1+\dfrac{a_0\xi^1}{c^2})}\frac{\partial\vec{B}_\xi}{c\partial\xi^0}$$

$$\frac{1}{(1+\dfrac{a_0\xi^1}{c^2})}\vec{\nabla}_{\hat{\xi}} \times \{\vec{E}_\xi(1+\frac{a_0\xi^1}{c^2})\} = -\frac{\partial\vec{B}_\xi}{c\partial\hat{\xi}^0} \tag{36-iv}$$

$$\vec{E}_\xi = (E_{\xi^1}, E_{\xi^2}, E_{\xi^3}), \vec{B}_\xi = (B_{\xi^1}, B_{\xi^2}, B_{\xi^3}),$$

$$\vec{\nabla}_\xi = (\frac{\partial}{\partial\xi^1}, \frac{\partial}{\partial\xi^2}, \frac{\partial}{\partial\xi^3}), \vec{\nabla}_{\hat{\xi}} = (\frac{\partial}{\partial\hat{\xi}^1}, \frac{\partial}{\partial\hat{\xi}^2}, \frac{\partial}{\partial\hat{\xi}^3})$$

Hence, the transformation of 4-vector $(c\rho, \vec{j}) = \rho_0\dfrac{dx^\alpha}{d\tau}$ is

$$\rho = \rho_\xi(1+\frac{a_0\xi^1}{c^2})\cosh(\frac{a_0\xi^0}{c}) + \frac{j_{\xi^1}}{c}\sinh(\frac{a_0\xi^0}{c})$$

$$j_x = j_{\xi^1}\cosh(\frac{a_0\xi^0}{c}) + c\rho_\xi(1+\frac{a_0}{c^2}\xi^1)\sinh(\frac{a_0\xi^0}{c}), \quad j_y = j_{\xi^2}, j_z = j_{\xi^3}$$

In this time, 4-vector $(c\rho_\xi, \vec{j}_\xi) = \rho_0\dfrac{d\xi^\alpha}{d\tau}$ \tag{37}

## 4. Electro-magnetic wave equation in Rindler space-time

The electro-magnetic wave function is

$$E_x = E_{x0}\sin\Phi, E_y = E_{y0}\sin\Phi, E_z = E_{z0}\sin\Phi$$

$$B_x = B_{x0}\sin\Phi, B_y = B_{y0}\sin\Phi, B_z = B_{z0}\sin\Phi$$

$$E_{\xi^1} = E_x, B_{\xi^1} = B_x$$

$$E_{\xi^1} = E_{X0}\sin\Phi', B_{\xi^1} = B_{X0}\sin\Phi'$$

$$E_{\xi^2} = E_y\cosh(\frac{a_0\xi^0}{c}) - B_z\sinh(\frac{a_0\xi^0}{c}),$$

$$= (E_{y0}\sin\Phi')\cosh(\frac{a_0\xi^0}{c}) - (B_{z0}\sin\Phi')\sinh(\frac{a_0\xi^0}{c})$$

$$B_{\xi^2} = B_y\cosh(\frac{a_0\xi^0}{c}) + E_z\sinh(\frac{a_0\xi^0}{c})$$

$$= (B_{y0}\sin\Phi')\cosh(\frac{a_0\xi^0}{c}) + (E_{z0}\sin\Phi')\sinh(\frac{a_0\xi^0}{c})$$

$$E_{\xi^3} = E_z\cosh(\frac{a_0\xi^0}{c}) + B_y\sinh(\frac{a_0\xi^0}{c})$$

$$= (E_{z0}\sin\Phi')\cosh(\frac{a_0\xi^0}{c}) + (B_{y0}\sin\Phi')\sinh(\frac{a_0\xi^0}{c})$$

$$B_{\xi^3} = B_z\cosh(\frac{a_0\xi^0}{c}) - E_y\sinh(\frac{a_0\xi^0}{c})$$

$$= (B_{z0}\sin\Phi')\cosh(\frac{a_0\xi^0}{c}) - (E_{y0}\sin\Phi')\sinh(\frac{a_0\xi^0}{c}) \qquad (38)$$

$$\Phi = \omega(t - l\frac{x}{c} - m\frac{y}{c} - n\frac{z}{c}),$$

$$\Phi' = \omega'(\hat{\xi}^0 - l'\frac{\hat{\xi}^1}{c} - m'\frac{\hat{\xi}^2}{c} - n'\frac{\hat{\xi}^3}{c})$$

$$l^2 + m^2 + n^2 = 1 \qquad , l'^2 + m'^2 + n'^2 = 1 \qquad (39)$$

Hence,

$$[\frac{1}{c^2}\frac{1}{(1+\frac{a_0}{c^2}\xi^1)^2}(\frac{\partial}{\partial\xi^0})^2 - \nabla_\xi^{\ 2}]E_{\xi^1}$$

$$= [\frac{1}{c^2}(\frac{\partial}{\partial\hat{\xi}^0})^2 - \nabla_{\hat{\xi}}^{\ 2}]E_{\xi^1} = 0$$

$$[\frac{1}{c^2}\frac{1}{(1+\frac{a_0}{c^2}\xi^1)^2}(\frac{\partial}{\partial\xi^0})^2 - \nabla_\xi^{\ 2}]B_{\xi^1}$$

$$= [\frac{1}{c^2}(\frac{\partial}{\partial\hat{\xi}^0})^2 - \nabla_{\hat{\xi}}^{\ 2}]B_{\xi^1} = 0$$

$$[\frac{1}{c^2}\frac{1}{(1+\frac{a_0}{c^2}\xi^1)^2}(\frac{\partial}{\partial\xi^0})^2 - \nabla_\xi{}^2]E_y$$

$$= [\frac{1}{c^2}(\frac{\partial}{\partial\hat{\xi}^0})^2 - \nabla_{\hat{\xi}}{}^2]E_y = 0$$

$$[\frac{1}{c^2}\frac{1}{(1+\frac{a_0}{c^2}\xi^1)^2}(\frac{\partial}{\partial\xi^0})^2 - \nabla_\xi{}^2]B_y$$

$$= [\frac{1}{c^2}(\frac{\partial}{\partial\hat{\xi}^0})^2 - \nabla_{\hat{\xi}}{}^2]B_y = 0$$

$$[\frac{1}{c^2}\frac{1}{(1+\frac{a_0}{c^2}\xi^1)^2}(\frac{\partial}{\partial\xi^0})^2 - \nabla_\xi{}^2]E_z$$

$$= [\frac{1}{c^2}(\frac{\partial}{\partial\hat{\xi}^0})^2 - \nabla_{\hat{\xi}}{}^2]E_z = 0$$

$$[\frac{1}{c^2}\frac{1}{(1+\frac{a_0}{c^2}\xi^1)^2}(\frac{\partial}{\partial\xi^0})^2 - \nabla_\xi{}^2]B_z$$

$$= [\frac{1}{c^2}(\frac{\partial}{\partial\hat{\xi}^0})^2 - \nabla_{\hat{\xi}}{}^2]B_z = 0 \tag{40}$$

The electro-magnetic wave equation is in vacuum

$$\vec{\nabla}_\xi \times (1+\frac{a_0}{c^2}\xi^1)\vec{\nabla}_\xi \times \{\vec{E}_\xi(1+\frac{a_0}{c^2}\xi^1)\}$$

$$= \vec{\nabla}_\xi(1+\frac{a_0}{c^2}\xi^1) \times \vec{\nabla}_\xi \times \{\vec{E}_\xi(1+\frac{a_0}{c^2}\xi^1)\} + (1+\frac{a_0}{c^2}\xi^1)\vec{\nabla}_\xi \times \vec{\nabla}_\xi \times \{\vec{E}_\xi(1+\frac{a_0}{c^2}\xi^1)\}$$

$$= \vec{\nabla}_\xi(1+\frac{a_0}{c^2}\xi^1) \times \vec{\nabla}_\xi(1+\frac{a_0}{c^2}\xi^1) \times \vec{E}_\xi$$

$$+ (1+\frac{a_0}{c^2}\xi^1)\vec{\nabla}_\xi(1+\frac{a_0}{c^2}\xi^1) \times \vec{\nabla}_\xi \times \vec{E}_\xi$$

$$+ (1+\frac{a_0}{c^2}\xi^1)\vec{\nabla}_\xi \times \vec{\nabla}_\xi(1+\frac{a_0}{c^2}\xi^1) \times \vec{E}_\xi$$

$$+ (1+\frac{a_0}{c^2}\xi^1)^2\vec{\nabla}_\xi \times \vec{\nabla}_\xi \times \vec{E}_\xi$$

$$= \vec{\nabla}_\xi(1+\frac{a_0}{c^2}\xi^1) \times \vec{\nabla}_\xi(1+\frac{a_0}{c^2}\xi^1) \times \vec{E}_\xi + (1+\frac{a_0}{c^2}\xi^1)^2\vec{\nabla}_\xi \times \vec{\nabla}_\xi \times \vec{E}_\xi$$

$$= [\vec{\nabla}_\xi(1+\frac{a_0}{c^2}\xi^1)\cdot\vec{E}_\xi]\vec{\nabla}_\xi(1+\frac{a_0}{c^2}\xi^1) - [\vec{\nabla}_\xi(1+\frac{a_0}{c^2}\xi^1)\cdot\vec{\nabla}_\xi(1+\frac{a_0}{c^2}\xi^1)]\vec{E}_\xi$$

$$+ (1+\frac{a_0}{c^2}\xi^1)^2[\vec{\nabla}_\xi(\vec{\nabla}_\xi\cdot\vec{E}_\xi) - \nabla_\xi^{\,2}\vec{E}_\xi]$$

$$= -\frac{1}{c}\frac{\partial}{\partial\xi^0}[\vec{\nabla}_\xi\times\{\vec{B}_\xi(1+\frac{a_0\xi^1}{c^2})\}] = -\frac{1}{c^2}(\frac{\partial}{\partial\xi^0})^2\vec{E}_\xi,$$

In this time, $\quad \vec{\nabla}_\xi(1+\frac{a_0}{c^2}\xi^1) = (\frac{a_0}{c^2},0,0)$ $\hfill(41)$

Hence,

$$\vec{\nabla}_\xi\times(1+\frac{a_0}{c^2}\xi^1)\vec{\nabla}_\xi\times\{\vec{E}_\xi(1+\frac{a_0}{c^2}\xi^1)\} + \frac{1}{c^2}(\frac{\partial}{\partial\xi^0})^2\vec{E}_\xi$$

$$= [\vec{\nabla}_\xi(1+\frac{a_0}{c^2}\xi^1)\cdot\vec{E}_\xi]\vec{\nabla}_\xi(1+\frac{a_0}{c^2}\xi^1) - [\vec{\nabla}_\xi(1+\frac{a_0}{c^2}\xi^1)\cdot\vec{\nabla}_\xi(1+\frac{a_0}{c^2}\xi^1)]\vec{E}_\xi$$

$$+ (1+\frac{a_0}{c^2}\xi^1)^2[\vec{\nabla}_\xi(\vec{\nabla}_\xi\cdot\vec{E}_\xi) - \nabla_\xi^{\,2}\vec{E}_\xi] + \frac{1}{c^2}(\frac{\partial}{\partial\xi^0})^2\vec{E}_\xi$$

$$= \frac{a_0^{\,2}}{c^4}(E_{\xi^1},0,0) - \frac{a_0^{\,2}}{c^4}(E_{\xi^1},E_{\xi^2},E_{\xi^3}) + (1+\frac{a_0}{c^2}\xi^1)^2[\frac{1}{c^2}\frac{1}{(1+\frac{a_0}{c^2}\xi^1)^2}(\frac{\partial}{\partial\xi^0})^2 - \nabla_\xi^{\,2}]\vec{E}_\xi$$

$$= \frac{a_0^{\,2}}{c^4}(0,-E_{\xi^2},-E_{\xi^3}) + (1+\frac{a_0}{c^2}\xi^1)^2[\frac{1}{c^2}\frac{1}{(1+\frac{a_0}{c^2}\xi^1)^2}(\frac{\partial}{\partial\xi^0})^2 - \nabla_\xi^{\,2}]\vec{E}_\xi$$

$$= \frac{a_0^{\,2}}{c^4}(0,-E_{\xi^2},-E_{\xi^3}) + (1+\frac{a_0}{c^2}\xi^1)^2[\frac{1}{c^2}(\frac{\partial}{\partial\hat{\xi}^0})^2 - \nabla_{\hat{\xi}}^{\,2}]\vec{E}_\xi$$

$$= \vec{0} \hfill(42)$$

Hence, the magnetic wave equation is in vacuum

$$\vec{\nabla}_\xi\times(1+\frac{a_0}{c^2}\xi^1)\vec{\nabla}_\xi\times\{\vec{B}_\xi(1+\frac{a_0}{c^2}\xi^1)\} + \frac{1}{c^2}(\frac{\partial}{\partial\xi^0})^2\vec{B}_\xi$$

$$= [\vec{\nabla}_\xi(1+\frac{a_0}{c^2}\xi^1)\cdot\vec{B}_\xi]\vec{\nabla}_\xi(1+\frac{a_0}{c^2}\xi^1) - [\vec{\nabla}_\xi(1+\frac{a_0}{c^2}\xi^1)\cdot\vec{\nabla}_\xi(1+\frac{a_0}{c^2}\xi^1)]\vec{B}_\xi$$

$$+ (1+\frac{a_0}{c^2}\xi^1)^2[\vec{\nabla}_\xi(\vec{\nabla}_\xi\cdot\vec{B}_\xi) - \nabla_\xi^{\,2}\vec{B}_\xi] + \frac{1}{c^2}(\frac{\partial}{\partial\xi^0})^2\vec{B}_\xi$$

$$= \frac{a_0^{\,2}}{c^4}(0,-B_{\xi^2},-B_{\xi^3}) + (1+\frac{a_0}{c^2}\xi^1)^2[\frac{1}{c^2}\frac{1}{(1+\frac{a_0}{c^2}\xi^1)^2}(\frac{\partial}{\partial\xi^0})^2 - \nabla_\xi^{\,2}]\vec{B}_\xi$$

$$= \frac{a_0^2}{c^4}(0, -B_{\xi^2}, -B_{\xi^3}) + (1 + \frac{a_0}{c^2}\xi^1)^2 [\frac{1}{c^2}(\frac{\partial}{\partial\hat{\xi}^0})^2 - \nabla_{\hat{\xi}}^2]\vec{B}_\xi$$

$$= \vec{0} \tag{43}$$

The electromagnetic wave function, Eq(38),Eq(39) satisfy the electromagnetic wave equation, Eq(42),Eq(43).

## 5. Conclusion

We find the electro-magnetic field transformation and the electro-magnetic equation in uniformly accelerated frame.

Generally, the coordinate transformation of accelerated frame is

(I) $\qquad ct = (\frac{c^2}{a_0} + \xi^1)\sinh(\frac{a_0\xi^0}{c})$

$$x = (\frac{c^2}{a_0} + \xi^1)\cosh(\frac{a_0\xi^0}{c}) - \frac{c^2}{a_0} \quad , y = \xi^2, z = \xi^3 \tag{44}$$

(II) $\quad ct = \frac{c^2}{a_0}\exp(\frac{a_0}{c^2}\xi^1)\sinh(\frac{a_0\xi^0}{c})$

$$x = \frac{c^2}{a_0}\exp(\frac{a_0}{c^2}\xi^1)\cosh(\frac{a_0\xi^0}{c}) - \frac{c^2}{a_0}, y = \xi^2, z = \xi^3 \tag{45}$$

Hence, this article say the accelerated frame is Rindler coordinate (I) that can treat electro-magnetic field equation.

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