

# **Electro-Magnetic Field Equation and Lorentz gauge 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 treat Lorentz gauge transformation in Rindler spacetime. Specially, this article say the uniqueness of the accelerated frame because the accelerated frame can treat electro-magnetic field equation.

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**Key words:General relativity theory,**

**Rindler spacetime,**

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## 1. Introduction

In 2007 year, G.F.Torres del Castillo and C.I.Perez Sanchez already discovered Maxwell equations in uniformly accelerated frame in vacuum (see Ref [13]). In 2011 year, J.W.Maluf and F.F.Faria discovered electro-magnetic field transformation in Rindler space-time on ArXiv preprint (see also Ref[11]). But they did mistake they used Maxwell equations of gravity field. Maxwell equations of uniformly accelerated frame have to treat in flat Minkowski space-time not in gravity space-time.

Our theory's aim is that we find electro-magnetic field equation in Rindler space-time in vacuum also not in vacuum in the general relativity theory. In Section 2, we prepare for finding electro-magnetic field equation in Rindler space-time. In this section, we discover Lorentz gauge transformation and Lorentz fixing condition, transformation of the electro-magnetic 4-vector potential in Rindler space-time. In Section 3, we define the electro-magnetic field in Rindler space-time and we find the transformation of the electro-magnetic field. In Section 4, we obtain the electro-magnetic field equation in Rindler space-time and we apply the gauge theory to Maxwell equations (discovered by us) in Rindler space-time for viewing invariant about the gauge transformation .

We think seriously electro-magnetic wave function (radiation) in Rindler space-time but we know it doesn't satisfy electro-magnetic wave equation in mathematically. (see APPENDIX A) Hence, In 2007 year and in 2011 year, all researchers mistake calculation of electro-magnetic wave function.

We understand electro-magnetic wave function can exist in inertial frame by J.C.Maxwell or A. Einstein.

## 2. Transformation of the electro-magnetic 4-vector potential, Lorentz gauge transformation and Lorentz gauge fixing condition

The Rindler coordinate is

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

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

In this time, the tetrad  $e^a{}_\mu$  is (see Ref [12])

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

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

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

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

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

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

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

$$e^{\alpha}_1(\xi^0) = \frac{\partial X^{\alpha}}{\partial \xi^1} = \left( \sinh\left(\frac{a_0 \xi^0}{c}\right), \cosh\left(\frac{a_0 \xi^0}{c}\right), 0, 0 \right) \quad (5)$$

Therefore,

$$\begin{aligned} c dt &= c \cosh\left(\frac{a_0 \xi^0}{c}\right) d\xi^0 \left(1 + \frac{a_0}{c^2} \xi^1\right) + \sinh\left(\frac{a_0 \xi^0}{c}\right) d\xi^1 \\ dx &= c \sinh\left(\frac{a_0 \xi^0}{c}\right) d\xi^0 \left(1 + \frac{a_0}{c^2} \xi^1\right) + \cosh\left(\frac{a_0 \xi^0}{c}\right) d\xi^1, \quad dy = d\xi^2, \quad dz = d\xi^3 \end{aligned} \quad (6)$$

The vector transformation is

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

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

$$\begin{aligned} A^{\alpha} &= \frac{\partial X^{\alpha}}{\partial X'^{\mu}} A'^{\mu} = \frac{\partial X^{\alpha}}{\partial \xi^{\mu}} A_{\xi}^{\mu} = e^{\alpha}_{\mu} A_{\xi}^{\mu}, \quad e^{\alpha}_{\mu} = \frac{\partial X^{\alpha}}{\partial \xi^{\mu}} \\ dx^{\alpha} &= \frac{\partial X^{\alpha}}{\partial X'^{\mu}} dx'^{\mu} = \frac{\partial X^{\alpha}}{\partial \xi^{\mu}} d\xi^{\mu} = e^{\alpha}_{\mu} d\xi^{\mu}, \quad e^{\alpha}_{\mu} = \frac{\partial X^{\alpha}}{\partial \xi^{\mu}} \end{aligned} \quad (8)$$

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

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

$$\text{4-vector } (c\rho, \vec{j}) = \rho_0 \frac{dx^{\alpha}}{d\tau} \quad (9)$$

Lorentz gauge transformation is in Rindler spacetime,

$$A^{\mu} \rightarrow A^{\mu} + \partial^{\mu} \Lambda = A^{\mu} + g^{\mu\nu} \partial_{\nu} \Lambda \quad , \quad \Lambda \text{ is a scalar function.}$$

$$g^{00} = -\frac{1}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)^2}, g^{11} = g^{22} = g^{33} = 1$$

Hence,

$$\phi_\xi \rightarrow \phi_\xi - \frac{1}{c} \frac{\partial \Lambda}{\partial \xi^0} \frac{1}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)^2}, \bar{A}_\xi \rightarrow \bar{A}_\xi + \bar{\nabla}_\xi \Lambda, \Lambda \text{ is a scalar function.} \quad (10)$$

Lorentz gauge fixing condition is in Rindler spacetime,

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

$$\Gamma^\mu{}_{\mu\rho} = \Gamma^0{}_{01} = \frac{1}{2} g^{00} \left( \frac{\partial g_{00}}{\partial \xi^1} \right) = \frac{a_0}{c^2} \frac{1}{\left(1 + \frac{a_0}{c^2} \xi^1\right)}$$

$$g^{00} = -\frac{1}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)^2}, g^{11} = g^{22} = g^{33} = 1 \quad (11)$$

$$0 = \frac{\partial \phi}{\partial t} + \bar{\nabla} \cdot \bar{A} = \frac{\partial \phi_\xi}{\partial \xi^0} + \bar{\nabla}_\xi \cdot \bar{A}_\xi + \frac{A_{\xi^1} a_0}{c^2} \frac{1}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)}$$

$$A^\mu \rightarrow A^\mu + \partial^\mu \Lambda = A^\mu + g^{\mu\nu} \partial_\nu \Lambda$$

$$\begin{aligned} A^\mu{}_{;\mu} &= \frac{\partial A^\mu}{\partial \xi^\mu} + \Gamma^\mu{}_{\mu\rho} A^\rho \rightarrow \partial_\mu (A^\mu + g^{\mu\nu} \partial_\nu \Lambda) + \Gamma^0{}_{01} \left( A^1 + \frac{\partial \Lambda}{\partial \xi^1} \right) \\ &= \partial_\mu A^\mu + (g^{\mu\nu} \partial_\mu \partial_\nu) \Lambda + \Gamma^0{}_{01} \left( A^1 + \frac{\partial \Lambda}{\partial \xi^1} \right) \end{aligned}$$

$$0 = \frac{\partial \phi_\xi}{\partial \xi^0} + \bar{\nabla}_\xi \cdot \bar{A}_\xi + \frac{A_{\xi^1} a_0}{c^2} \frac{1}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)}$$

$$\rightarrow \frac{1}{c} \frac{\partial \phi_\xi}{\partial \xi^0} + \bar{\nabla}_\xi \cdot \bar{A}_\xi - \left[ \frac{1}{c^2} \frac{1}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)^2} \left( \frac{\partial}{\partial \xi^0} \right)^2 - \nabla_\xi^2 \right] \Lambda$$

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

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

(12)

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

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

$$\begin{aligned} \phi &= \cosh\left(\frac{a_0 \xi^0}{c}\right) \left(1 + \frac{a_0}{c^2} \xi^1\right) \phi_{\xi} + \sinh\left(\frac{a_0 \xi^0}{c}\right) A_{\xi^1} \\ A_x &= \sinh\left(\frac{a_0 \xi^0}{c}\right) \left(1 + \frac{a_0}{c^2} \xi^1\right) \phi_{\xi} + \cosh\left(\frac{a_0 \xi^0}{c}\right) A_{\xi^1} \\ A_y &= A_{\xi^2}, A_z = A_{\xi^3} \end{aligned}$$

(13)

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

(see Ref [12])

$$e^a_{\mu} e_b^{\mu} = \delta^a_b, \quad e^a_{\mu} e_a^{\nu} = \delta_{\mu}^{\nu}$$

$$e^a_{\mu} e_b^{\nu} \eta_{ab} = g_{\mu\nu} \rightarrow A^T \eta A = g$$

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

$$e^a_{\mu} = \eta^{ab} g_{\mu\nu} e_b^{\nu} \rightarrow \eta^{-1} (A^T)^{-1} A^T \eta A = A = \eta^{-1} (A^T)^{-1} g \quad (14)$$

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

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

(15)

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

$$= \begin{pmatrix} \frac{\cosh(\frac{a_0\xi^0}{c})}{(1 + \frac{a_0\xi^1}{c^2})} & -\frac{\sinh(\frac{a_0\xi^0}{c})}{(1 + \frac{a_0\xi^1}{c^2})} & 0 & 0 \\ -\sinh(\frac{a_0\xi^0}{c}) & \cosh(\frac{a_0\xi^0}{c}) & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

(16)

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

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

$$= \begin{pmatrix} \cosh(\frac{a_0 \xi^0}{c}) & -\sinh(\frac{a_0 \xi^0}{c}) & 0 & 0 \\ -\sinh(\frac{a_0 \xi^0}{c}) & \cosh(\frac{a_0 \xi^0}{c}) & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} \frac{1}{c} \frac{\partial}{\partial \hat{\xi}^0} \\ \frac{\partial}{\partial \hat{\xi}^1} \\ \frac{\partial}{\partial \hat{\xi}^2} \\ \frac{\partial}{\partial \hat{\xi}^3} \end{pmatrix} \quad (17)$$

$$\begin{aligned} \frac{1}{c} \frac{\partial}{\partial t} &= \frac{\partial \xi^0}{\partial t} \frac{1}{c} \frac{\partial}{\partial \xi^0} + \frac{\partial \xi^1}{\partial t} \frac{\partial}{\partial \xi^1} \\ &= \frac{\cosh(\frac{a_0 \xi^0}{c})}{(1 + \frac{a_0 \xi^1}{c^2})} \frac{\partial}{\partial \xi^0} - \sinh(\frac{a_0 \xi^0}{c}) \frac{\partial}{\partial \xi^1} \\ \frac{\partial}{\partial x} &= \frac{\partial \xi^0}{\partial x} \frac{1}{c} \frac{\partial}{\partial \xi^0} + \frac{\partial \xi^1}{\partial x} \frac{\partial}{\partial \xi^1} \end{aligned}$$

$$\begin{aligned}
&= -\frac{\sinh(\frac{a_0 \xi^0}{c})}{(1 + \frac{a_0 \xi^1}{c^2})} \frac{\partial}{\partial \xi^0} + \cosh(\frac{a_0 \xi^0}{c}) \frac{\partial}{\partial \xi^1} \\
\frac{\partial}{\partial y} &= \frac{\partial}{\partial \xi^2}, \quad \frac{\partial}{\partial z} = \frac{\partial}{\partial \xi^3} \\
\frac{1}{c^2} \frac{\partial^2}{\partial t^2} - \nabla^2 &= \frac{1}{c^2 (1 + \frac{a_0 \xi^1}{c^2})^2} \left( \frac{\partial}{\partial \xi^0} \right)^2 - \nabla_{\xi}^2 \\
\vec{\nabla} &= \left( \frac{\partial}{\partial x}, \frac{\partial}{\partial y}, \frac{\partial}{\partial z} \right), \quad \vec{\nabla}_{\xi} = \left( \frac{\partial}{\partial \xi^1}, \frac{\partial}{\partial \xi^2}, \frac{\partial}{\partial \xi^3} \right)
\end{aligned} \tag{18}$$

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

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

$$\vec{E} = -\vec{\nabla} \phi - \frac{\partial \vec{A}}{\partial t}, \quad \vec{B} = \vec{\nabla} \times \vec{A} \tag{19}$$

We have to calculate for define electro-magnetic field in Rindler space-time.

$$\begin{aligned}
E_x &= -\frac{\partial \phi}{\partial x} - \frac{\partial A_x}{\partial t} \\
&= -\left[ -\frac{\sinh(\frac{a_0 \xi^0}{c})}{(1 + \frac{a_0 \xi^1}{c^2})} \frac{\partial}{\partial \xi^0} + \cosh(\frac{a_0 \xi^0}{c}) \frac{\partial}{\partial \xi^1} \right] \cdot \left[ \cosh(\frac{a_0 \xi^0}{c}) \left(1 + \frac{a_0 \xi^1}{c^2}\right) \phi_{\xi} + \sinh(\frac{a_0 \xi^0}{c}) A_{\xi^1} \right] \\
&\quad - \left[ \frac{\cosh(\frac{a_0 \xi^0}{c})}{(1 + \frac{a_0 \xi^1}{c^2})} \frac{\partial}{\partial \xi^0} - \sinh(\frac{a_0 \xi^0}{c}) \frac{\partial}{\partial \xi^1} \right] \cdot \left[ \sinh(\frac{a_0 \xi^0}{c}) \left(1 + \frac{a_0 \xi^1}{c^2}\right) \phi_{\xi} + \cosh(\frac{a_0 \xi^0}{c}) A_{\xi^1} \right] \\
&= -\frac{1}{(1 + \frac{a_0 \xi^1}{c^2})} \frac{\partial A_{\xi^1}}{\partial \xi^0} - \left(1 + \frac{a_0 \xi^1}{c^2}\right) \frac{\partial \phi_{\xi}}{\partial \xi^1} - 2\phi_{\xi} \frac{a_0}{c^2} \\
&= -\frac{1}{(1 + \frac{a_0 \xi^1}{c^2})} \frac{\partial}{\partial \xi^1} \left[ \left(1 + \frac{a_0 \xi^1}{c^2}\right)^2 \phi_{\xi} \right] - \frac{1}{(1 + \frac{a_0 \xi^1}{c^2})} \frac{\partial A_{\xi^1}}{\partial \xi^0} \tag{20}
\end{aligned}$$

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



$$\begin{aligned}
& - \left[ \frac{\cosh\left(\frac{a_0 \xi^0}{c}\right)}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)} \frac{\partial}{\partial \xi^0} - \sinh\left(\frac{a_0 \xi^0}{c}\right) \frac{\partial}{\partial \xi^1} \right] A_{\xi^2} \\
= & - \left(1 + \frac{a_0 \xi^1}{c^2}\right) \cosh\left(\frac{a_0 \xi^0}{c}\right) \frac{\partial \phi_\xi}{\partial \xi^2} - \frac{1}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)} \cosh\left(\frac{a_0 \xi^0}{c}\right) \frac{\partial A_{\xi^2}}{\partial \xi^0} \\
& + \sinh\left(\frac{a_0}{c} \xi^0\right) \left[ \frac{\partial A_{\xi^2}}{\partial \xi^1} - \frac{\partial A_{\xi^1}}{\partial \xi^2} \right] \\
= & \cosh\left(\frac{a_0}{c} \xi^0\right) \left[ - \frac{1}{\left(1 + \frac{a_0}{c^2} \xi^1\right)} \frac{\partial}{\partial \xi^2} \left[ \phi_\xi \left(1 + \frac{a_0 \xi^1}{c^2}\right)^2 \right] - \frac{1}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)} \frac{\partial A_{\xi^2}}{\partial \xi^0} \right] \\
& + \sinh\left(\frac{a_0}{c} \xi^0\right) \left[ \frac{\partial A_{\xi^2}}{\partial \xi^1} - \frac{\partial A_{\xi^1}}{\partial \xi^2} \right] \tag{21}
\end{aligned}$$

$$\begin{aligned}
E_z = -\frac{\partial \phi}{\partial z} - \frac{\partial A_z}{\partial t} = & - \frac{\partial}{\partial \xi^3} \left[ \cosh\left(\frac{a_0 \xi^0}{c}\right) \left(1 + \frac{a_0}{c^2} \xi^1\right) \phi_\xi + \sinh\left(\frac{a_0 \xi^0}{c}\right) A_{\xi^1} \right] \\
& - \left[ \frac{\cosh\left(\frac{a_0 \xi^0}{c}\right)}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)} \frac{\partial}{\partial \xi^0} - \sinh\left(\frac{a_0 \xi^0}{c}\right) \frac{\partial}{\partial \xi^1} \right] A_{\xi^3} \\
= & - \left(1 + \frac{a_0 \xi^1}{c^2}\right) \cosh\left(\frac{a_0 \xi^0}{c}\right) \frac{\partial \phi_\xi}{\partial \xi^3} - \frac{1}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)} \cosh\left(\frac{a_0 \xi^0}{c}\right) \frac{\partial A_{\xi^3}}{\partial \xi^0} \\
& + \sinh\left(\frac{a_0}{c} \xi^0\right) \left[ \frac{\partial A_{\xi^3}}{\partial \xi^1} - \frac{\partial A_{\xi^1}}{\partial \xi^3} \right] \\
= & \cosh\left(\frac{a_0}{c} \xi^0\right) \left[ - \frac{1}{\left(1 + \frac{a_0}{c^2} \xi^1\right)} \frac{\partial}{\partial \xi^3} \left[ \phi_\xi \left(1 + \frac{a_0 \xi^1}{c^2}\right)^2 \right] - \frac{1}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)} \frac{\partial A_{\xi^3}}{\partial \xi^0} \right] \\
& + \sinh\left(\frac{a_0}{c} \xi^0\right) \left[ \frac{\partial A_{\xi^3}}{\partial \xi^1} - \frac{\partial A_{\xi^1}}{\partial \xi^3} \right]
\end{aligned} \tag{22}$$

$$B_x = \frac{\partial A_z}{\partial y} - \frac{\partial A_y}{\partial z} = \frac{\partial A_{\xi^3}}{\partial \xi^2} - \frac{\partial A_{\xi^2}}{\partial \xi^3} \quad (23)$$

$$\begin{aligned} B_y &= \frac{\partial A_x}{\partial z} - \frac{\partial A_z}{\partial x} = \frac{\partial A_x}{\partial \xi^3} - \frac{\partial A_{\xi^3}}{\partial x} \\ &= \frac{\partial}{\partial \xi^3} \left[ \sinh\left(\frac{a_0 \xi^0}{c}\right) \left(1 + \frac{a_0}{c^2} \xi^1\right) \phi_\xi + \cosh\left(\frac{a_0 \xi^0}{c}\right) A_{\xi^1} \right] \\ &\quad - \left[ -\frac{\sinh\left(\frac{a_0 \xi^0}{c}\right)}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)} \frac{\partial}{\partial \xi^0} + \cosh\left(\frac{a_0 \xi^0}{c}\right) \frac{\partial}{\partial \xi^1} \right] A_{\xi^3} \\ &= \cosh\left(\frac{a_0}{c} \xi^0\right) \left[ \frac{\partial A_{\xi^1}}{\partial \xi^3} - \frac{\partial A_{\xi^3}}{\partial \xi^1} \right] \\ &\quad - \sinh\left(\frac{a_0}{c} \xi^0\right) \left[ -\frac{1}{\left(1 + \frac{a_0}{c^2} \xi^1\right)} \frac{\partial}{\partial \xi^3} \left[ \phi_\xi \left(1 + \frac{a_0 \xi^1}{c^2}\right)^2 \right] - \frac{1}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)} \frac{\partial A_{\xi^3}}{\partial \xi^0} \right] \end{aligned} \quad (24)$$

$$\begin{aligned} B_z &= \frac{\partial A_y}{\partial x} - \frac{\partial A_x}{\partial y} = \frac{\partial A_{\xi^2}}{\partial x} - \frac{\partial A_x}{\partial \xi^2} \\ &= \left[ -\frac{\sinh\left(\frac{a_0 \xi^0}{c}\right)}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)} \frac{\partial}{\partial \xi^0} + \cosh\left(\frac{a_0 \xi^0}{c}\right) \frac{\partial}{\partial \xi^1} \right] A_{\xi^2} \\ &\quad - \frac{\partial}{\partial \xi^2} \left[ \sinh\left(\frac{a_0 \xi^0}{c}\right) \left(1 + \frac{a_0}{c^2} \xi^1\right) \phi_\xi + \cosh\left(\frac{a_0 \xi^0}{c}\right) A_{\xi^1} \right] \\ &= \cosh\left(\frac{a_0}{c} \xi^0\right) \left[ \frac{\partial A_{\xi^2}}{\partial \xi^1} - \frac{\partial A_{\xi^1}}{\partial \xi^2} \right] \\ &\quad + \sinh\left(\frac{a_0}{c} \xi^0\right) \left[ -\frac{1}{\left(1 + \frac{a_0}{c^2} \xi^1\right)} \frac{\partial}{\partial \xi^2} \left[ \phi_\xi \left(1 + \frac{a_0 \xi^1}{c^2}\right)^2 \right] - \frac{1}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)} \frac{\partial A_{\xi^2}}{\partial \xi^0} \right] \end{aligned} \quad (25)$$

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

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

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

In this time,  $\vec{\nabla}_\xi = \left( \frac{\partial}{\partial \xi^1}, \frac{\partial}{\partial \xi^2}, \frac{\partial}{\partial \xi^3} \right), \vec{A}_\xi = (A_{\xi^1}, A_{\xi^2}, A_{\xi^3})$  (26)

Lorentz gauge transformation is in Rindler spacetime,

$$\phi_\xi \rightarrow \phi_\xi - \frac{1}{c} \frac{\partial \Lambda}{\partial \xi^0} \frac{1}{(1+\frac{a_0\xi^1}{c^2})}, \vec{A}_\xi \rightarrow \vec{A}_\xi + \vec{\nabla}_\xi \Lambda, \Lambda \text{ is a scalar function.} \quad (27)$$

$$\begin{aligned} \vec{E}_\xi &= -\frac{1}{(1+\frac{a_0\xi^1}{c^2})} \vec{\nabla}_\xi \left\{ \phi_\xi \left(1 + \frac{a_0\xi^1}{c^2}\right)^2 \right\} + \frac{1}{(1+\frac{a_0\xi^1}{c^2})} \vec{\nabla}_\xi \frac{\partial \Lambda}{\partial \xi^0} \\ &\quad - \frac{1}{(1+\frac{a_0\xi^1}{c^2})} \frac{\partial \vec{A}_\xi}{\partial \xi^0} - \frac{1}{(1+\frac{a_0\xi^1}{c^2})} \frac{\partial}{\partial \xi^0} \vec{\nabla}_\xi \Lambda \\ &= -\frac{1}{(1+\frac{a_0\xi^1}{c^2})} \vec{\nabla}_\xi \left\{ \phi_\xi \left(1 + \frac{a_0\xi^1}{c^2}\right)^2 \right\} - \frac{1}{(1+\frac{a_0\xi^1}{c^2})} \frac{\partial \vec{A}_\xi}{\partial \xi^0} \\ \vec{B}_\xi &= \vec{\nabla}_\xi \times \vec{A}_\xi + \vec{\nabla}_\xi \times \vec{\nabla}_\xi \Lambda = \vec{\nabla}_\xi \times \vec{A}_\xi \end{aligned} \quad (28)$$

Lorentz gauge fixing condition is in Rindler spacetime,

$$\begin{aligned} 0 &= \frac{\partial \phi_\xi}{\partial \xi^0} + \vec{\nabla}_\xi \cdot \vec{A}_\xi + \frac{A_{\xi^1} a_0}{c^2} \frac{1}{(1+\frac{a_0\xi^1}{c^2})} \\ &\rightarrow \frac{1}{c} \frac{\partial \phi_\xi}{\partial \xi^0} + \vec{\nabla}_\xi \cdot \vec{A}_\xi - \left[ \frac{1}{c^2} \frac{1}{(1+\frac{a_0\xi^1}{c^2})^2} \left( \frac{\partial}{\partial \xi^0} \right)^2 - \nabla_\xi^2 \right] \Lambda \end{aligned}$$

$$\begin{aligned}
& + \frac{A_{\xi^1} a_0}{c^2} \frac{1}{(1 + \frac{a_0}{c^2} \xi^1)} + \frac{\partial \Lambda}{\partial \xi^1} \frac{a_0}{c^2} \frac{1}{(1 + \frac{a_0}{c^2} \xi^1)} = 0 \\
& \left[ \frac{1}{c^2} \frac{1}{(1 + \frac{a_0}{c^2} \xi^1)^2} \left( \frac{\partial}{\partial \xi^0} \right)^2 - \nabla_{\xi}^2 \right] \Lambda - \frac{\partial \Lambda}{\partial \xi^1} \frac{a_0}{c^2} \frac{1}{(1 + \frac{a_0}{c^2} \xi^1)} = 0 \\
& \phi - \frac{1}{c} \frac{\partial \Lambda}{\partial t} = \cosh\left(\frac{a_0 \xi^0}{c}\right) \left(1 + \frac{a_0}{c^2} \xi^1\right) \left\{ \phi_{\xi} - \frac{1}{c} \frac{\partial \Lambda}{\partial \xi^0} \frac{1}{(1 + \frac{a_0}{c^2} \xi^1)^2} \right\} \\
& + \sinh\left(\frac{a_0 \xi^0}{c}\right) \left( A_{\xi^1} + \frac{\partial \Lambda}{\partial \xi^1} \right) \\
& A_x + \frac{\partial \Lambda}{\partial x} = \sinh\left(\frac{a_0 \xi^0}{c}\right) \left(1 + \frac{a_0}{c^2} \xi^1\right) \left\{ \phi_{\xi} - \frac{1}{c} \frac{\partial \Lambda}{\partial \xi^0} \frac{1}{(1 + \frac{a_0}{c^2} \xi^1)^2} \right\} \\
& + \cosh\left(\frac{a_0 \xi^0}{c}\right) \left( A_{\xi^1} + \frac{\partial \Lambda}{\partial \xi^1} \right) \\
& A_y + \frac{\partial \Lambda}{\partial y} = A_{\xi^2} + \frac{\partial \Lambda}{\partial \xi^2}, \quad A_z + \frac{\partial \Lambda}{\partial z} = A_{\xi^3} + \frac{\partial \Lambda}{\partial \xi^3} \tag{29}
\end{aligned}$$

We obtain the transformation of the electro-magnetic field.

$$\begin{aligned}
E_x &= - \frac{1}{(1 + \frac{a_0}{c^2} \xi^1)} \frac{\partial}{\partial \xi^1} \left\{ \phi_{\xi} \left(1 + \frac{a_0}{c^2} \xi^1\right)^2 \right\} - \frac{1}{(1 + \frac{a_0}{c^2} \xi^1)} \frac{\partial A_{\xi^1}}{\partial \xi^0} = E_{\xi^1}, \\
E_y &= E_{\xi^2} \cosh\left(\frac{a_0 \xi^0}{c}\right) + B_{\xi^3} \sinh\left(\frac{a_0 \xi^0}{c}\right), \\
E_z &= E_{\xi^3} \cosh\left(\frac{a_0 \xi^0}{c}\right) - B_{\xi^2} \sinh\left(\frac{a_0 \xi^0}{c}\right) \\
B_x &= B_{\xi^1}, \\
B_y &= B_{\xi^2} \cosh\left(\frac{a_0 \xi^0}{c}\right) - E_{\xi^3} \sinh\left(\frac{a_0 \xi^0}{c}\right) \\
B_z &= B_{\xi^3} \cosh\left(\frac{a_0 \xi^0}{c}\right) + E_{\xi^2} \sinh\left(\frac{a_0 \xi^0}{c}\right) \tag{30}
\end{aligned}$$

Hence,

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

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

$$H = \begin{pmatrix} \cosh\left(\frac{a_0 \xi^0}{c}\right) & 0 & 0 & \sinh\left(\frac{a_0 \xi^0}{c}\right) \\ 0 & \cosh\left(\frac{a_0 \xi^0}{c}\right) & -\sinh\left(\frac{a_0 \xi^0}{c}\right) & 0 \\ 0 & -\sinh\left(\frac{a_0 \xi^0}{c}\right) & \cosh\left(\frac{a_0 \xi^0}{c}\right) & 0 \\ \sinh\left(\frac{a_0 \xi^0}{c}\right) & 0 & 0 & \cosh\left(\frac{a_0 \xi^0}{c}\right) \end{pmatrix} \quad (31)$$

The inverse-transformation of the electro-magnetic field is

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

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

$$H^{-1} = \begin{pmatrix} \cosh\left(\frac{a_0 \xi^0}{c}\right) & 0 & 0 & -\sinh\left(\frac{a_0 \xi^0}{c}\right) \\ 0 & \cosh\left(\frac{a_0 \xi^0}{c}\right) & \sinh\left(\frac{a_0 \xi^0}{c}\right) & 0 \\ 0 & \sinh\left(\frac{a_0 \xi^0}{c}\right) & \cosh\left(\frac{a_0 \xi^0}{c}\right) & 0 \\ -\sinh\left(\frac{a_0 \xi^0}{c}\right) & 0 & 0 & \cosh\left(\frac{a_0 \xi^0}{c}\right) \end{pmatrix} \quad (32)$$

(see also Ref [11])

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

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

$$\begin{aligned}
B_{\xi^2} &= B_y \cosh\left(\frac{a_0 \xi^0}{c}\right) + E_z \sinh\left(\frac{a_0 \xi^0}{c}\right) \\
E_{\xi^3} &= E_z \cosh\left(\frac{a_0 \xi^0}{c}\right) + B_y \sinh\left(\frac{a_0 \xi^0}{c}\right) \\
B_{\xi^3} &= B_z \cosh\left(\frac{a_0 \xi^0}{c}\right) - E_y \sinh\left(\frac{a_0 \xi^0}{c}\right)
\end{aligned} \tag{33}$$

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

Maxwell equation is

$$\vec{\nabla} \cdot \vec{E} = 4\pi\rho \tag{34-i}$$

$$\vec{\nabla} \times \vec{B} = \frac{\partial \vec{E}}{c \partial t} + 4\pi \vec{j} \tag{34-ii}$$

$$\vec{\nabla} \cdot \vec{B} = 0 \tag{34-iii}$$

$$\vec{\nabla} \times \vec{E} = -\frac{\partial \vec{B}}{c \partial t} \tag{34-iv}$$

We continue boring calculation for discovering Maxwell equations in Rindler space-time..

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

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

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

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

$$\begin{aligned}
4\pi\rho &= \frac{\partial E_x}{\partial x} + \frac{\partial E_y}{\partial y} + \frac{\partial E_z}{\partial z} \\
&= \left[ -\frac{\sinh\left(\frac{a_0 \xi^0}{c}\right)}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)} \frac{\partial}{c \partial \xi^0} + \cosh\left(\frac{a_0 \xi^0}{c}\right) \frac{\partial}{\partial \xi^1} \right] E_{\xi^1} \\
&+ \frac{\partial}{\partial \xi^2} \left[ E_{\xi^2} \cosh\left(\frac{a_0 \xi^0}{c}\right) + B_{\xi^3} \sinh\left(\frac{a_0 \xi^0}{c}\right) \right] \\
&+ \frac{\partial}{\partial \xi^3} \left[ E_{\xi^3} \cosh\left(\frac{a_0 \xi^0}{c}\right) - B_{\xi^2} \sinh\left(\frac{a_0 \xi^0}{c}\right) \right]
\end{aligned}$$

$$= \cosh\left(\frac{a_0}{c} \xi^0\right) (\vec{\nabla}_\xi \cdot \vec{E}_\xi) + \sinh\left(\frac{a_0}{c} \xi^0\right) \left[ \frac{\partial B_{\xi^3}}{\partial \xi^2} - \frac{\partial B_{\xi^2}}{\partial \xi^3} - \frac{1}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)} \frac{\partial E_{\xi^1}}{\partial \xi^0} \right] \quad (35)$$

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

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

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

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

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

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

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

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

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

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

Hence,

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

$$= \sinh\left(\frac{a_0 \xi^0}{c}\right) (\vec{\nabla}_\xi \cdot \vec{E}_\xi) + \cosh\left(\frac{a_0 \xi^0}{c}\right) \left[ \frac{\partial B_{\xi^3}}{\partial \xi^2} - \frac{\partial B_{\xi^2}}{\partial \xi^3} - \frac{1}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)} \frac{\partial E_{\xi^1}}{\partial \xi^0} \right] \quad (36)$$

$$\begin{aligned}
& \text{Y-component) } \frac{\partial B_x}{\partial z} - \frac{\partial B_z}{\partial x} \\
&= \frac{\partial B_{\xi^1}}{\partial \xi^3} \\
&= \left[ -\frac{\sinh(\frac{a_0 \xi^0}{c})}{(1 + \frac{a_0 \xi^1}{c^2})} \frac{\partial}{\partial \xi^0} + \cosh(\frac{a_0 \xi^0}{c}) \frac{\partial}{\partial \xi^1} \right] \cdot [B_{\xi^3} \cosh(\frac{a_0 \xi^0}{c}) + E_{\xi^2} \sinh(\frac{a_0 \xi^0}{c})] \\
&= \frac{\partial E_y}{\partial t} + \frac{4\pi}{c} j_y \\
&= \left[ \frac{\cosh(\frac{a_0 \xi^0}{c})}{(1 + \frac{a_0 \xi^1}{c^2})} \frac{\partial}{\partial \xi^0} - \sinh(\frac{a_0 \xi^0}{c}) \frac{\partial}{\partial \xi^1} \right] \cdot [E_{\xi^2} \cosh(\frac{a_0 \xi^0}{c}) + B_{\xi^3} \sinh(\frac{a_0 \xi^0}{c})] \\
&\quad + \frac{4\pi}{c} j_y \\
&\frac{4\pi}{c} j_y = \frac{\partial B_{\xi^1}}{\partial \xi^3} - \frac{\partial B_{\xi^3}}{\partial \xi^1} - \frac{1}{(1 + \frac{a_0}{c^2} \xi^1)} \frac{a_0}{c^2} B_{\xi^3} - \frac{1}{(1 + \frac{a_0}{c^2} \xi^1)} \frac{\partial E_{\xi^2}}{\partial \xi^0} \\
&= \frac{1}{(1 + \frac{a_0}{c^2} \xi^1)} \frac{\partial}{\partial \xi^3} \{B_{\xi^1} (1 + \frac{a_0}{c^2} \xi^1)\} - \frac{1}{(1 + \frac{a_0}{c^2} \xi^1)} \frac{\partial}{\partial \xi^1} \{B_{\xi^3} (1 + \frac{a_0}{c^2} \xi^1)\} - \frac{1}{(1 + \frac{a_0}{c^2} \xi^1)} \frac{\partial E_{\xi^2}}{\partial \xi^0}
\end{aligned}$$

(37)

$$\begin{aligned}
& \text{Z-component) } \frac{\partial B_y}{\partial x} - \frac{\partial B_x}{\partial y} \\
&= \left[ -\frac{\sinh(\frac{a_0 \xi^0}{c})}{(1 + \frac{a_0 \xi^1}{c^2})} \frac{\partial}{\partial \xi^0} + \cosh(\frac{a_0 \xi^0}{c}) \frac{\partial}{\partial \xi^1} \right] \cdot [B_{\xi^2} \cosh(\frac{a_0 \xi^0}{c}) - E_{\xi^3} \sinh(\frac{a_0 \xi^0}{c})] \\
&\quad - \frac{\partial B_{\xi^1}}{\partial \xi^2}
\end{aligned}$$



$$\begin{aligned}
&= \frac{\partial E_z}{\partial t} + \frac{4\pi}{c} j_z \\
&= \left[ \frac{\cosh\left(\frac{a_0 \xi^0}{c}\right)}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)} \frac{\partial}{\partial \xi^0} - \sinh\left(\frac{a_0 \xi^0}{c}\right) \frac{\partial}{\partial \xi^1} \right] \cdot [E_{\xi^3} \cosh\left(\frac{a_0 \xi^0}{c}\right) - B_{\xi^2} \sinh\left(\frac{a_0 \xi^0}{c}\right)] \\
&\quad + \frac{4\pi}{c} j_z \\
\frac{4\pi}{c} j_z &= \frac{\partial B_{\xi^2}}{\partial \xi^1} - \frac{\partial B_{\xi^1}}{\partial \xi^2} + \frac{1}{\left(1 + \frac{a_0}{c^2} \xi^1\right)} \frac{a_0}{c^2} B_{\xi^2} - \frac{1}{\left(1 + \frac{a_0}{c^2} \xi^1\right)} \frac{\partial E_{\xi^3}}{\partial \xi^0} \\
&= \frac{1}{\left(1 + \frac{a_0}{c^2} \xi^1\right)} \frac{\partial}{\partial \xi^1} \{B_{\xi^2} (1 + \frac{a_0}{c^2} \xi^1)\} - \frac{1}{\left(1 + \frac{a_0}{c^2} \xi^1\right)} \frac{\partial}{\partial \xi^2} \{B_{\xi^1} (1 + \frac{a_0}{c^2} \xi^1)\} - \frac{1}{\left(1 + \frac{a_0}{c^2} \xi^1\right)} \frac{\partial E_{\xi^3}}{\partial \xi^0}
\end{aligned}$$

(38)

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

$$\begin{aligned}
\vec{\nabla} \cdot \vec{B} &= \frac{\partial B_x}{\partial x} + \frac{\partial B_y}{\partial y} + \frac{\partial B_z}{\partial z} \\
&= \left[ -\frac{\sinh\left(\frac{a_0 \xi^0}{c}\right)}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)} \frac{\partial}{\partial \xi^0} + \cosh\left(\frac{a_0 \xi^0}{c}\right) \frac{\partial}{\partial \xi^1} \right] B_{\xi^1} \\
&\quad + \frac{\partial}{\partial \xi^2} [B_{\xi^2} \cosh\left(\frac{a_0 \xi^0}{c}\right) - E_{\xi^3} \sinh\left(\frac{a_0 \xi^0}{c}\right)] \\
&\quad + \frac{\partial}{\partial \xi^3} [B_{\xi^3} \cosh\left(\frac{a_0 \xi^0}{c}\right) + E_{\xi^2} \sinh\left(\frac{a_0 \xi^0}{c}\right)] \\
&= \cosh\left(\frac{a_0 \xi^0}{c}\right) (\vec{\nabla}_{\xi} \cdot \vec{B}_{\xi}) + \sinh\left(\frac{a_0 \xi^0}{c}\right) \left[ -\left( \frac{\partial E_{\xi^2}}{\partial \xi^3} + \frac{\partial E_{\xi^3}}{\partial \xi^2} \right) - \frac{1}{\left(1 + \frac{a_0}{c^2} \xi^1\right)} \frac{\partial B_{\xi^1}}{\partial \xi^0} \right] = 0
\end{aligned}$$

(39)

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

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

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

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

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

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

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

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

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

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

Hence,

$$- \sinh\left(\frac{a_0 \xi^0}{c}\right) (\vec{\nabla}_\xi \cdot \vec{B}_\xi) + \cosh\left(\frac{a_0 \xi^0}{c}\right) \left[ \left( \frac{\partial E_{\xi^3}}{\partial \xi^2} - \frac{\partial E_{\xi^2}}{\partial \xi^3} \right) + \frac{1}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)} \frac{\partial B_{\xi^1}}{\partial \xi^0} \right] = 0 \quad (40)$$

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

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

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

$$\begin{aligned}
&= -\frac{\partial B_y}{\partial t} \\
&= -\left[ \frac{\cosh\left(\frac{a_0 \xi^0}{c}\right)}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)} \frac{\partial}{\partial \xi^0} - \sinh\left(\frac{a_0 \xi^0}{c}\right) \frac{\partial}{\partial \xi^1} \right] \cdot [B_{\xi^2} \cosh\left(\frac{a_0 \xi^0}{c}\right) - E_{\xi^3} \sinh\left(\frac{a_0 \xi^0}{c}\right)] \\
&\quad \frac{\partial E_{\xi^1}}{\partial \xi^3} - \frac{\partial E_{\xi^3}}{\partial \xi^1} - \frac{1}{\left(1 + \frac{a_0}{c^2} \xi^1\right)} \frac{a_0}{c^2} E_{\xi^3} + \frac{1}{\left(1 + \frac{a_0}{c^2} \xi^1\right)} \frac{\partial B_{\xi^2}}{\partial \xi^0} \\
&= \frac{1}{\left(1 + \frac{a_0}{c^2} \xi^1\right)} \frac{\partial}{\partial \xi^3} \left\{ E_{\xi^1} \left(1 + \frac{a_0}{c^2} \xi^1\right) \right\} - \frac{1}{\left(1 + \frac{a_0}{c^2} \xi^1\right)} \frac{\partial}{\partial \xi^1} \left\{ E_{\xi^3} \left(1 + \frac{a_0 \xi^1}{c^2}\right) \right\} + \frac{1}{\left(1 + \frac{a_0}{c^2} \xi^1\right)} \frac{\partial B_{\xi^2}}{\partial \xi^0} \\
&= 0
\end{aligned} \tag{41}$$

$$\begin{aligned}
&\text{Z-component) } \frac{\partial E_y}{\partial x} - \frac{\partial E_x}{\partial y} \\
&= \left[ -\frac{\sinh\left(\frac{a_0 \xi^0}{c}\right)}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)} \frac{\partial}{\partial \xi^0} + \cosh\left(\frac{a_0 \xi^0}{c}\right) \frac{\partial}{\partial \xi^1} \right] \cdot [E_{\xi^2} \cosh\left(\frac{a_0 \xi^0}{c}\right) + B_{\xi^3} \sinh\left(\frac{a_0 \xi^0}{c}\right)] \\
&\quad - \frac{\partial E_{\xi^1}}{\partial \xi^2} \\
&= -\frac{\partial B_z}{\partial t} \\
&= -\left[ \frac{\cosh\left(\frac{a_0 \xi^0}{c}\right)}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)} \frac{\partial}{\partial \xi^0} - \sinh\left(\frac{a_0 \xi^0}{c}\right) \frac{\partial}{\partial \xi^1} \right] \cdot [B_{\xi^3} \cosh\left(\frac{a_0 \xi^0}{c}\right) + E_{\xi^2} \sinh\left(\frac{a_0 \xi^0}{c}\right)] \\
&\quad \frac{\partial E_{\xi^2}}{\partial \xi^1} - \frac{\partial E_{\xi^1}}{\partial \xi^2} + \frac{1}{\left(1 + \frac{a_0}{c^2} \xi^1\right)} \frac{a_0}{c^2} E_{\xi^2} + \frac{1}{\left(1 + \frac{a_0}{c^2} \xi^1\right)} \frac{\partial B_{\xi^3}}{\partial \xi^0} \\
&= \frac{1}{\left(1 + \frac{a_0}{c^2} \xi^1\right)} \frac{\partial}{\partial \xi^1} \left\{ E_{\xi^2} \left(1 + \frac{a_0}{c^2} \xi^1\right) \right\} - \frac{1}{\left(1 + \frac{a_0}{c^2} \xi^1\right)} \frac{\partial}{\partial \xi^2} \left\{ E_{\xi^1} \left(1 + \frac{a_0 \xi^1}{c^2}\right) \right\} + \frac{1}{\left(1 + \frac{a_0}{c^2} \xi^1\right)} \frac{\partial B_{\xi^3}}{\partial \xi^0}
\end{aligned}$$

= 0

(42)

Therefore, we obtain the electro-magnetic field equation by Eq (35)-Eq(42) in Rindler spacetime. (see also Ref[13])

$$\vec{\nabla}_\xi \cdot \vec{E}_\xi = 4\pi\rho_\xi \left(1 + \frac{a_0\xi^1}{c^2}\right) \quad (43-i)$$

$$\frac{1}{\left(1 + \frac{a_0\xi^1}{c^2}\right)} \vec{\nabla}_\xi \times \left\{ \vec{B}_\xi \left(1 + \frac{a_0\xi^1}{c^2}\right) \right\} = \frac{1}{\left(1 + \frac{a_0\xi^1}{c^2}\right)} \frac{\partial \vec{E}_\xi}{\partial \xi^0} + \frac{4\pi}{c} \vec{j}_\xi \quad (43-ii)$$

$$\vec{\nabla}_\xi \cdot \vec{B}_\xi = 0 \quad (43-iii)$$

$$\frac{1}{\left(1 + \frac{a_0\xi^1}{c^2}\right)} \vec{\nabla}_\xi \times \left\{ \vec{E}_\xi \left(1 + \frac{a_0\xi^1}{c^2}\right) \right\} = -\frac{1}{\left(1 + \frac{a_0\xi^1}{c^2}\right)} \frac{\partial \vec{B}_\xi}{\partial \xi^0} \quad (43-iv)$$

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

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

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

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

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

$$\text{In this time, 4-vector } (c\rho_\xi, \vec{j}_\xi) = \rho_0 \frac{d\xi^\alpha}{d\tau} \quad (44)$$

Generally, the continuity equation is in Rindler spacetime,

$$0 = j^\mu{}_{;\mu} = \frac{\partial j^\mu}{\partial \xi^\mu} + \Gamma^\mu{}_{\mu\rho} j^\rho,$$

$$\Gamma^\mu{}_{\mu\rho} = \Gamma^0{}_{01} = \frac{1}{2} g^{00} \left( \frac{\partial g_{00}}{\partial \xi^1} \right) = \frac{a_0}{c^2} \frac{1}{\left(1 + \frac{a_0}{c^2} \xi^1\right)}$$

$$g^{00} = -\frac{1}{(1 + \frac{a_0 \xi^1}{c^2})^2}, g^{11} = g^{22} = g^{33} = 1$$

$$0 = \frac{\partial \rho}{\partial t} + \vec{\nabla} \cdot \vec{j} = \frac{\partial \rho_\xi}{\partial \xi^0} + \vec{\nabla}_\xi \cdot \vec{j}_\xi + \frac{j_{\xi^1} a_0}{c^2} \frac{1}{(1 + \frac{a_0 \xi^1}{c^2})} \quad (45)$$

We treat Lorentz gauge transformation about the electro-magnetic field equation in Rindler spacetime.

Eq(43-i) is

$$\begin{aligned} \vec{\nabla}_\xi \cdot \vec{E}_\xi &= \vec{\nabla}_\xi \cdot \left\{ -\frac{1}{(1 + \frac{a_0 \xi^1}{c^2})} \vec{\nabla}_\xi \left\{ \phi_\xi \left(1 + \frac{a_0 \xi^1}{c^2}\right)^2 \right\} - \frac{1}{(1 + \frac{a_0 \xi^1}{c^2})} \frac{\partial \vec{A}_\xi}{\partial \xi^0} \right\} \\ &= -\vec{\nabla}_\xi \left\{ \frac{1}{(1 + \frac{a_0 \xi^1}{c^2})} \right\} \cdot \left[ \vec{\nabla}_\xi \left\{ \phi_\xi \left(1 + \frac{a_0 \xi^1}{c^2}\right)^2 \right\} + \frac{\partial \vec{A}_\xi}{\partial \xi^0} \right] \\ &\quad - \frac{1}{(1 + \frac{a_0 \xi^1}{c^2})} \left[ \nabla_\xi^2 \left\{ \phi_\xi \left(1 + \frac{a_0 \xi^1}{c^2}\right)^2 \right\} + \frac{\partial}{\partial \xi^0} (\vec{\nabla}_\xi \cdot \vec{A}_\xi) \right] \\ &= \frac{a_0}{c^2} \frac{1}{(1 + \frac{a_0 \xi^1}{c^2})^2} \left[ \frac{\partial}{\partial \xi^1} \left\{ \phi_\xi \left(1 + \frac{a_0 \xi^1}{c^2}\right)^2 \right\} + \frac{\partial A_{\xi^1}}{\partial \xi^0} \right] \\ &\quad - \frac{1}{(1 + \frac{a_0 \xi^1}{c^2})} \left[ \nabla_\xi^2 - \frac{1}{c^2} \frac{1}{(1 + \frac{a_0 \xi^1}{c^2})^2} \left( \frac{\partial}{\partial \xi^0} \right)^2 \right] \left\{ \phi_\xi \left(1 + \frac{a_0 \xi^1}{c^2}\right)^2 \right\} \\ &\quad - \frac{1}{(1 + \frac{a_0 \xi^1}{c^2})} \frac{\partial}{\partial \xi^0} \left[ -\frac{1}{(1 + \frac{a_0 \xi^1}{c^2})} \frac{A_{\xi^1} a_0}{c^2} \right] \\ &\quad \frac{1}{c} \frac{\partial \phi_\xi}{\partial \xi^0} + \vec{\nabla}_\xi \cdot \vec{A}_\xi = -\frac{1}{(1 + \frac{a_0 \xi^1}{c^2})} \frac{a_0}{c^2} A_{\xi^1} \\ &= -\frac{a_0}{c^2} \frac{1}{(1 + \frac{a_0 \xi^1}{c^2})} E_{\xi^1} - \frac{1}{(1 + \frac{a_0 \xi^1}{c^2})} \left[ \nabla_\xi^2 - \frac{1}{c^2} \frac{1}{(1 + \frac{a_0 \xi^1}{c^2})^2} \left( \frac{\partial}{\partial \xi^0} \right)^2 \right] \left\{ \phi_\xi \left(1 + \frac{a_0 \xi^1}{c^2}\right)^2 \right\} \end{aligned}$$

$$\begin{aligned}
& + \frac{1}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)^2} \frac{\partial A_{\xi^1}}{\partial \xi^0} \frac{a_0}{c^2} \\
& = 4\pi\rho_{\xi} \left(1 + \frac{a_0 \xi^1}{c^2}\right)
\end{aligned} \tag{46}$$

If we apply Lorentz gauge transformation to Eq (46),

$$\begin{aligned}
\phi_{\xi} & \rightarrow \phi_{\xi} - \frac{1}{c} \frac{\partial \Lambda}{\partial \xi^0} \frac{1}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)^2}, \quad \bar{A}_{\xi} \rightarrow \bar{A}_{\xi} + \vec{\nabla}_{\xi} \Lambda, \quad \Lambda \text{ is a scalar function.} \\
& = -\frac{a_0}{c^2} \frac{1}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)} E_{\xi^1} - \frac{1}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)} \left[ \nabla_{\xi}^2 - \frac{1}{c^2} \frac{1}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)^2} \left(\frac{\partial}{\partial \xi^0}\right)^2 \right] \left\{ \phi_{\xi} \left(1 + \frac{a_0 \xi^1}{c^2}\right)^2 \right\} \\
& + \frac{1}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)} \left[ \nabla_{\xi}^2 - \frac{1}{c^2} \frac{1}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)^2} \left(\frac{\partial}{\partial \xi^0}\right)^2 \right] \frac{1}{c} \frac{\partial \Lambda}{\partial \xi^0} \\
& + \frac{1}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)^2} \frac{\partial A_{\xi^1}}{\partial \xi^0} \frac{a_0}{c^2} + \frac{1}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)^2} \frac{a_0}{c^2} \frac{\partial}{\partial \xi^0} \frac{\partial \Lambda}{\partial \xi^1} \\
& = -\frac{a_0}{c^2} \frac{1}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)} E_{\xi^1} - \frac{1}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)} \left[ \nabla_{\xi}^2 - \frac{1}{c^2} \frac{1}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)^2} \left(\frac{\partial}{\partial \xi^0}\right)^2 \right] \left\{ \phi_{\xi} \left(1 + \frac{a_0 \xi^1}{c^2}\right)^2 \right\} \\
& + \frac{1}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)} \frac{\partial}{\partial \xi^0} \left\{ \left[ \nabla_{\xi}^2 - \frac{1}{c^2} \frac{1}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)^2} \left(\frac{\partial}{\partial \xi^0}\right)^2 \right] \Lambda + \frac{1}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)} \frac{a_0}{c^2} \frac{\partial \Lambda}{\partial \xi^1} \right\} \\
& + \frac{1}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)^2} \frac{\partial A_{\xi^1}}{\partial \xi^0} \frac{a_0}{c^2}
\end{aligned} \tag{47}$$

In this time,

$$\left[ \frac{1}{c^2} \frac{1}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)^2} \left(\frac{\partial}{\partial \xi^0}\right)^2 - \nabla_{\xi}^2 \right] \Lambda - \frac{1}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)} \frac{a_0}{c^2} \frac{\partial \Lambda}{\partial \xi^1} = 0 \tag{48}$$

Hence, Eq(43-i) is

$$\vec{\nabla}_{\xi} \cdot \vec{E}_{\xi}$$

$$\begin{aligned}
&= -\frac{a_0}{c^2} \frac{1}{(1 + \frac{a_0 \xi^1}{c^2})} E_{\xi^1} - \frac{1}{(1 + \frac{a_0 \xi^1}{c^2})} [\nabla_{\xi}^2 - \frac{1}{c^2} \frac{1}{(1 + \frac{a_0 \xi^1}{c^2})^2} (\frac{\partial}{\partial \xi^0})^2] \{\phi_{\xi} (1 + \frac{a_0 \xi^1}{c^2})^2\} \\
&+ \frac{1}{(1 + \frac{a_0 \xi^1}{c^2})^2} \frac{\partial A_{\xi^1}}{\partial \xi^0} \frac{a_0}{c^2} \\
&= 4\pi\rho_{\xi} (1 + \frac{a_0 \xi^1}{c^2}) \tag{49}
\end{aligned}$$

Eq(43-i) is invariant about Lorentz gauge transformation in Rindler spacetime.

Eq (43-ii) is

$$\begin{aligned}
&\frac{1}{(1 + \frac{a_0 \xi^1}{c^2})} \vec{\nabla}_{\xi} \times \{\vec{B}_{\xi} (1 + \frac{a_0 \xi^1}{c^2})\} \\
&= \frac{1}{(1 + \frac{a_0 \xi^1}{c^2})} \vec{\nabla}_{\xi} \times \{\vec{\nabla}_{\xi} \times \vec{A}_{\xi} (1 + \frac{a_0 \xi^1}{c^2})\} \\
&= \frac{1}{(1 + \frac{a_0 \xi^1}{c^2})} \vec{\nabla}_{\xi} (1 + \frac{a_0 \xi^1}{c^2}) \times \{\vec{\nabla}_{\xi} \times \vec{A}_{\xi}\} + \vec{\nabla}_{\xi} \times \vec{\nabla}_{\xi} \times \vec{A}_{\xi} \\
&= \frac{1}{(1 + \frac{a_0 \xi^1}{c^2})} \frac{a_0}{c^2} (1,0,0) \times \vec{B}_{\xi} + \{-\nabla_{\xi}^2 \vec{A}_{\xi} + \vec{\nabla}_{\xi} (\vec{\nabla}_{\xi} \cdot \vec{A}_{\xi})\} \\
&= \frac{1}{(1 + \frac{a_0 \xi^1}{c^2})} \frac{a_0}{c^2} (0, -B_{\xi^3}, B_{\xi^2}) + \{-\nabla_{\xi}^2 \vec{A}_{\xi} + \vec{\nabla}_{\xi} (\vec{\nabla}_{\xi} \cdot \vec{A}_{\xi})\} \\
&= \frac{1}{(1 + \frac{a_0 \xi^1}{c^2})} \frac{\partial \vec{E}_{\xi}}{\partial \xi^0} + \frac{4\pi}{c} \vec{j}_{\xi} \\
&= -\frac{1}{(1 + \frac{a_0 \xi^1}{c^2})^2} \frac{\partial}{\partial \xi^0} [\vec{\nabla}_{\xi} \{\phi_{\xi} (1 + \frac{a_0 \xi^1}{c^2})^2\}] - \frac{1}{(1 + \frac{a_0 \xi^1}{c^2})^2} \frac{1}{c^2} (\frac{\partial}{\partial \xi^0})^2 \vec{A}_{\xi} + \frac{4\pi \vec{j}_{\xi}}{c} \\
&= -\frac{\partial}{\partial \xi^0} \vec{\nabla}_{\xi} \phi_{\xi} - \frac{1}{(1 + \frac{a_0 \xi^1}{c^2})} \frac{2a_0}{c^2} \frac{\partial \phi_{\xi}}{\partial \xi^0} (1,0,0) - \frac{1}{(1 + \frac{a_0 \xi^1}{c^2})^2} \frac{1}{c^2} (\frac{\partial}{\partial \xi^0})^2 \vec{A}_{\xi} + \frac{4\pi \vec{j}_{\xi}}{c}
\end{aligned}$$

(50)

Therefore,

$$\begin{aligned}
& \frac{4\pi}{c} \vec{j}_\xi \\
&= \frac{1}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)} \frac{a_0}{c^2} (0, -B_{\xi^3}, B_{\xi^2}) + \{-\nabla_\xi^2 \vec{A}_\xi + \vec{\nabla}_\xi (\vec{\nabla}_\xi \cdot \vec{A}_\xi)\} \\
&+ \frac{\partial}{c \partial \xi^0} \vec{\nabla}_\xi \phi_\xi + \frac{1}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)} \frac{2a_0}{c^2} \frac{\partial \phi_\xi}{c \partial \xi^0} (1, 0, 0) + \frac{1}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)^2} \frac{1}{c^2} \left(\frac{\partial}{\partial \xi^0}\right)^2 \vec{A}_\xi \\
&= \frac{a_0}{c^2} \frac{1}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)} (0, -B_{\xi^3}, B_{\xi^2}) + \frac{1}{\left(1 + \frac{a_0}{c^2} \xi^1\right)} \frac{2a_0}{c^2} \frac{\partial \phi_\xi}{c \partial \xi^0} (1, 0, 0) \\
&+ [-\nabla_\xi^2 + \frac{1}{c^2} \frac{1}{\left(1 + \frac{a_0}{c^2} \xi^1\right)^2} \left(\frac{\partial}{\partial \xi^0}\right)^2] \vec{A}_\xi + \vec{\nabla}_\xi \left[-\frac{1}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)} \frac{a_0}{c^2} A_{\xi^1}\right] \\
&\quad \frac{1}{c} \frac{\partial \phi_\xi}{\partial \xi^0} + \vec{\nabla}_\xi \cdot \vec{A}_\xi = -\frac{1}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)} \frac{a_0}{c^2} A_{\xi^1} \tag{51}
\end{aligned}$$

$$\begin{aligned}
& \frac{4\pi}{c} \vec{j}_\xi \\
&= \frac{a_0}{c^2} \frac{1}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)} (0, -B_{\xi^3}, B_{\xi^2}) + \frac{1}{\left(1 + \frac{a_0}{c^2} \xi^1\right)} \frac{2a_0}{c^2} \frac{\partial \phi_\xi}{c \partial \xi^0} (1, 0, 0) \\
&+ [-\nabla_\xi^2 + \frac{1}{c^2} \frac{1}{\left(1 + \frac{a_0}{c^2} \xi^1\right)^2} \left(\frac{\partial}{\partial \xi^0}\right)^2] \vec{A}_\xi \\
&+ \vec{\nabla}_\xi \left[-\frac{1}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)} \frac{a_0}{c^2} A_{\xi^1}\right] \tag{52}
\end{aligned}$$

If we apply Lorentz gauge transformation to Eq (52),

$$\phi_\xi \rightarrow \phi_\xi - \frac{1}{c} \frac{\partial \Lambda}{\partial \xi^0} \frac{1}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)}, \quad \vec{A}_\xi \rightarrow \vec{A}_\xi + \vec{\nabla}_\xi \Lambda, \quad \Lambda \text{ is a scalar function.}$$

$$\frac{4\pi}{c} \vec{j}_\xi$$



$$\begin{aligned}
&= \frac{a_0}{c^2} \frac{1}{(1 + \frac{a_0 \xi^1}{c^2})} (0, -B_{\xi^3}, B_{\xi^2}) + \frac{1}{(1 + \frac{a_0}{c^2} \xi^1)} \frac{2a_0}{c^2} \frac{\partial \phi_\xi}{\partial \xi^0} (1, 0, 0) \\
&\quad - \frac{1}{(1 + \frac{a_0}{c^2} \xi^1)^3} \frac{2a_0}{c^2} \frac{1}{c^2} \left( \frac{\partial}{\partial \xi^0} \right)^2 \Lambda (1, 0, 0) \\
&+ \left[ -\nabla_\xi^2 + \frac{1}{c^2} \frac{1}{(1 + \frac{a_0}{c^2} \xi^1)^2} \left( \frac{\partial}{\partial \xi^0} \right)^2 \right] \bar{A}_\xi + \left[ -\nabla_\xi^2 + \frac{1}{c^2} \frac{1}{(1 + \frac{a_0}{c^2} \xi^1)^2} \left( \frac{\partial}{\partial \xi^0} \right)^2 \right] \bar{\nabla}_\xi \Lambda \\
&+ \bar{\nabla}_\xi \left[ -\frac{1}{(1 + \frac{a_0 \xi^1}{c^2})} \frac{a_0}{c^2} A_{\xi^1} \right] + \bar{\nabla}_\xi \left[ -\frac{1}{(1 + \frac{a_0 \xi^1}{c^2})} \frac{a_0}{c^2} \frac{\partial \Lambda}{\partial \xi^1} \right] \\
&= \frac{a_0}{c^2} \frac{1}{(1 + \frac{a_0 \xi^1}{c^2})} (0, -B_{\xi^3}, B_{\xi^2}) + \frac{1}{(1 + \frac{a_0}{c^2} \xi^1)} \frac{2a_0}{c^2} \frac{\partial \phi_\xi}{\partial \xi^0} (1, 0, 0) \\
&\quad - \frac{1}{(1 + \frac{a_0}{c^2} \xi^1)^3} \frac{2a_0}{c^2} \frac{1}{c^2} \left( \frac{\partial}{\partial \xi^0} \right)^2 \Lambda (1, 0, 0) \\
&+ \left[ -\nabla_\xi^2 + \frac{1}{c^2} \frac{1}{(1 + \frac{a_0}{c^2} \xi^1)^2} \left( \frac{\partial}{\partial \xi^0} \right)^2 \right] \bar{A}_\xi + \left[ -\nabla_\xi^2 + \frac{1}{c^2} \frac{1}{(1 + \frac{a_0}{c^2} \xi^1)^2} \left( \frac{\partial}{\partial \xi^0} \right)^2 \right] \bar{\nabla}_\xi \Lambda \\
&+ \frac{1}{(1 + \frac{a_0 \xi^1}{c^2})^2} \frac{a_0^2}{c^4} A_{\xi^1} (1, 0, 0) - \frac{1}{(1 + \frac{a_0 \xi^1}{c^2})} \frac{a_0}{c^2} \bar{\nabla}_\xi A_{\xi^1} \\
&+ \frac{1}{(1 + \frac{a_0 \xi^1}{c^2})^2} \frac{a_0^2}{c^4} \frac{\partial \Lambda}{\partial \xi^1} (1, 0, 0) - \frac{1}{(1 + \frac{a_0 \xi^1}{c^2})} \frac{a_0}{c^2} \frac{\partial}{\partial \xi^1} \bar{\nabla}_\xi \Lambda
\end{aligned}$$

(53)

In this time,

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

$$\begin{aligned}
0 &= \vec{\nabla}_\xi \left[ \left\{ -\nabla_\xi^2 + \frac{1}{c^2} \frac{1}{\left(1 + \frac{a_0}{c^2} \xi^1\right)^2} \left(\frac{\partial}{\partial \xi^0}\right)^2 - \frac{1}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)} \frac{a_0}{c^2} \frac{\partial}{\partial \xi^1} \right\} \Lambda \right] \\
&= \vec{\nabla}_\xi \left\{ \frac{1}{c^2} \frac{1}{\left(1 + \frac{a_0}{c^2} \xi^1\right)^2} \right\} \left(\frac{\partial}{\partial \xi^0}\right)^2 \Lambda + \left[ -\nabla_\xi^2 + \frac{1}{c^2} \frac{1}{\left(1 + \frac{a_0}{c^2} \xi^1\right)^2} \left(\frac{\partial}{\partial \xi^0}\right)^2 \right] \vec{\nabla}_\xi \Lambda \\
&\quad - \vec{\nabla}_\xi \left\{ \frac{a_0}{c^2} \frac{1}{\left(1 + \frac{a_0}{c^2} \xi^1\right)} \right\} \frac{\partial \Lambda}{\partial \xi^1} - \frac{1}{\left(1 + \frac{a_0}{c^2} \xi^1\right)} \frac{a_0}{c^2} \frac{\partial}{\partial \xi^1} \vec{\nabla}_\xi \Lambda \\
&= -\frac{2}{c^2} \frac{1}{\left(1 + \frac{a_0}{c^2} \xi^1\right)^3} \frac{a_0}{c^2} \left(\frac{\partial}{\partial \xi^0}\right)^2 \Lambda(1,0,0) + \left[ -\nabla_\xi^2 + \frac{1}{c^2} \frac{1}{\left(1 + \frac{a_0}{c^2} \xi^1\right)^2} \left(\frac{\partial}{\partial \xi^0}\right)^2 \right] \vec{\nabla}_\xi \Lambda \\
&\quad + \frac{a_0^2}{c^4} \frac{1}{\left(1 + \frac{a_0}{c^2} \xi^1\right)^2} \frac{\partial \Lambda}{\partial \xi^1}(1,0,0) - \frac{1}{\left(1 + \frac{a_0}{c^2} \xi^1\right)} \frac{a_0}{c^2} \frac{\partial}{\partial \xi^1} \vec{\nabla}_\xi \Lambda \tag{54}
\end{aligned}$$

Therefore,

$$\begin{aligned}
&\frac{4\pi}{c} \vec{j}_\xi \\
&= \frac{a_0}{c^2} \frac{1}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)} (0, -B_{\xi^3}, B_{\xi^2}) + \frac{1}{\left(1 + \frac{a_0}{c^2} \xi^1\right)} \frac{2a_0}{c^2} \frac{\partial \phi_\xi}{\partial \xi^0}(1,0,0) \\
&\quad - \frac{1}{\left(1 + \frac{a_0}{c^2} \xi^1\right)^3} \frac{2a_0}{c^2} \frac{1}{c^2} \left(\frac{\partial}{\partial \xi^0}\right)^2 \Lambda(1,0,0) \\
&\quad + \left[ -\nabla_\xi^2 + \frac{1}{c^2} \frac{1}{\left(1 + \frac{a_0}{c^2} \xi^1\right)^2} \left(\frac{\partial}{\partial \xi^0}\right)^2 \right] \vec{A}_\xi + \frac{1}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)^2} \frac{a_0^2}{c^4} A_{\xi^1}(1,0,0) \\
&\quad - \frac{1}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)} \frac{a_0}{c^2} \vec{\nabla}_\xi A_{\xi^1} + \frac{1}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)^2} \frac{a_0^2}{c^4} \frac{\partial \Lambda}{\partial \xi^1}(1,0,0) - \frac{1}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)} \frac{a_0}{c^2} \frac{\partial}{\partial \xi^1} \vec{\nabla}_\xi \Lambda \\
&\quad + \vec{\nabla}_\xi \left[ \left\{ -\nabla_\xi^2 + \frac{1}{c^2} \frac{1}{\left(1 + \frac{a_0}{c^2} \xi^1\right)^2} \left(\frac{\partial}{\partial \xi^0}\right)^2 - \frac{1}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)} \frac{a_0}{c^2} \frac{\partial}{\partial \xi^1} \right\} \Lambda \right]
\end{aligned}$$

$$\begin{aligned}
& + \frac{2}{c^2} \frac{1}{\left(1 + \frac{a_0}{c^2} \xi^1\right)^3} \frac{a_0}{c^2} \left(\frac{\partial}{\partial \xi^0}\right)^2 \Lambda(1,0,0) - \frac{a_0^2}{c^4} \frac{1}{\left(1 + \frac{a_0}{c^2} \xi^1\right)^2} \frac{\partial \Lambda}{\partial \xi^1}(1,0,0) \\
& + \frac{1}{\left(1 + \frac{a_0}{c^2} \xi^1\right)} \frac{a_0}{c^2} \frac{\partial}{\partial \xi^1} \vec{\nabla}_\xi \Lambda \\
& = \frac{a_0}{c^2} \frac{1}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)} (0, -B_{\xi^3}, B_{\xi^2}) + \frac{1}{\left(1 + \frac{a_0}{c^2} \xi^1\right)} \frac{2a_0}{c^2} \frac{\partial \phi_\xi}{\partial \xi^0}(1,0,0) \\
& \quad + [-\nabla_\xi^2 + \frac{1}{c^2} \frac{1}{\left(1 + \frac{a_0}{c^2} \xi^1\right)^2} \left(\frac{\partial}{\partial \xi^0}\right)^2] \vec{A}_\xi \\
& + \frac{1}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)^2} \frac{a_0^2}{c^4} A_{\xi^1}(1,0,0) - \frac{1}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)} \frac{a_0}{c^2} \vec{\nabla}_\xi A_{\xi^1} \tag{55}
\end{aligned}$$

Hence, Eq(43-ii) is invariant about Lorentz gauge transformation in Rindler spacetime.

Eq (43-iii) is

$$\vec{\nabla}_\xi \cdot \vec{B}_\xi = \vec{\nabla}_\xi \cdot (\vec{\nabla}_\xi \times \vec{A}_\xi + \vec{\nabla}_\xi \times \vec{\nabla}_\xi \Lambda) = \vec{\nabla}_\xi \times \vec{\nabla}_\xi \cdot \vec{A}_\xi = 0 \tag{56}$$

Eq (43-iv) is

$$\begin{aligned}
& \frac{1}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)} \vec{\nabla}_\xi \times \left\{ \vec{E}_\xi \left(1 + \frac{a_0 \xi^1}{c^2}\right) \right\} \\
& = - \frac{1}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)} \vec{\nabla}_\xi \times \left[ \vec{\nabla}_\xi \left\{ \phi_\xi \left(1 + \frac{a_0 \xi^1}{c^2}\right)^2 \right\} - \vec{\nabla}_\xi \left( \frac{\partial \Lambda}{\partial \xi^0} \right) + \frac{\partial \vec{A}_\xi}{\partial \xi^0} + \frac{\partial}{\partial \xi^0} (\vec{\nabla}_\xi \Lambda) \right] \\
& = - \frac{1}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)} \vec{\nabla}_\xi \times \frac{\partial \vec{A}_\xi}{\partial \xi^0} = - \frac{1}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)} \frac{\partial (\vec{\nabla}_\xi \times \vec{A}_\xi)}{\partial \xi^0} = - \frac{1}{\left(1 + \frac{a_0 \xi^1}{c^2}\right)} \frac{\partial \vec{B}_\xi}{\partial \xi^0} \tag{57}
\end{aligned}$$

Hence, Eq (43-iii), Eq (43-iv) are invariant about Lorentz gauge transformation in Rindler spacetime.

Hence, the electro-magnetic field equations(Maxwell Equations) in Rindler spacetime are invariant about Lorentz gauge transformation.

## 5. Conclusion

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

Generally, the coordinate transformation of accelerated frame is (see Ref [9])

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

$$x = \left(\frac{c^2}{a_0} + \xi^1\right) \cosh\left(\frac{a_0 \xi^0}{c}\right) - \frac{c^2}{a_0}, y = \xi^2, z = \xi^3 \quad (58)$$

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

$$x = \frac{c^2}{a_0} \exp\left(\frac{a_0}{c^2} \xi^1\right) \cosh\left(\frac{a_0 \xi^0}{c}\right) - \frac{c^2}{a_0}, y = \xi^2, z = \xi^3 \quad (59)$$

If you try to use Eq(59) for make Maxwell equation in Rindler space-time, You have to fail it.

In A.Einstein's article (see Ref [10]), Einstein obtain Lorenz transformation by Maxwell equation in inertial frame, Einstein give up Galilei transformation in inertial frame. In accelerated frame, we think our article's choice is Rindler coordinate (I) can treat electro-magnetic field equation likely Einstein's election.

## APPENDIX A

In 2-Dimension Rindler space-time, if we mistake calculation, we think the electro-magnetic wave function.

$$E_{\xi^1} = E_x = E_{x0} \sin \omega \left(t - \frac{x}{c}\right)$$

$$= E_{x0} \sin \omega \left\{ \left[ \frac{c}{a_0} + \frac{\xi^1}{c} \right] \exp\left(\frac{a_0}{c} \xi^0\right) + \frac{c}{a_0} \right\} = E_{x0} \sin \Phi \quad (A-1)$$

$$ct = \left(\frac{c^2}{a_0} + \xi^1\right) \sinh\left(\frac{a_0 \xi^0}{c}\right), \quad x = \left(\frac{c^2}{a_0} + \xi^1\right) \cosh\left(\frac{a_0 \xi^0}{c}\right) - \frac{c^2}{a_0}$$

In this time,

$$\exp\left(-\frac{a_0}{c} \xi^0\right) = \sinh\left(\frac{a_0 \xi^0}{c}\right) - \cosh\left(\frac{a_0 \xi^0}{c}\right) \quad (A-2)$$

(A-1) have to satisfy the following equation.

$$\frac{1}{(1 + \frac{a_0 \xi^1}{c})^2} \frac{1}{c^2} (\frac{\partial}{\partial \xi^0})^2 \sin \Phi = (\frac{\partial}{\partial \xi^1})^2 \sin \Phi \quad (\text{A-3})$$

$$\begin{aligned} (\frac{\partial}{\partial \xi^1})^2 \sin \Phi &= \frac{\partial}{\partial \xi^1} (\frac{\partial}{\partial \xi^1} \sin \omega \{ \frac{c}{a_0} + \frac{\xi^1}{c} \} \exp(-\frac{a_0}{c} \xi^0) + \frac{c}{a_0}) \\ &= \frac{\partial}{\partial \xi^1} \{ (\cos \Phi) \cdot \omega \frac{1}{c} \exp(-\frac{a_0}{c} \xi^0) \} = (-\sin \Phi) \cdot \frac{\omega^2}{c^2} \exp(-2 \frac{a_0}{c} \xi^0) \end{aligned}$$

(A-4)

But this calculation situation is different.

$$\begin{aligned} &\frac{1}{(1 + \frac{a_0 \xi^1}{c})^2} \frac{1}{c^2} (\frac{\partial}{\partial \xi^0})^2 \sin \Phi \\ &= \frac{1}{(1 + \frac{a_0 \xi^1}{c^2})^2} \frac{1}{c^2} \frac{\partial}{\partial \xi^0} (\frac{\partial}{\partial \xi^0} \sin \omega \{ \frac{c}{a_0} + \frac{\xi^1}{c} \} \exp(-\frac{a_0}{c} \xi^0) + \frac{c}{a_0}) \\ &= \frac{1}{(1 + \frac{a_0 \xi^1}{c^2})^2} \frac{1}{c^2} \frac{\partial}{\partial \xi^0} (-(\cos \Phi) \cdot \omega \{ \frac{c}{a_0} + \frac{\xi^1}{c} \} \frac{a_0}{c} \exp(-\frac{a_0}{c} \xi^0)) \end{aligned}$$

In this time,  $D^2(\alpha\beta) = D(\beta D\alpha + \alpha D\beta)$

$$\begin{aligned} &= \frac{1}{(1 + \frac{a_0 \xi^1}{c^2})^2} \frac{1}{c^2} \{ -\frac{\partial}{\partial \xi^0} (\cos \Phi) \cdot \omega \{ \frac{c}{a_0} + \frac{\xi^1}{c} \} \frac{a_0}{c} \exp(-\frac{a_0}{c} \xi^0) \\ &\quad - (\cos \Phi) \cdot \omega \{ \frac{c}{a_0} + \frac{\xi^1}{c} \} \frac{a_0}{c} \frac{\partial}{\partial \xi^0} (\exp(-\frac{a_0}{c} \xi^0)) \} \\ &= \frac{1}{(1 + \frac{a_0 \xi^1}{c^2})^2} \frac{1}{c^2} \{ -\sin \Phi \cdot \omega^2 \{ \frac{c}{a_0} + \frac{\xi^1}{c} \}^2 \frac{a_0^2}{c^2} \exp(-2 \frac{a_0}{c} \xi^0) \\ &\quad + (\cos \Phi) \cdot \omega \{ \frac{c}{a_0} + \frac{\xi^1}{c} \} \frac{a_0^2}{c^2} \exp(-\frac{a_0}{c} \xi^0) \} \quad (\text{A-5}) \end{aligned}$$

Hence, if we compare Eq(A-4) and Eq(A-5),

$$(\frac{\partial}{\partial \xi^1})^2 \sin \Phi = (-\sin \Phi) \cdot \frac{\omega^2}{c^2} \exp(-2 \frac{a_0}{c} \xi^0)$$

$$\neq -\sin \Phi \cdot \omega^2 \frac{1}{c^2} \exp(-2 \frac{a_0}{c} \xi^0)$$

$$+ \frac{1}{(1 + \frac{a_0 \xi^1}{c^2})} (\cos \Phi) \cdot \omega \frac{a_0}{c} \frac{1}{c^2} \exp(-\frac{a_0}{c} \xi^0) = \frac{1}{(1 + \frac{a_0 \xi^1}{c^2})^2} \frac{1}{c^2} (\frac{\partial}{\partial \xi^0})^2 \sin \Phi \quad (\text{A-6})$$

Therefore, we think it cannot exist electro-magnetic wave function in Rindler space-time.

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