$$e_{\mathbb{R}}(x) = e^{\pi i x/\ell}$$

$$0|\ell_{\tau} \underset{\infty}{\triangle}\, \mathfrak{t}^{\mathbb{C}} \boxtimes \mathbb{R} \xrightarrow[()^{\mu}]{{}_{0}()^{\mu}} \mathbb{R}: \quad 0|\ell \underset{\infty}{\triangle}\, \mathfrak{t}^{\mathbb{C}} \boxtimes \mathbb{R} \xrightarrow[()^{\mu}_{n}]{()^{\mu}_{n}} \mathbb{C}: \quad 0|\ell_{\tau} \underset{\infty}{\triangle}\, \mathfrak{t}^{\mathbb{C}} \boxtimes \mathbb{R} \xrightarrow[\overset{\mathbb{R}}{()}{}^{\mu}_{n} : \overset{\mathbb{I}}{()}{}^{\mu}_{n}]{\overset{\mathbb{R}}{()}{}^{\mu}_{n} : \overset{\mathbb{I}}{()}{}^{\mu}_{n}} \mathbb{R}$$

$$^{\sigma}(\tau)^{\mu} = ()^{\mu} + \tau \frac{2\alpha'}{\ell\!\!\!/}\, {}_{0}()^{\mu} + i\sqrt{2\alpha'} \sum_{n>0}^{1/\sqrt{n}} {}^{\sigma n/\ell\!\!\!/}\mathfrak{c}\, \underbrace{()^{\mu}_{n} e_{\mathbb{R}}^{-\tau n} - \overset{*}{()}{}^{\mu}_{n} e_{\mathbb{R}}^{\tau n}}$$

$$^{\tau\sigma}X^{\mu} = X^{\mu} + \tau \frac{2\alpha'}{\ell\!\!\!/}\, {}_{0}X^{\mu} + i\sqrt{2\alpha'} \sum_{n\neq 0}^{1/n} {}^{\sigma n/\ell\!\!\!/}\mathfrak{c}\, \alpha^{\mu}_{n}\, e_{\mathbb{R}}^{-\tau n}$$

$$\sum_{n\neq 0}^{1/n} {}^{\sigma n/\ell\!\!\!/}\mathfrak{c}\, \alpha^{\mu}_{n}\, e_{\mathbb{R}}^{-\tau n} = \sum_{n>0}^{1/n} {}^{\sigma n/\ell\!\!\!/}\mathfrak{c}\, \underbrace{\alpha^{\mu}_{n} e_{\mathbb{R}}^{-\tau n} - \alpha^{\mu}_{n} e_{\mathbb{R}}^{\tau n}}$$

$$= \sum_{n>0}^{1/n} {}^{\sigma n/\ell\!\!\!/}\mathfrak{c}\, \underbrace{\alpha^{\mu}_{n} e_{\mathbb{R}}^{-\tau n} - \overset{*}{\alpha}{}^{\mu}_{n} e_{\mathbb{R}}^{\tau n}} = \sum_{n>0}^{1/\sqrt{n}} {}^{\sigma n/\ell\!\!\!/}\mathfrak{c}\, \underbrace{()^{\mu}_{n} e_{\mathbb{R}}^{-\tau n} - \overset{*}{()}{}^{\mu}_{n} e_{\mathbb{R}}^{\tau n}}$$

$$^{\sigma}_{0}(\tau)^{\mu} = \frac{2\alpha'}{\ell\!\!\!/}\, {}_{0}()^{\mu} + \frac{\sqrt{\alpha'/2}}{\ell\!\!\!/} \sum_{n>0}^{\sqrt{n}} {}^{\sigma n/\ell\!\!\!/}\mathfrak{c}\, \underbrace{()^{\mu}_{n} e_{\mathbb{R}}^{-\tau n} + \overset{*}{()}{}^{\mu}_{n} e_{\mathbb{R}}^{\tau n}}$$

$$^{\sigma}_{0}(\tau)^{\mu} = \frac{2\alpha'}{\ell\!\!\!/}\, {}_{0}()^{\mu} + i\sqrt{2\alpha'} \sum_{n>0}^{1/\sqrt{n}} {}^{\sigma n/\ell\!\!\!/}\mathfrak{c}\, \underbrace{()^{\mu}_{n} e_{\mathbb{R}}^{-\tau n} \frac{-ni}{\ell\!\!\!/} - \overset{*}{()}{}^{\mu}_{n} e_{\mathbb{R}}^{\tau n} \frac{ni}{\ell\!\!\!/}}$$

$$
{}^{\sigma}\daleth = {}^{\sharp}\daleth_0 + \sqrt{2}\sum_{n>0} {}^{\sigma n/\not\ell}\mathfrak{c}\,{}^{\sharp}\daleth_n \Longrightarrow \begin{cases} {}^{\sharp}\daleth_0 = \int\limits_{d\sigma/\ell}^{0|\ell} {}^{\sigma}\daleth \\ {}^{\sharp}\daleth_m = \sqrt{2}\int\limits_{d\sigma/\ell}^{0|\ell} {}^{\sigma m/\not\ell}\mathfrak{c}\,{}^{\sigma}\daleth \end{cases}
$$

$$
m \neq n \Longrightarrow 2\int\limits_{d\sigma/\ell}^{0|\ell} {}^{\sigma m/\not\ell}\mathfrak{c}\,{}^{\sigma n/\not\ell}\mathfrak{c} = \int\limits_{d\sigma/\ell}^{0|\ell} {}^{\sigma(m+n)/\not\ell}\mathfrak{c} + \int\limits_{d\sigma/\ell}^{0|\ell} {}^{\sigma(m-n)/\not\ell}\mathfrak{c} = \left.\frac{{}^{\sigma(m+n)/\not\ell}\mathfrak{s}}{\ell\,(m+n)/\pi}\right|_0^{\ell} + \left.\frac{{}^{\sigma(m-n)/\not\ell}\mathfrak{s}}{\ell\,(m-n)/\pi}\right|_0^{\ell} = 0
$$

$$
n > 0 \Longrightarrow \int\limits_{d\sigma/\ell}^{0|\ell} {}^{\sigma n/\not\ell}\mathfrak{c}^2 = \int\limits_{d\sigma/\ell}^{0|\ell} {}^{\sigma n/\not\ell}\mathfrak{s}^2 = \frac{1}{2}
$$

$$
\int\limits_{d\sigma/\ell}^{0|\ell} {}^{\sigma}\daleth = \int\limits_{d\sigma/\ell}^{0|\ell} {}^{\sharp}\daleth_0 + \sqrt{2}\sum_{n>0} {}^{\sigma n/\not\ell}\mathfrak{c}\,{}^{\sharp}\daleth_n = \int\limits_{d\sigma/\ell}^{0|\ell} {}^{\sharp}\daleth_0 = {}^{\sharp}\daleth_0
$$

$$
m > 0 \Longrightarrow \int\limits_{d\sigma/\ell}^{0|\ell} \sqrt{2}\,{}^{\sigma m/\not\ell}\mathfrak{c}\,{}^{\sigma}\daleth = \int\limits_{d\sigma/\ell}^{0|\ell} \sqrt{2}\,{}^{\sigma m/\not\ell}\mathfrak{c}\,\overbrace{{}^{\sharp}\daleth_0 + \sqrt{2}\sum_{n>0} {}^{\sigma n/\not\ell}\mathfrak{c}\,{}^{\sharp}\daleth_n} = 2\int\limits_{d\sigma/\ell}^{0|\ell} {}^{\sigma m/\not\ell}\mathfrak{c}^2\,{}^{\sharp}\daleth_m = {}^{\sharp}\daleth_m
$$

$$
()^{\mu} = \int\limits_{d\sigma/\ell}^{0|\ell} {}^{\sigma}(\tau)^{\mu} - \tau\,{}^{\sigma}_{0}(\tau)^{\mu} : \quad {}_{0}()^{\mu} = \frac{\not\ell}{2\alpha'}\int\limits_{d\sigma/\ell}^{0|\ell} {}^{\sigma}_{0}(\tau)^{\mu}
$$

$$
()^{\mu} + \frac{2\alpha'}{\not\ell}\,{}_{0}()^{\mu}\,\tau = \int\limits_{d\sigma/\ell}^{0|\ell} {}^{\sigma}(\tau)^{\mu} : \quad \frac{2\alpha'}{\not\ell}\,{}_{0}()^{\mu} = \int\limits_{d\sigma/\ell}^{0|\ell} {}^{\sigma}_{0}(\tau)^{\mu}
$$

$$()^{\mu} \times {}_{0}()^{\nu} = i\,\eta^{\mu\nu}$$

$$2\,\alpha'\,()^{\mu} \times {}_{0}()^{\nu} = \int_{d\varrho/\ell}^{0|\ell} \underbrace{{}^{\varrho}(\tau)^{\mu} - \tau\,{}^{\varrho}_{0}(\tau)^{\mu}} \times \int_{d\sigma/\ell}^{0|\ell} \not{\ell}\;{}^{\sigma}_{0}(\tau)^{\nu}$$

$$= \int_{d\varrho/\ell}^{0|\ell} \int_{d\sigma/\ell}^{0|\ell} \underbrace{\not{\ell}^{\varrho}(\tau)^{\mu} \times {}^{\sigma}_{0}(\tau)^{\nu}}_{=2\ell\alpha' i\eta^{\mu\nu}\delta^{\varrho\sigma}} - \not{\ell}\,\tau\,\underbrace{{}^{\varrho}_{0}(\tau)^{\mu} \times {}^{\sigma}_{0}(\tau)^{\nu}}_{=0} = 2\,\alpha'\,i\,\eta^{\mu\nu} \int_{d\sigma/\ell}^{0|\ell} 1 = 2\,\alpha'\,i\,\eta^{\mu\nu}$$

$$\sqrt{2\alpha'}\,()^{\mu}_{n} = e^{\tau n}_{\mathbb{R}} \int_{d\sigma/\ell}^{0|\ell} {}^{\sigma n/\not{\ell}}\mathfrak{c}\; \underbrace{-i\sqrt{n}\,{}^{\sigma}(\tau)^{\mu} + \not{\ell}\,{}^{\sigma}_{0}(\tau)^{\mu}/\sqrt{n}}$$

$$\sqrt{2\alpha'}\,\overset{*}{()}{}^{\mu}_{n} = e^{-\tau n}_{\mathbb{R}} \int_{d\sigma/\ell}^{0|\ell} {}^{\sigma n/\not{\ell}}\mathfrak{c}\; \underbrace{i\sqrt{n}\,{}^{\sigma}(\tau)^{\mu} + \not{\ell}\,{}^{\sigma}_{0}(\tau)^{\mu}/\sqrt{n}}$$

$$()^{\mu}_{n}\,e^{-\tau n}_{\mathbb{R}} - \overset{*}{()}{}^{\mu}_{n}\,e^{\tau n}_{\mathbb{R}} = \frac{-i}{\sqrt{\alpha'/2}} \int_{d\sigma/\ell}^{0|\ell} {}^{\sigma n/\not{\ell}}\mathfrak{c}\;{}^{\sigma}(\tau)^{\mu}\sqrt{n}$$

$$()^{\mu}_{n}\,e^{-\tau n}_{\mathbb{R}} + \overset{*}{()}{}^{\mu}_{n}\,e^{\tau n}_{\mathbb{R}} = \frac{\not{\ell}}{\sqrt{\alpha'/2}} \int_{d\sigma/\ell}^{0|\ell} {}^{\sigma n/\not{\ell}}\mathfrak{c}\;{}^{\sigma}_{0}(\tau)^{\mu}/\sqrt{n}$$

$$2\,()^{\mu}_{n}\,e^{-\tau n}_{\mathbb{R}} = \frac{-i}{\sqrt{\alpha'/2}} \int_{d\sigma/\ell}^{0|\ell} {}^{\sigma n/\not{\ell}}\mathfrak{c}\;{}^{\sigma}(\tau)^{\mu}\sqrt{n} + \frac{\not{\ell}}{\sqrt{\alpha'/2}} \int_{d\sigma/\ell}^{0|\ell} {}^{\sigma n/\not{\ell}}\mathfrak{c}\;{}^{\sigma}_{0}(\tau)^{\mu}/\sqrt{n}$$

$$2\,\overset{*}{()}{}^{\mu}_{n}\,e^{\tau n}_{\mathbb{R}} = \frac{i}{\sqrt{\alpha'/2}} \int_{d\sigma/\ell}^{0|\ell} {}^{\sigma n/\not{\ell}}\mathfrak{c}\;{}^{\sigma}(\tau)^{\mu}\sqrt{n} + \frac{\not{\ell}}{\sqrt{\alpha'/2}} \int_{d\sigma}^{0|\ell} {}^{\sigma n/\not{\ell}}\mathfrak{c}\;{}^{\sigma}_{0}(\tau)^{\mu}/\sqrt{n}$$

$$()^{\mu} \ast ()^{\nu}_{n} = 0\text{:} \quad {}_{0}()^{\mu} \ast ()^{\nu}_{n} = 0$$

$$()^{\mu} \ast ()^{\nu}_{n} = \int_{d\varrho/\ell}^{0|\ell} \underbrace{{}^{\varrho}(\tau)^{\mu} - \tau\,{}^{\varrho}_{0}(\tau)^{\mu}}_{} \ast \int_{d\sigma/\ell}^{0|\ell} {}^{\sigma n/\not\ell}\mathfrak{c}\; \underbrace{-i^{\sigma}(\tau)^{\nu}\sqrt{n} + \not\ell^{\sigma}_{0}(\tau)^{\nu}/\sqrt{n}}_{}$$

$$= \int_{d\varrho/\ell}^{0|\ell}\int_{d\sigma/\ell}^{0|\ell} {}^{\sigma n/\not\ell}\mathfrak{c}\; \underbrace{{}^{\varrho}(\tau)^{\mu} - \tau\,{}^{\varrho}_{0}(\tau)^{\mu}}_{} \ast \underbrace{-i^{\sigma}(\tau)^{\nu}\sqrt{n} + \not\ell^{\sigma}_{0}(\tau)^{\nu}/\sqrt{n}}_{}$$

$$= \int_{d\varrho/\ell}^{0|\ell}\int_{d\sigma/\ell}^{0|\ell} {}^{\sigma n/\not\ell}\mathfrak{c}\; \overbrace{-i\underbrace{{}^{\varrho}(\tau)^{\mu} \ast {}^{\sigma}(\tau)^{\nu}}_{=0}\sqrt{n} + \underbrace{\not\ell^{\varrho}(\tau)^{\mu} \ast {}^{\sigma}_{0}(\tau)^{\nu}}_{=2\ell i\alpha'\eta^{\mu\nu}\delta^{\varrho\sigma}}/\sqrt{n} + i\tau\underbrace{{}^{\varrho}_{0}(\tau)^{\mu} \ast {}^{\sigma}(\tau)^{\nu}}_{=-2\pi i\alpha'\eta^{\mu\nu}\delta^{\varrho\sigma}}\sqrt{n} - \not\ell\tau\underbrace{{}^{\varrho}_{0}(\tau)^{\mu} \ast {}^{\sigma}_{0}(\tau)^{\nu}}_{=0}/\sqrt{n}}$$

$$= {}^{\mu\nu}\eta\;\alpha' \int_{d\sigma/\ell}^{0|\ell} {}^{\sigma n/\not\ell}\mathfrak{c}\; \underbrace{i/\sqrt{n} - \tau\frac{2\pi}{\ell}\sqrt{n}}_{} = 0$$

$$()^{\mu}_{m} \ast ()^{\nu}_{n} = 0$$

$$2\,\alpha'\, e_{\mathbb{R}}^{-\tau\,(m+n)}\, ()^{\mu}_{m} \ast ()^{\nu}_{n} = \int_{d\varrho/\ell}^{0|\ell} {}^{\varrho m/\not\ell}\mathfrak{c}\; \underbrace{-i^{\varrho}(\tau)^{\mu}\sqrt{m} + \not\ell^{\varrho}_{0}(\tau)^{\mu}/\sqrt{m}}_{} \ast \int_{d\sigma/\ell}^{0|\ell} {}^{\sigma n/\not\ell}\mathfrak{c}\; \underbrace{-i^{\sigma}(\tau)^{\nu}\sqrt{n} + \not\ell^{\sigma}_{0}(\tau)^{\nu}/\sqrt{n}}_{}$$

$$= \int_{d\varrho/\ell}^{0|\ell}\int_{d\sigma/\ell}^{0|\ell} {}^{\varrho m/\not\ell}\mathfrak{c}\; {}^{\sigma n/\not\ell}\mathfrak{c}\; \underbrace{-i^{\varrho}(\tau)^{\mu}\sqrt{m} + \not\ell^{\varrho}_{0}(\tau)^{\mu}/\sqrt{m}}_{} \ast \underbrace{-i^{\sigma}(\tau)^{\nu}\sqrt{n} + \not\ell^{\sigma}_{0}(\tau)^{\nu}/\sqrt{n}}_{}$$

$$= \int_{d\varrho/\ell}^{0|\ell}\int_{d\sigma/\ell}^{0|\ell} {}^{\varrho m/\not\ell}\mathfrak{c}\; {}^{\sigma n/\not\ell}\mathfrak{c}\; \overbrace{-\underbrace{{}^{\varrho}(\tau)^{\mu} \ast {}^{\sigma}(\tau)^{\nu}}_{=0}\sqrt{mn} - \not\ell\underbrace{i^{\varrho}_{0}(\tau)^{\mu} \ast {}^{\sigma}(\tau)^{\nu}}_{=2\ell\alpha'\eta^{\mu\nu}\delta^{\varrho\sigma}}\sqrt{\frac{n}{m}} - \not\ell\underbrace{i^{\varrho}(\tau)^{\mu} \ast {}^{\sigma}_{0}(\tau)^{\nu}}_{-2\ell\alpha'\eta^{\nu\mu}\delta^{\sigma\varrho}}\sqrt{\frac{m}{n}} + \not\ell^{2}\underbrace{{}^{\varrho}_{0}(\tau)^{\mu} \ast {}^{\sigma}_{0}(\tau)^{\nu}}_{=0}/\sqrt{mn}}$$

$$= 2\,\alpha'\,{}^{\mu\nu}\eta\;\underbrace{\sqrt{\frac{m}{n}} - \sqrt{\frac{n}{m}}}_{}\;\underbrace{\int_{d\sigma/\ell}^{0|\ell} {}^{\sigma m/\not\ell}\mathfrak{c}\,{}^{\sigma n/\not\ell}\mathfrak{c}}_{\delta_{mn}/2} = 0$$

$$()_m^{\mu} \times \overset{*}{()}_n^{\nu} = {}^{\mu\nu}\eta \; \delta_{mn}$$

$$2\,\alpha' \, e_{\mathbb{R}}^{\tau\,(n-m)} \, ()_m^{\mu} \times \overset{*}{()}_n^{\nu} = \int_{d\varrho/\ell}^{0|\ell} {}^{\varrho m/\not\ell}\mathfrak{c} \, \underbrace{-i^{\varrho}(\tau)^{\mu}\sqrt{m} + \underset{0}{\not\ell}^{\varrho}(\tau)^{\mu}/\sqrt{m}} \times \int_{d\sigma/\ell}^{0|\ell} {}^{\sigma n/\not\ell}\mathfrak{c} \, \underbrace{i^{\sigma}(\tau)^{\nu}\sqrt{n} + \underset{0}{\not\ell}^{\sigma}(\tau)^{\nu}/\sqrt{n}}$$

$$= \int_{d\varrho/\ell}^{0|\ell} \int_{d\sigma/\ell}^{0|\ell} {}^{\varrho m/\not\ell}\mathfrak{c} \; {}^{\sigma n/\not\ell}\mathfrak{c} \, \underbrace{-i^{\varrho}(\tau)^{\mu}\sqrt{m} + \underset{0}{\not\ell}^{\varrho}(\tau)^{\mu}/\sqrt{m}} \times \underbrace{i^{\sigma}(\tau)^{\nu}\sqrt{n} + \underset{0}{\not\ell}^{\sigma}(\tau)^{\nu}/\sqrt{n}}$$

$$= \int_{d\varrho/\ell}^{0|\ell} \int_{d\sigma/\ell}^{0|\ell} {}^{\varrho m/\not\ell}\mathfrak{c} \; {}^{\sigma n/\not\ell}\mathfrak{c} \, \overbrace{\underbrace{{}^{\varrho}(\tau)^{\mu} \times {}^{\sigma}(\tau)^{\nu}}_{=0}\sqrt{mn} + \underbrace{\not\ell \underset{0}{i}^{\varrho}(\tau)^{\mu} \times {}^{\sigma}(\tau)^{\nu}}_{=2\ell\alpha' {}^{\mu\nu}\eta \, {}^{\varrho\sigma}\delta}\sqrt{\frac{n}{m}} - \underbrace{\not\ell i^{\varrho}(\tau)^{\mu} \times \underset{0}{}^{\sigma}(\tau)^{\nu}}_{-2\ell\alpha' {}^{\nu\mu}\eta \, {}^{\sigma\varrho}\delta}\sqrt{\frac{m}{n}} + \not\ell^{2} \underbrace{\underset{0}{}^{\varrho}(\tau)^{\mu} \times \underset{0}{}^{\sigma}(\tau)^{\nu}}_{=0}/\sqrt{mn}}$$

$$= 2\,\alpha' \, {}^{\mu\nu}\eta \; \underbrace{\sqrt{\frac{n}{m}} + \sqrt{\frac{m}{n}}} \; \underbrace{\int_{d\sigma/\ell}^{0|\ell} {}^{\sigma m/\not\ell}\mathfrak{c} \, {}^{\sigma n/\not\ell}\mathfrak{c}}_{\delta_{mn}/2} = 2\,\alpha' \, {}^{\mu\nu}\eta \; \delta_{mn}$$