

$$\mathbf{t} = \mathbb{R}^{1:d} i$$

$$\sigma \in 0|\ell$$

$${}^{0:\tau} X^\mu = {}^{\ell:\tau} X^\mu$$

$$0|\ell \xrightarrow{\mathbf{t}^c} \mathbb{R}^{\mathbf{t}} \xrightarrow{\frac{\sigma(\tau)^\mu}{\sigma(\tau)^\mu}} \mathbb{R}$$

$$0|\ell \times \mathbb{R} \xrightarrow{\mathbb{R}^{1:d}} \mathbb{R}^{1:d} \ni {}^{\sigma\tau} X$$

$$S(X) = -\frac{1}{4\pi\alpha'} \int_{d\sigma} \int_{d\tau} \sqrt{-\gamma} \gamma^{\alpha\beta} \partial_\alpha X^\mu \eta_{\mu\nu} \partial_\beta X^\nu$$

$${}^{\sigma\tau} \overline{\mathcal{L}(X)} = -\frac{1}{4\pi\alpha'} {}^{\tau\sigma} \overline{\partial_\alpha X^\mu} \eta^{\alpha\beta} \eta_{\mu\nu} {}^{\tau\sigma} \overline{\partial_\beta X^\nu}$$

$${}^{\tau\sigma} \overline{\mathcal{L}(X)} = -\frac{1}{4\pi\alpha'} {}^{\tau\sigma} X^\mu \eta^{\alpha\beta} \eta_{\mu\nu} {}^{\tau\sigma} X^\nu$$

$$4\pi\alpha' {}^{\sigma} \overline{\mathcal{L}(\tau)} = -{}^{\sigma}(\tau)^\mu \eta^{\alpha\beta} \eta_{\mu\nu} {}^{\sigma}(\tau)^\nu = {}^{\sigma}(\tau)^\mu \eta_{\mu\nu} {}^{\sigma}(\tau)^\nu - {}^{\sigma}(\tau)^\mu \eta_{\mu\nu} {}^{\sigma}(\tau)^\nu = {}^{\ell}(\tau)^\mu \eta_{\mu\nu} \delta^{\sigma}{}^{\nu}{}_{\ell} {}^{\sigma}(\tau)^\nu - {}^{\ell}(\tau)^\mu \eta_{\mu\nu} \delta^{\sigma}{}^{\nu}{}_{\ell} {}^{\sigma}(\tau)^\nu$$

$${}^{\ell}(\tau)^\mu \times {}^{\sigma}(\tau)^\nu = -2\pi i \alpha' \eta^{\mu\nu} \delta^{\ell\sigma}$$

$${}^{\mu}(\tau)_{\ell} = \frac{\partial \mathcal{L}}{\partial {}^{\ell}(\tau)^\mu} = \frac{1}{2\pi\alpha'} \eta_{\mu\nu} {}^{\sigma}(\tau)^\nu \delta_{\ell}^{\sigma}$$

$$i {}^{\mu}(\tau)_{\ell} \times {}^{\sigma}(\tau)^\nu = {}^{\sigma}{}_{\mu} \delta_{\ell}^{\nu}$$