

Exercices: D-branes and Orientifolds

1. Compute the mode expansion for a free boson (open string) with Neumann boundary conditions at $\sigma = 0$ and Dirichlet boundary conditions at $\sigma = \pi$.
2. Show that the Neumann boundary state

$$|B\rangle_N = \exp\left(-\sum_{n=1}^{\infty} \frac{1}{n} j_{-n} \bar{j}_{-n}\right) |\pi_0 = 0\rangle.$$

can be expressed as

$$|B\rangle_N = \sum_{\mathbf{m}} |\mathbf{m}\rangle \otimes |U \bar{\mathbf{m}}\rangle.$$

and find the explicit expression for the complete orthonormal basis of states $|\mathbf{m}\rangle$.

3. Compute the overlap

$$\langle B|e^{-2\pi l(L_0 + \bar{L}_0 - \frac{c}{12})}|B\rangle_N,$$

i.e. the tree-channel annulus diagram.

4. Show that the gauge group of the orientifold of the critical bosonic string is $SO(8192)$.