Errata and comments for the book:

String Theory in a Nutshell, second edition

by Elias Kiritsis

August 24, 2022

Contents

1 Chapter 1: Introduction

2 Chapter 2: Classical String Theory

Section 2.1: The point particle

- In equations (2.1.25)-(2.1.27) a factor of π is missing. The equations should read:

  The solution is

$$\psi_n(\tau) = C_n \sin(n\pi\tau) \quad , \quad \lambda_n = \frac{n^2\pi^2}{L^2} \quad , \quad n = 1, 2, \ldots \tag{2.1.25}$$

and therefore

$$\det\left(-\frac{1}{L^2}\partial_\tau^2\right) = \prod_{n=1}^{\infty} \frac{n^2\pi^2}{L^2}\,. \tag{2.1.26}$$

Obviously the determinant is infinite and we have to regularize it. We shall use ζ-function regularization in which[1]

$$\prod_{n=1}^{\infty}(L/\pi)^{-2} = (L/\pi)^{-2\zeta(0)} = \frac{L}{\pi} \quad , \quad \prod_{n=1}^{\infty} n^a = e^{-a\zeta'(0)} = (2\pi)^{a/2}\,. \tag{2.1.27}$$

The propagator in (2.1.28) is not affected by this as we adjusted the normalization.

Thanks to Xinyu Zhang who pointed out the error.

[1] The Riemann ζ-function is defined as $\zeta(s) = \sum_{n=1}^{\infty} n^{-s}$.

3 Chapter 3: Quantization of Bosonic Strings

Section 3.3: Spectrum of the bosonic string

- Below equation (3.3.2) the order should change and read:

  These states can be interpreted as an antisymmetric tensor B_{ij}, a spin-2 particle G_{ij} (graviton) and a scalar Φ.

  Thanks to Xinyu Zhang who pointed out the error.

4 Chapter 4: Conformal Field Theory

Section 4.2: Conformally Invariant Field Theory

- Equation (4.2.4) should read

$$\delta_{\epsilon,\bar{\epsilon}}\Phi(z,\bar{z}) \equiv \Phi(z,\bar{z}) - \Phi'(z,\bar{z}) = \left[(\Delta\partial\epsilon + \epsilon\partial) + (\bar{\Delta}\bar{\partial}\bar{\epsilon} + \bar{\epsilon}\bar{\partial})\right]\Phi(z,\bar{z})\,, \tag{4.2.4}$$

Thanks to Ching-Chia, Hsu who pointed out the error.

Section 4.12: Free fermions and O(N) affine symmetry

- Below (4.12.1) an index should raised It should read

  Clearly, this model exhibits a global O(N) symmetry, $\psi^i \to \Omega_{ij}\psi^j$, $\Omega^T\Omega = 1$, which leads to the chirally conserved Hermitian ($J_m^{ij\dagger} = J_{-m}^{ij}$) currents

- Just above equation (4.12.33)the line should read:

  Therefore, we obtain the spinor $S = (1+\gamma^{\mathrm{N}+1})/2\ \hat{S}$ and the conjugate spinor $C = (1-\gamma^{\mathrm{N}+1})/2\ \hat{S}$.

  Thanks to Xinyu Zhang who pointed out the error.

Section 4.14: Scalars with background charge

- Equation (4.14.3) should read:

$$\delta R^{(2)} = \left[R^{(2)}{}_{\mu\nu} + g_{\mu\nu}\Box - \nabla_\mu\nabla_\nu\right]\delta g^{\mu\nu}\ , \tag{4.14.3}$$

Thanks to Xinyu Zhang who pointed out the error.

Section 4.16.2: Free Massless Fermions on the disk

- Equation (4.16.11) should read

$$G + \bar{G}\big|_{\sigma=0} = 0 \quad , \quad G - \bar{G}\big|_{\sigma=\pi} = 0 \quad , \quad \text{NS} \quad \text{sector} \; . \qquad (4.16.11)$$

Thanks to Xinyu Zhang who pointed out the error.

5 Chapter 5: Scattering Amplitudes and Vertex Operators

Section 5.2.2: The open String

- Equation (5.2.9) should be replaced by the following equation and text

$$\langle\prod_{i=1}^{m} : e^{ip_i\cdot X(z_i,\bar{z}_i)} : \prod_{I=1}^{n} : e^{iq_I\cdot X(w_I)} :\rangle_{D_2} = (2\pi)^{26}\delta^{(26)}\left(\sum_i p_i + \sum_I q_I\right)\times \qquad (5.2.9)$$

$$\times\prod_{i<j}^{m}|(z_i-z_j)(z_i-\bar{z}_j)|^{\ell_s^2 p_i\cdot p_j} \prod_{i=1}^{m} |(z_i-\bar{z}_i)|^{\ell_s^2 p_i^2}\times$$

$$\times\prod_{I<J}^{n}|w_I-w_J|^{2\ell_s^2 q_I\cdot q_J}\prod_{I,i}|w_I-z_i|^{\ell_s^2 q_I\cdot p_i}|w_I-\bar{z}_i|^{\ell_s^2 q_I\cdot p_i}\,,$$

where w_I are coordinates on the boundary (the real line).

The extra factor in red above comes from the incomplete normal-ordering of the scalar fields with NN boundary conditions. For all surfaces we define the normal order product as

$$: X^\mu(z)X^\nu(z) :\equiv \lim_{\epsilon\to 0}\left[X^\mu(z+\epsilon)X^\nu(z) + \frac{\ell_s^2}{2}\eta^{\mu\nu}\log|\epsilon|^2\right]$$

so that on the sphere

$$\langle : X^\mu(z)X^\nu(z) :\rangle = 0$$

On the disk however with, for example, NN boundary conditions, using the NN propagator

$$\langle X^\mu(z,\bar{z})X^\nu(w,\bar{w})\rangle_{D_2} = -\frac{\ell_s^2}{2}\eta^{\mu\nu}\left(\log|z-w|^2+\log|z-\bar{w}|^2\right)\ . \qquad (5.0.1)$$

we obtain

$$\langle : X^\mu(z)X^\nu(z) :\rangle = -\frac{\ell_s^2}{2}\eta^{\mu\nu}\log|z-\bar{z}|^2$$

Thanks to Pascal Anastasopoulos for bringing this to my attention.

6 Chapter 6: Strings in Background Fields

7 Chapter 7: Superstrings and Supersymmetry

8 Chapter 8: D-branes

9 Chapter 9: Compactification and Supersymmetry breaking

10 Chapter 10: Loop Corrections to String Effective Couplings

11 Chapter 11: Duality Connections and Non-perturbative Effects

12 Chapter 12: Compactifications with Fluxes

13 Chapter 13: Black Holes and Entropy in String Theory

14 Chapter 14: The Bulk/Boundary (Holographic) Correspondence

15 Chapter 15: Applications of the Holographic Correspondence

16 Chapter 16: String Theory and Matrix Models

Appendix A: Two-dimensional Complex Geometry

Appendix B: Differential Forms

Appendix C: Conformal Transformations and Curvature

Appendix D: Theta and Other Elliptic Functions

Appendix E: Toroidal lattice sums

Appendix F: Toroidal Kaluza-Klein reduction

Appendix G: The Reissner-Nordström Black Hole

Appendix H: Electric-Magnetic Duality in $D = 4$

Appendix I: Supersymmetric Actions in Ten and Eleven Dimensions

Appendix J: $\mathcal{N}$=$\mathbf{1}_4$,$\mathbf{2}_4$, Four-Dimensional Supergravity Coupled to Matter

Appendix K: BPS Multiplets in Four Dimensions

Appendix L: Geometry of Anti-de Sitter Space