String Theory Seminar

The room for the seminar will alternate between

- SR 125, Ernst-Zermelo-Str. 1 (MATH) and
- SR II (Physik-Hochhaus), Hermann-Herder-Str. 3 (PHYS).

The reference throughout will be Zwiebach's "A First Course in String Theory", 2nd Edition.

Talk 1: Introduction/Motivation and the Veneziano amplitude

Date: 20.04.
Room: MATH
Speaker: Jochum van der Bij
Reference: Chapters 1, 25.

Talk 2: Review of Lagrangian mechanics and Noether's Theorem

Date: 27.04.
Room: PHYS
Speaker: ?

- Introduce Lagrangians and Lagrangian densities.
- Derive the Euler-Lagrange equations for a dynamical variable. For simplicity, may restrict to case of point particle moving in a time-independent potential.
- Write down the Euler-Lagrange equations for dynamical field variables.
- Define physical motions.
- Explain how to obtain conserved charges/currents from symmetries of Lagrangians/Lagrangian densities.
- Discuss the example of electric charge conservation in Maxwell theory.

Reference: Sections 4.5, 8.1, 8.2.

Talk 3: The non-relativistic string

Date: 04.05.
Room: MATH
Speaker: ?

- Derive the equations of motion for the transverse oscillations of a stretched string.
- Discuss boundary conditions and frequencies of transverse oscillations.
- Present the Lagrangian formulation for the non-relativistic string.

Reference: Chapter 4.

Talk 4: The relativistic point particle

Date: 11.05.
Room: PHYS
Speaker: ?

- Construct the action for the relativistic free point particle.
- Discuss the reparametrisation invariance of the above action.
- Derive the equations of motion of the relativistic free point particle.
- If there is time, discuss the action of an electrically charged relativistic point particle.

Reference: Chapter 5.

Talk 5: The area functional and the Nambu-Goto string action

Date: 18.05.
Room: MATH
Speaker: ?

- Construct the area functional for spatial/space-time surfaces and discuss the reparametrisation invariance.
- Introduce the Nambu-Goto string action.
- Derive the equations of motion and if time permits, discuss their physical interpretation.
- Discuss various boundary conditions and the static gauge.
- Compute the tension and energy of a stretched relativistic string.

Reference: Chapter 6 and Section 7.2.

Talk 6: Conserved currents on the world-sheet

Date: 25.05.
Room: PHYS
Speaker: ?

- Discuss conserved currents on the world-sheet.
- Discuss how one may compute the momentum current using (almost) arbitrary curves on the world-sheet together with an arbitrary parametrisation of the world-sheet.
- Construct the conserved charges associated with Lorentz symmetries.
- Introduce the slope parameter α' and discuss its physical interpretation and relation to the string tension.

Reference: Chapter 8.

Talk 7: Light-cone solution of string equations of motion

Date: 08.06.
Room: MATH
Speaker: ?

- Introduce the light-cone gauge.
- Show how the equations of motions become wave equations in this new gauge.
- Solve the wave equation corresponding to the open string using mode expansions.

Reference: Chapter 9.

Talk 8: Light-cone fields and particles

Date: 15.06.
Room: PHYS
Speaker: ?

- Show how to quantise scalar fields in order to obtain one-particle states.
- Discuss the Maxwell fields and the one-photon states.
- If time permits, discuss gravitational fields and graviton states.

Reference: Chapter 10.

Talk 9: The light-cone point particle and its quantisation

Date: 22.06.
Room: MATH
Speaker: ?

- Compare the Heisenberg and Schrödinger pictures of quantum mechanics.
- Discuss the quantisation of the relativistic point particle and the correspondence with the one-particle states of the scalar field from the previous talk.
- Discuss the light-cone momentum operators and the symmetries they generate.
- Discuss the conserved charges corresponding to light-cone Lorentz generators.

Reference: Chapter 11.

Talk 10: Light-cone string quantisation I

Date: 29.06.
Room: PHYS
Speaker: ?

- Set up the Schrödinger/Heisenberg operators, the commutation relations, and the Hamiltonian.
- Reformulate the commutation relations in terms of oscillators.
- Write down the mode expansions of the transverse and light-cone coordinates in terms of creation and annihilation operators.
- Introduce the Virasoro algebra and discuss how it acts on the string coordinates.

Reference: Chapter 12, 12.1–12.4

Talk 11: Light-cone string quantisation II

Date: 06.07
Room: MATH
Speaker: ?

- Define the quantum Lorentz generators in light-cone gauge.
- Discuss the constraint on the dimension of space-time.
- Construct the space of states for the quantum open string and present some particular states in details (e.g. ground states, general massless states, etc.).
- If time permits, discuss the Schrödinger equations satisfied by string wavefunctions.

Reference: Chapter 12, 12.5–12.7.

Talk 12: Covariant quantization

Date: 13.07.
Room: PHYS
Speaker: ?

- Discuss the advantages/disadvantages of light-cone vs. covariant quantisation.
- Show how to select the physical states using Virasoro operators for open strings.
- Construct the Lorentz covariant state space and describe some of its physical states.

Reference: Chapter 24, 24.1–24.4.

Talk 13: No-ghost Theorem

Date: 20.07.
Room: MATH
Speaker: ?

- Describe the spectrum generating algebra that gives all possible physical states for the covariantly quantised string.
- State the no-ghost theorem and give a proof.
- Explain the importance of the no-ghost theorem in terms of the relation between light-cone and covariant quantisation.

Reference: Here we make the only exception and look at 2.3.2–2.3.3 of "Superstring Theory", Vol I by Green, Schwarz, and Witten.