

Particules Élémentaires, Gravitation et Cosmologie
Année 2006-2007

String Theory: basic concepts and applications

Lecture 1: 20 February 2007

The birth of string theory: a personal recollection

General remarks about the course

- Not really a course on string theory
- Most technicalities left out
- Emphasis on physical concepts and open problems
- Choice of topics reflects personal taste/competence

Outline of the course

1. **20 February** *The birth of string theory: a personal recollection*
2. **23 February** *The string effective action: Symmetries and perturbative expansions*
3. **27 February** *Strings and black holes*
4. **2 March** *Transplanckian string collisions*
5. **13 March** *String cosmology I: basic ideas*
6. **16 March** *String cosmology II: results and open problems*

19-21 March: miniworkshop on
Supersymmetry, Supergravity, Superstrings

The birth of String Theory: a personal recollection

1. Prehistory (see transp. 1-4)

- 1.1 Sergio Fubini's talk(s) in Pisa, spring 1966
- 1.2 Playing with Current-Algebra and Superconvergence at the WIS (1966-'67)
- 1.3 M. Gell-Mann's talk at Erice, July 1967:
Chew's expensive bootstrap.
DHS duality and a cheap bootstrap
- 1.4 $\pi\pi \rightarrow \pi\omega$ at the WIS/Harvard (1967-'68)
- 1.5. A cheap solution to a cheap bootstrap (summer 1968)

2. Dual Resonance Models (see transp. 5-11)

2.1 Counting states

- n-point generalizations
- Counting via factorization
- The Hagedorn spectrum

2.2 Operators

- Operator formalism
- Ghosts

2.3 Ghost-hunting and $\alpha_0=1$

2.4 Algebras

- Vertex operators
- $O(2,1)$ and manifest duality
- Classical and quantum Virasoro algebra
- The no-ghost theorem

2.5 $D=26$

- Planar and non-planar loops
- The Pomeron and $D=26$
- $D=26$ and DDF states

3. Early hints of underlying string (see transp. 12)

- 3.1 From duality and duality diagrams
- 3.2 From the linear Regge trajectories
- 3.3 From the harmonic oscillators
- 3.3 From $Q(z)$ and its correlators

4. Good and bad news (see transp. 13)

4.1 The good (theoretical) news

NS and R extensions,
GSO projection and tachion elimination
A fully consistent superstring

4.2 The bad (phenomenological) news

$D \neq 4$

$m=0$ states with $J = 0, ..2$

Softness, whereas...

Scaling in R

B_j scaling

Large p_+ at the ISR

were all showing point-like structures in the hadrons

5. QCD takes over (see transp. 14)

5.1 Asymptotic freedom and hard processes

5.2 Infrared slavery and a non-conventional QFT

5.3 Large-N and the reasons behind a red-herring

6. A theory of Quantum Gravity? (see transp. 15)