

# Generalizing String Theory, p-adic Numbers

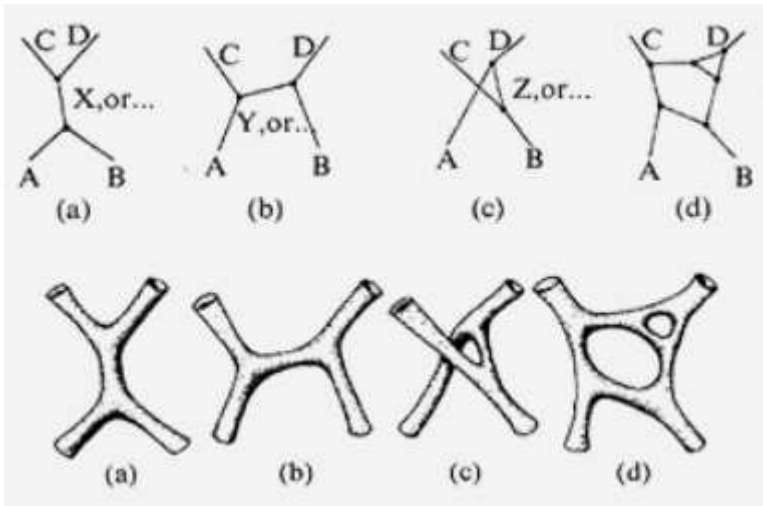
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Bled , June, 2018

<sup>4</sup> *The Niels Bohr Institute, Copenhagen*  
*H.B. Nielsen presents the talk.*

# Searching for a Non-divergent Quantum-Field-Theory-like Theory

(Super) String theories have that constructing loop corrections does **not lead to ultraviolet divergences!** Nevertheless they have so good physical properties, that they are **serious** candidates for the theory of Nature. From the point of view of the Novel String Field Theory of M. Ninomiya and HBN we can consider the strings composite from an infinite number of what we call “objects” - to some extend similar to C. Thorn's string bits, but deviate by our objects corresponding to a discretization of the right and left variables on the string  $\tau - \sigma$  and  $\tau + \sigma$ , while C. Thorn rather discretize  $\sigma$  just.

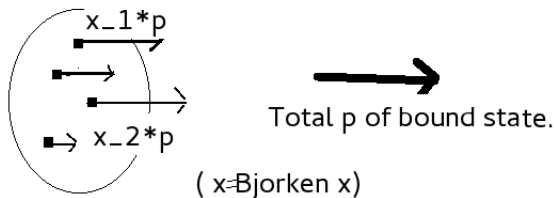


# Even the Loop Corrections in Veneziano Model / String Theory are Nicely Gaussianly Cut Off at High Momentum Transfer → No Ultraviolet Divergences.

String theory actually avoids the ultraviolet divergences in the loop corrections (corresponding to the loops in quantum field theory, which usually have such divergences) by giving amplitudes - both at first in the Veneziano model and in the calculated loop corrections - falling off exponentially with a squared of the external momenta expression.

One can consider the string as composed of infinitely many constituents, which thus have Bjorken  $x = 0$ .

In deep inelastic scattering one often uses the concept of a hadron / proton is composed of partons as a bound state:



Partons move for large total momentum  $p$  with a fraction  $x * p$ .

# Large Transverse Momentum Events Typically Due to Parton(=Quarks or Gluons) Hitting Each Other

When the Bjorken  $x$  is non-zero one can for sufficiently high collision energy obtain large transverse momenta - jets - for scattering of constituent partons with  $x \neq 0$ .

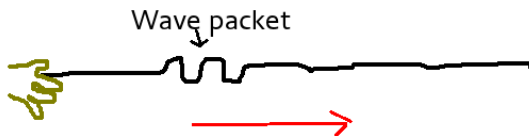
Such scattering could again give ultraviolet divergences, so to realize our dream of getting rid of ultraviolet divergences for the bound states we should use bound states with all Bjorken  $x = 0$  !

# Ninomiya and mine Novel String Field Theory (= Theory of Several Strings)

Some characteristic features of our novel string field theory:

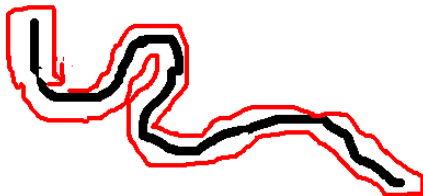
- Our novel SFT is a kind of string-bit theory like that of Charles Thorn; but **we discretize using the right and left mover variables  $\tau - \sigma$  and  $\tau + \sigma$  contrary to Charles**, who uses the genuine string parameter  $\sigma$ . So our constituents/**objects** are associated rather with wave packets **running along the string back and forth**.
- It turns out that our constituents =**objects do not change** at all.
- Thus **scattering is exchange of objects**, rather than interpreted as collisions of the objects.

# Ninomiya and mine Novel String Field Theory (Many String Theory)



Shaking an at first straight and resting string you may produce a wave-packet moving in just ONE direction, untill it reflects at the end.





A little wave-packet of phonons would run along the string, first one way and then be reflected at an end and run back.

The whole way around in a period would correspond to a run both forth and back and have the topology of  $S^1$ .

# Great Point: Objects do Not Change.

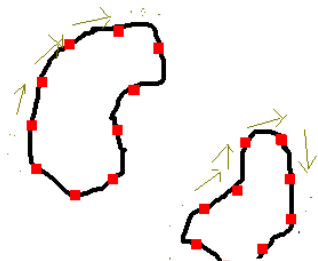
Corresponding to that the wave packets run along the string without any change we arrange that our “objects” - which describe these wave structures as moving along - do Not change in time at all! So our description of a several string theory (= a string field theory) has no development in the object formulation. The string theory is so to speak **solved** in terms of objects! This is the great hallmark of our novel string field theory: **Nothing moves!** All the scattering (etc.) is faked.

# Idea of Adding Faked Degrees of Freedom, Successor Function.

To form the cyclically ordered chains of objects corresponding to going forth and backward along the open string we need a cyclic ordering of a series of objects. We could describe that by a successor function  $f$  mapping one object to the next one in the chain:

$$f(obj_I) = obj_{I+2(mod N)}. \quad (1)$$

(Due to a technical detail we only consider objects with an even number in the cyclic chain serious.)



cyclically ordered chains.

→ is the  $f$  map.

# Admit, That Annihilation of Objects with Each Other has Plagued and Even Plagues Us in Generalizing Our Novel String Field Theory

In order that our string field theory - i.e. the model with “objects” being exchanged from bound state (= string) to Bound state (= another string), which should be a reformulation of string theory (with several strings) - shall give the full Veneziano model we need to introduce the possibility for **objects to annihilate with each other**.

( However, I still **do not feel I can formulate in the quite correct way** in the generalization of our novel string field theory, which we hope for.)

## Definitions:

Given a number  $b \in \mathbf{Q}$  = the set of rational numbers, write  $b = rp^n/s$  for  $r, s, n \in \mathbf{Z}$ , where  $p$  divides neither  $r$  nor  $s$ . Then  $\text{ord}_p(b) := n$ . The  $p$ -adic **norm** on  $\mathbf{Q}$  is defined by

$$|b|_p := \frac{1}{p^{\text{ord}_p(b)}} \quad (2)$$

and the  $p$ -adic metric on  $\mathbf{Q}$  is the metric induced by the  $p$ -adic norm, so  $|xy|_p$  is the  $p$ -adic distance between  $x$  and  $y$ . One checks that  $|\cdot|_p$  is indeed a norm, and that the  $p$ -adic metric is an ultrametric.

$$A_p(s, t) = \frac{\Gamma_p(\alpha(s))\Gamma_p(\alpha(t))}{\Gamma_p(\alpha(s) + \alpha(t))}. \quad (3)$$

Here Moritas p-adic gamma function  $\Gamma_p : \mathbf{Z}_p \rightarrow \mathbf{Z}_p^*$  is defined on positive integers as

$$\Gamma_p(n+1) = (-)^{(n+1)} \prod_{m=1, p \nmid m}^n m \quad (4)$$

where,  $p \nmid m$  means that  $m$  is not divisible by  $p$ . This is then extended to  $\mathbf{Z}_p$  by continuity and is a generalisation of the factorial function to p-adic integers.

# Conclusion

The main point was:

- Following the idea of our - M. Ninomiyas and HBNS - Novel String Field Theory, one may make some **general formalism**, that hopefully includes p-adic string theory.
- By means of a “faked Hamiltonian” only developing the “faked” d.o.f. telling about how the objects (in our novel SFT) are ordered along in cyclically ordered chains (but not about the energy and momentum  $J^\mu$  of the objects) we can argue for the unitarity of somewhat truncated, but loop containing version of the unitarized Veneziano model. This model was really a first version of our novel SFT attempted unitarized in analogy with the unitarization of the Veneziano model.



## Conclusion (Continued)

- We also at least attempted to put forward generally the following idea:
  - Take as fundamental a model in which there are objects, the momenta, say, of which are static (do not change);
  - But interpret nevertheless such a - seemingly empty model - as having scattering among bunches of the objects.
  - This interpretation is achieved by saying, that the objects incomming contained in the incomming bound states (or strings) are being redistributed between these incomming particles, and thenafter this redistribution the clumps of the object are interpreted as the outgoing particles.