Golden Jubilee of String Theory

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What is perturbative string theory?

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Three facets of weakly coupled strings

1. The spacetime S-matrix

[Veneziano '68, ..., Caron-Huot, Komargodski, Sever, Zhiboedov, '16, ...]

2. The effective string

[Nambu-Goto, Green-Schwarz '81, ... Polchinski, Strominger '91, Dubovsky, Flauger, Gorbenko '12, Aharony, Komargodski '13, Hellerman, Swanson '13, ...]

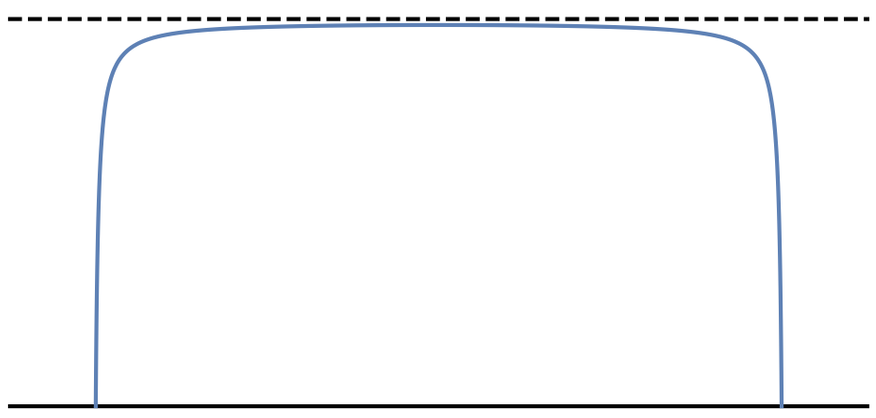
3. The worldsheet CFT

[Polyakov '81, ... Friedan, Martinec, Shenker '85, ..., Zwiebach '92, ..., Berkovits, Vafa, Witten '99, Berkovits '00, ..., Sen '14, ...]

Weakly coupled relativistic string theories are ubiquitous, e.g. flux strings in large N confining gauge theories. Excitations are trapped on the string in the free-string/infinite-N limit.

In critical string theories, excitations on a long string happen to be integrable.

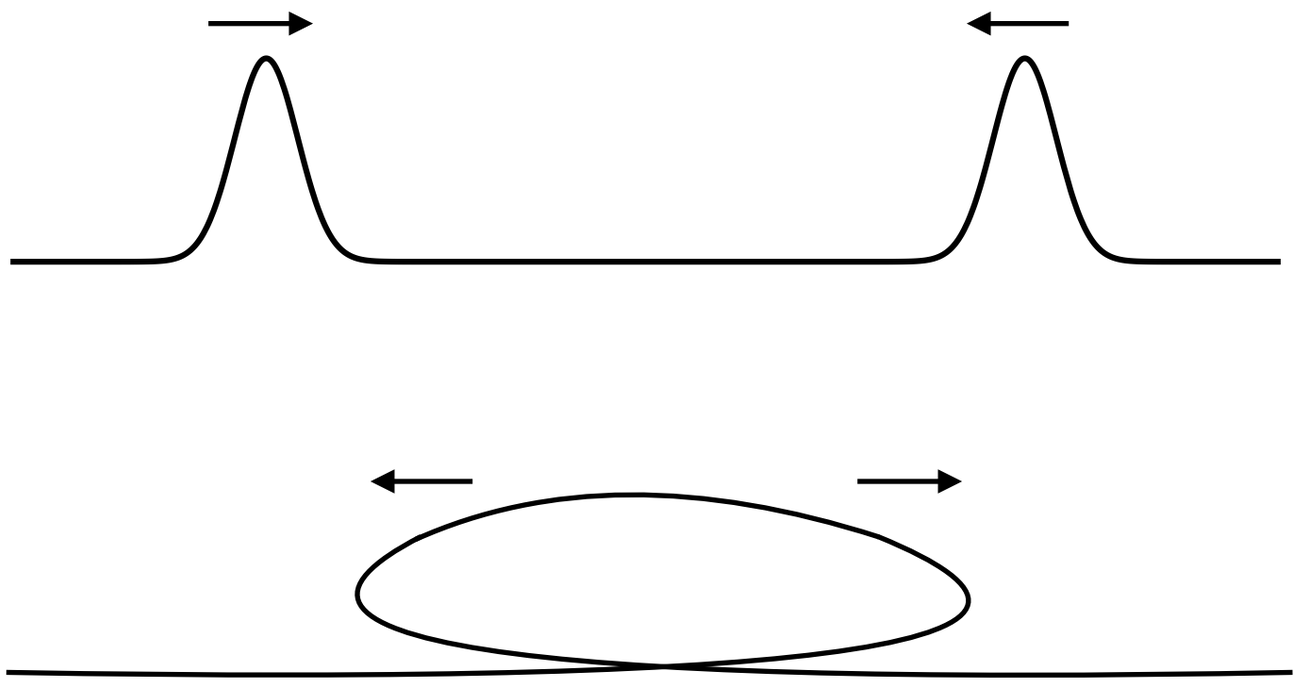
A more general relativistic string … may be embeddable in critical string theory in a nontrivially warped background?



[Maldacena ’98, Witten ’98, Aharony, Karzbrun ’09, …]

... or bootstrapped through the 1+1 dim S-matrix on a long string? [Paulos, Penedones, Toledo, van Rees, Vieira, '16]

Note: not a local 1+1 d QFT in static gauge.



UV/IR connection, reminiscent of gravity S-matrix ...

[Dubovsky, Gorbenko '15, Dubovsky '18]

Standard recipe for UV completion of the effective theory of weakly coupled strings: worldsheet CFT with BRST symmetry.

Implicit assumption: locality on the worldsheet (in the conformal gauge).

But, is a local worldsheet CFT necessary? Or is it just an accident in critical string theory?

A clue: superstrings in RR flux background.

It is often asserted that NSR formalism does not apply in RR flux background.

Not a problem in closed superstring field theory based on NSR formalism and PCOs. [Pius, coffee break]

Can also describe RR flux background as deformation of worldsheet CFT in NSR formalism. [Berenstein, Leigh '99]

Insert into the worldsheet correlator

$$\exp\left(-\int V^{0,0}_{\mathrm{NS,NS}}\right)\sum_{n=0}^{\infty}\frac{1}{(2n)!}\left(\int V^{-\frac{1}{2},-\frac{1}{2}}_{\mathrm{R,R}}\right)^n\left(\int V^{\frac{1}{2},\frac{1}{2}}_{\mathrm{R,R}}\right)^n$$

Cancelation of Weyl anomaly due to colliding RR vertex operators by NS-NS operators (that would have been off-shell by themselves) leads to supergravity equations involving RR fluxes. [Berenstein, Leigh '99]

Can compute correction to string spectrum, agrees with expectation in pp-wave and AdS_3xS^3 with RR-flux.

[Cho, Collier, XY, W.I.P.]

This looks like a nonlocal deformation of the worldsheet CFT.

Perhaps the worldsheet nonlocality in RR flux background is circumvented in pure spinor formalism, but this is far from obvious, as interacting ghost systems are hard to define quantumly. [Berkovits, Vafa, Witten, '99, Berkovits '00, '02, ...]

A cautionary tale: Liouville CFT cannot be thought of as a perturbation of linear dilaton theory.

Doing so in the early 90s (pre-DOZZ era) has led to a great deal of confusion in the study of c=1 string theory, much of which is resolved when the correct CFT results are applied.

[Balthazar, Rodriguez, XY, '17 + W.I.P.]

Interacting ghost systems resemble non-unitary Liouville theories... rule of quantization a priori unclear.

Conclusion: there is much to be understood on the worldsheet.

Hope for the future: a more general framework for UV completion of effective strings.