QFT and Strings

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CERN Theory Retreat
Les Houches 2015
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visiting TH until Jan 2016

AdS/CFT, conformal bootstrap, ...
Group activities

Journal club: Monday 2pm

String/QFT Seminar: Tuesday 2pm

Winter school on String theory and QFT: 1st week of February

TH-institutes:

M-theory and string theory, February 2016

Emergence Institute, Summer 2016 (together with COS, LAT)
What is “formal theory”? 
QFT (at strong coupling)
QCD, BSM physics?, condensed matter

Quantum Gravity
physics at Planck scale, black holes, cosmology
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String theory
fundamental principles, mathematical physics, string phenomenology
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**AdS/CFT**: QFT ⇔ gravity
Developments and challenges
(a personal selection)
CFTs, conformal bootstrap

\[ \sum_{k} \frac{1}{k} = \sum_{k} \frac{1}{k} \]

Non-perturbative constraints for CFTs (spectrum/correlators) — (in various dimensions, SUSY or not, etc.)

Numerical results for specific CFTs (3d Ising model, ...)

Lorentzian OPE

Bootstrap and emergence of bulk in AdS/CFT, consistency of CFTs and AdS-gravity
SUSY QFT
Supersymmetric localization

\[ \int [dA_\mu] e^{-S[A_\mu]} \Rightarrow \int [d\lambda] e^{-S_{\text{BPS}}[\lambda]} \]

Exact computation of observables (all orders in perturbation theory + instanton corrections)

Partition function, correlation functions, superconformal indices

Window to non-perturbative physics, dualities between QFTs

Families of 3d/4d SCFTs, geometry of conformal manifolds
Other QFT developments

**Integrability** spectrum of planar $\mathcal{N} = 4$ SYM correlators using integrability
IIB AdS string dual of planar $\mathcal{N} = 4$ ?

**Amplitudes**
String theory fundamentals

Dualities, non-perturbative physics

Topological strings

Higher loop computations in string perturbation theory

Counting of BPS black hole microstates, wall crossing
String phenomenology
compactifications of string theory, phenomenology
F-theory, non-perturbative IIB string theory and geometry
SUSY breaking, inflation in string theory, de Sitter vacua
Consistency of KKLT and string landscape
Gravity and Quantum Mechanics

AdS/CFT: spacetime (and gravity) are emergent

Locality is approximate (BHs, cosmology)

How exactly do we understand emergence of bulk from boundary? New tools: entanglement, quantum information
Entanglement and spacetime
Ruy Takayanagi

\[ S = A/4G \]

\[ S = -\text{Tr}(\rho \log \rho) \]

Consider \( \rho \to \rho + \delta \rho \) \( \Rightarrow \delta S = \delta E \) \( \Rightarrow \) Einstein equations
**ER=EPR**

Entanglement = Wormhole

\[ H = H_L + H_R \]

\[ |\Psi\rangle = \sum_{E} \frac{e^{-\frac{\beta E}{2}}}{\sqrt{Z}} |E\rangle_L \otimes |E\rangle_R \]
Dynamics and thermalization
Quark Gluon Plasma $\iff$ Black Hole
Hydrodynamics of QGP, transport coefficients
Time dependent collapse, AdS instabilities

Quantum Chaos: transplanckian collisions near horizon $\Rightarrow$
Lyapunov exponent for plasma
What I am thinking about:

Quantum aspects of Black Holes

Holography (emergence of locality in AdS/CFT, flat/dS holography)

Aspects of non-perturbative QFT (SUSY, CFTs)
Black hole info paradox

Firewall/fuzzball: Unitarity inconsistent (?) with smooth interior.

Is there spacetime behind the horizon?
Black hole interior in AdS/CFT
Concrete proposal on how to reconstruct the black hole interior in AdS/CFT.

Towards a resolution of firewall/info paradox, in progress...
Relevance of BH interior for thermalization?
Probing the black hole singularity
Thank you