Confinglement

Niko Jokela

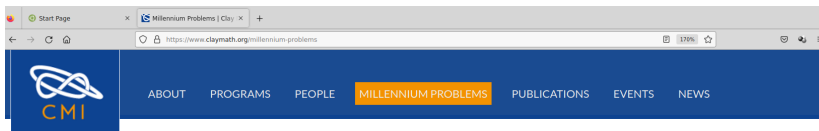UNIVERSITY OF HELSINKI   HELSINKI INSTITUTE OF PHYSICS

works in progress w/ A.Pönni, T.Rindlisbacher, K.Rummukainen, A.Salami

Particle Physics Day
Hotel Arthur – 24 November 2022

- Color confinement is poorly understood
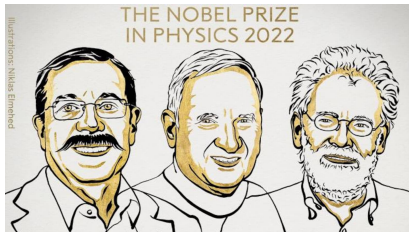

- ∃ physicist's proofs of confinement in exotic gauge theories
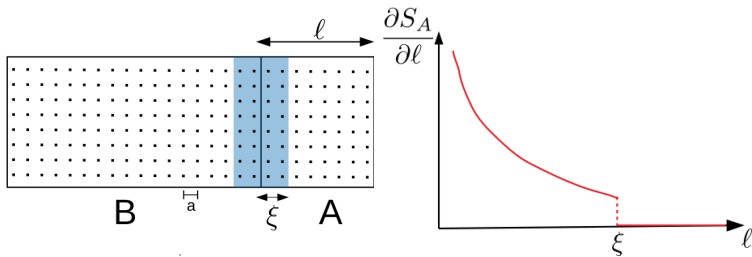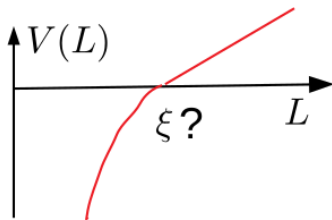- Can we get insights with other tools?

- Despite

entanglement is very poorly understood
- Because in QFT

$$\mathcal{H}_{\mathsf{physical}} \longrightarrow \mathcal{H}^{(1)}_{\mathsf{physical}} \otimes \mathcal{H}^{(2)}_{\mathsf{physical}}$$

Confinglement

- Entanglement probes confinement:

  - number of colors is $N_c = 3 \sim \infty$
  - entropy density scales as $\mathcal{O}(N^0)$ (confined) vs. $\mathcal{O}(N^2)$ (deconfined): order parameter
 - can define entanglement function that measures dofs

Can one compute entanglement entropies?

- Yes: put Yang-Mills theory on the lattice
  [Buividovich-Polikarpov 0802.4247]
  [Itou-Nagata-Nakagawa-Nakamura-Zakharov 1512.01334]
  [Rabenstein-Bodendorfer-Buividovich-Schäfer 1812.04279]

- Bad signal-to-noise ratio, improved it w/ a new method
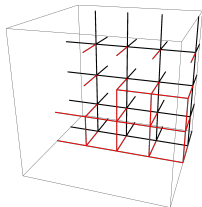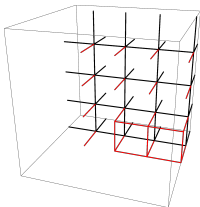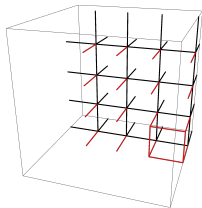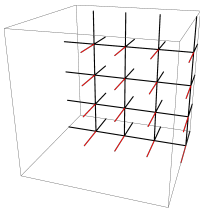
Can one compute entanglement entropies?

- Find the dof "order parameter" $C(\ell) \sim \ell^3 \frac{\partial S}{\partial \ell}$:

  [NJ-Pönni-Rindlisbacher-Rummukainen-Salami to appear]
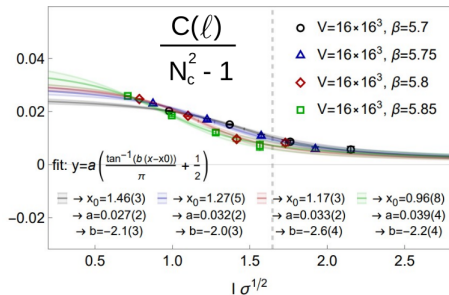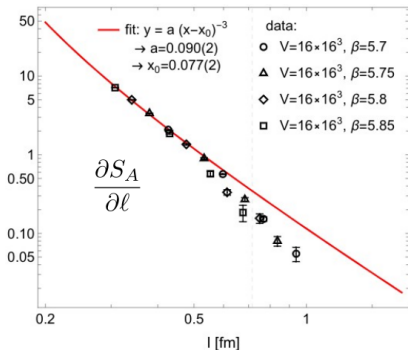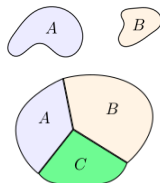

- SU(3) Yang-Mills mass gap $1/\xi$ from entanglement somewhat comparable to $T_c \sim 276 \text{MeV} \sim 0.73 \text{fm}^{-1}$

Points of interest

Recent progress (mostly) in exotic field theories (>2014):

- dependence of A (shape, topology, singularities)
- characterization of fixed points and RG flows, also w/ anisotropy
- mutual (entanglement+correlations), tripartite info (correlations of correlations)...

Applications

- black holes
- correlations of fields in cosmological spacetimes
- probe of Fermi vs. non-Fermi liquid behavior
- probe of quenches, thermalization, propagation of entanglement, chaos
- deep inelastic scattering

  [Kharzeev-Levin 1702.03489]

- $\bar{\nu}_\mu + N \to \mu^+ + \pi^0 + X$

  [Iskander-Pan-Tyler-Weber-Baker 2010.00709]

- indicative of QCD accidental symmetries
  [Beane-Kaplan-Klco-Savage 1812.03138, Liu-Low-Mehen 2210.12085]