Color Memory

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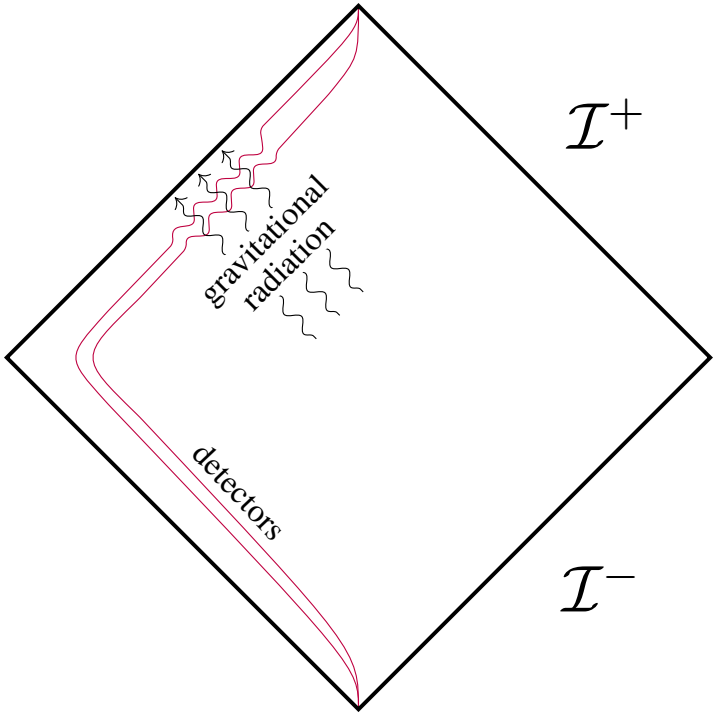
Based on:

1707.08016/hep-th with Raclariu and Strominger
1805.12224/hep-ph with Ball, Raclariu, Strominger and Venugopalan

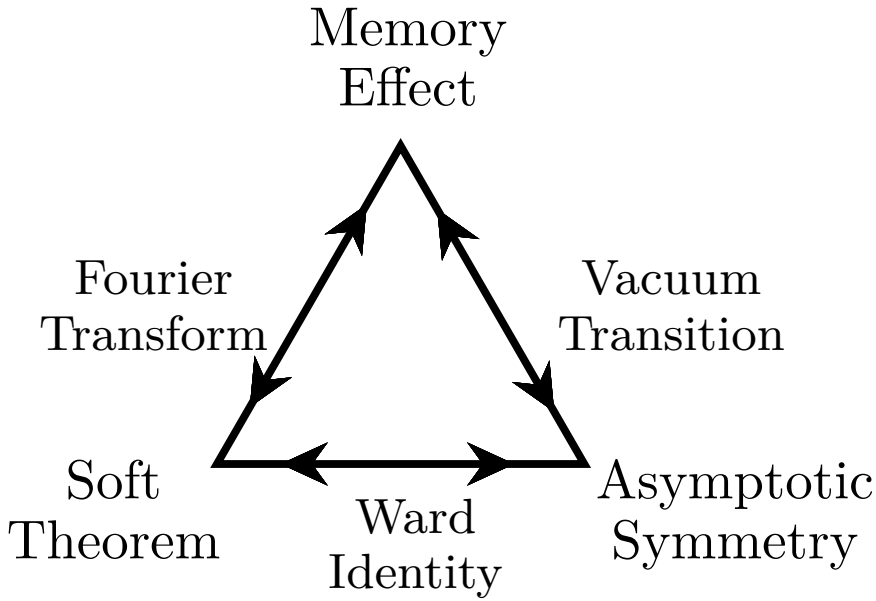
Background

Gravitational Memory



Zel'dovich & Polnarev, 1974

The Infrared Triangle

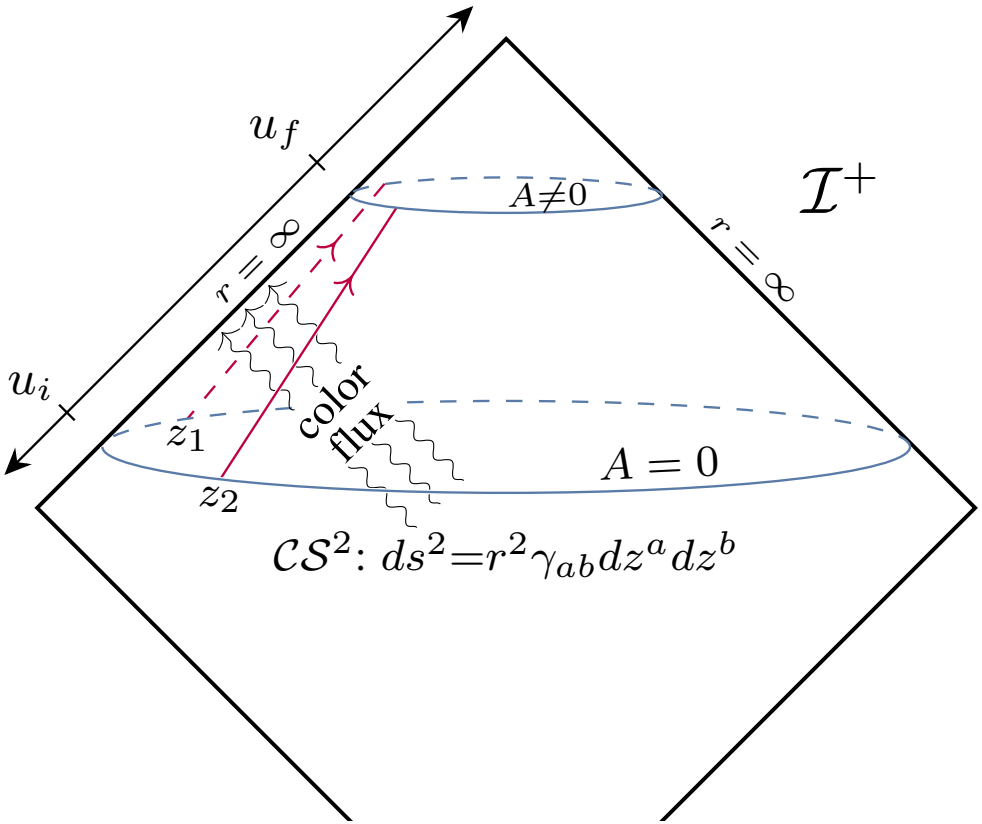


Strominger & Zhiboedov, 1411.5745

Strominger, 1703.05448

The Color Memory Effect

A permanent relative color rotation of a pair of "test" quarks induced by the transit of color flux across null infinity.



$\underline{u < u_i}$:

- color singlet
- flat connection on $\mathcal{CS}^2$

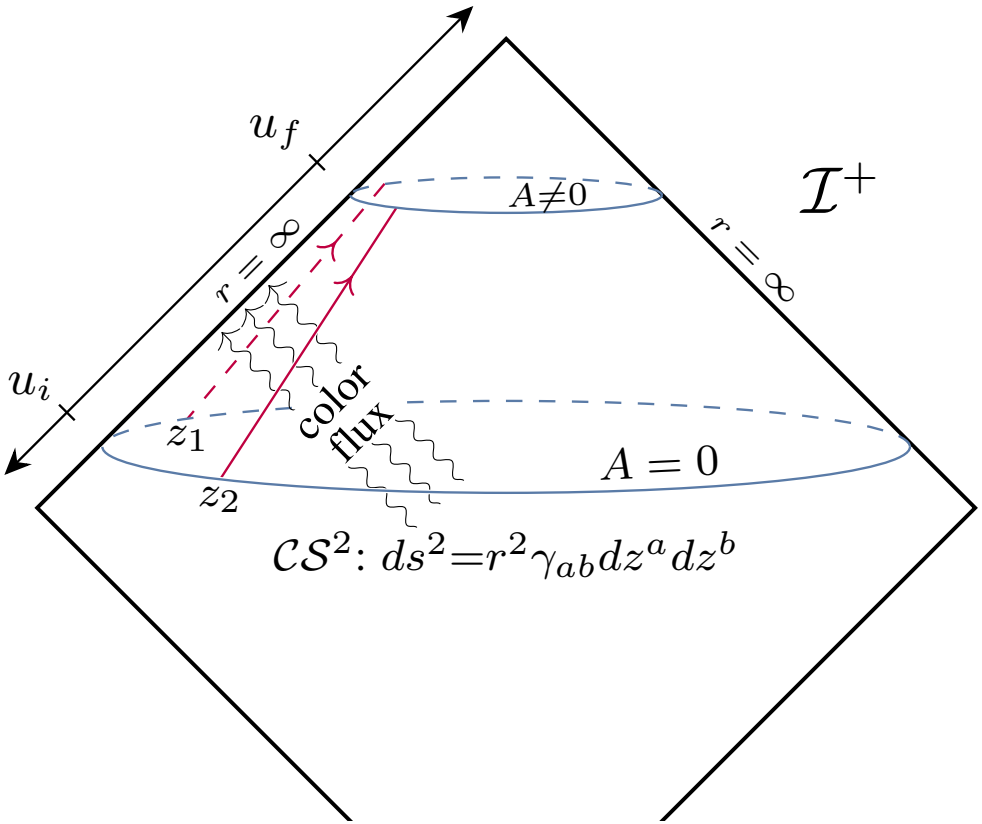
$$A = iUdU^{-1} = 0,$$
$$(U = 1).$$

$\underline{u_i < u < u_f}$:

- color radiation flux through $\mathcal{I}^+$
- gauge choice $A_u = 0$
  $\Rightarrow$ no color evolution
  $(\partial_u q = iA_u q = 0)$

The Color Memory Effect (continued)

A permanent relative color rotation of a pair of "test" quarks induced by the transit of color flux across null infinity.



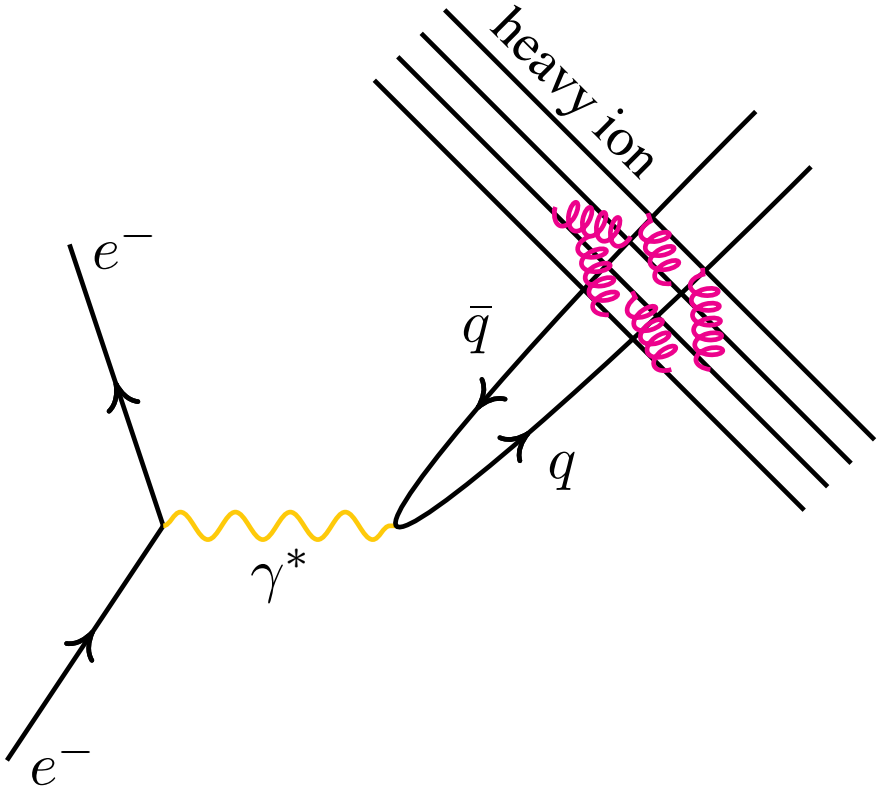
$\underline{u > u_f}$:

- no radiation $\Rightarrow$ flat connection
$$A = iUdU^{-1}$$
- classical constraint
$$-\partial_u D^a A_a = J_u + \partial_u F_{ru}$$
$$\Rightarrow A \neq 0 \; (U \neq 1)$$
- quarks acquire relative color rotation

$$U(z_1)U^{-1}(z_2) = \mathcal{P}\exp\left(i\int_{z_2}^{z_1} A\Big|_{u_f}\right)$$

$\Rightarrow$ "memory" of color flux

Measuring Color Memory



- DIS of electrons off heavy ions
- Regge limit $\rightarrow$ classical YM sourced by hard partons

  (McLerran, Venugopalan, and many more)
- "test" quarks $\rightarrow$ quark dipole $(q\bar{q})$
- color flux $\rightarrow$ hard partons in ion
- dipole cross-section $\sim$ color singlet survival probability

$$\sigma_{\text{dipole}} \sim 1 - \left\langle \text{Tr}\left(U(z_1)U(z_2)^{-1}\right)\right\rangle_{\substack{\text{color}\\ \text{source}\\ \text{ave.}}}$$

- inclusive DIS virtual photon-heavy ion cross-section

$$\sigma_{\gamma^* \text{ion}} \sim \int_{z_1,z_2} |\psi_{\gamma^* \rightarrow q\bar{q}}|^2 \sigma_{\text{dipole}}$$

Summary

- The memory effect in classical Yang-Mills theory is the permanent relative color rotation of a pair of "test" quarks induced by the transit of color flux across null infinity.

- Measurement of a color memory effect may be experimentally accessible in the Regge limit of deeply inelastic scattering processes at electron-ion colliders.