ArXiv: 1510.xxxx

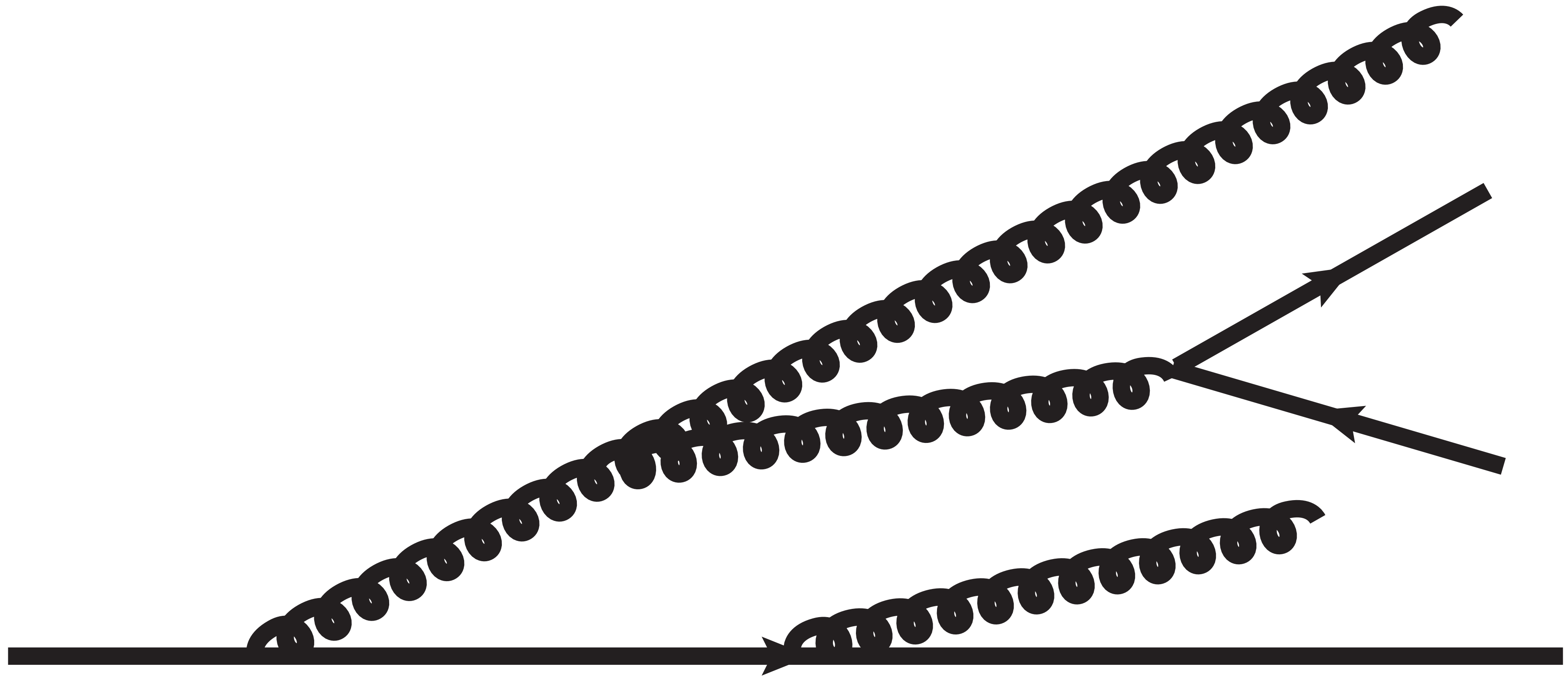
Jet Formation and Interference in Quark Gluon Plasma

Jorge Casalderrey-Solana

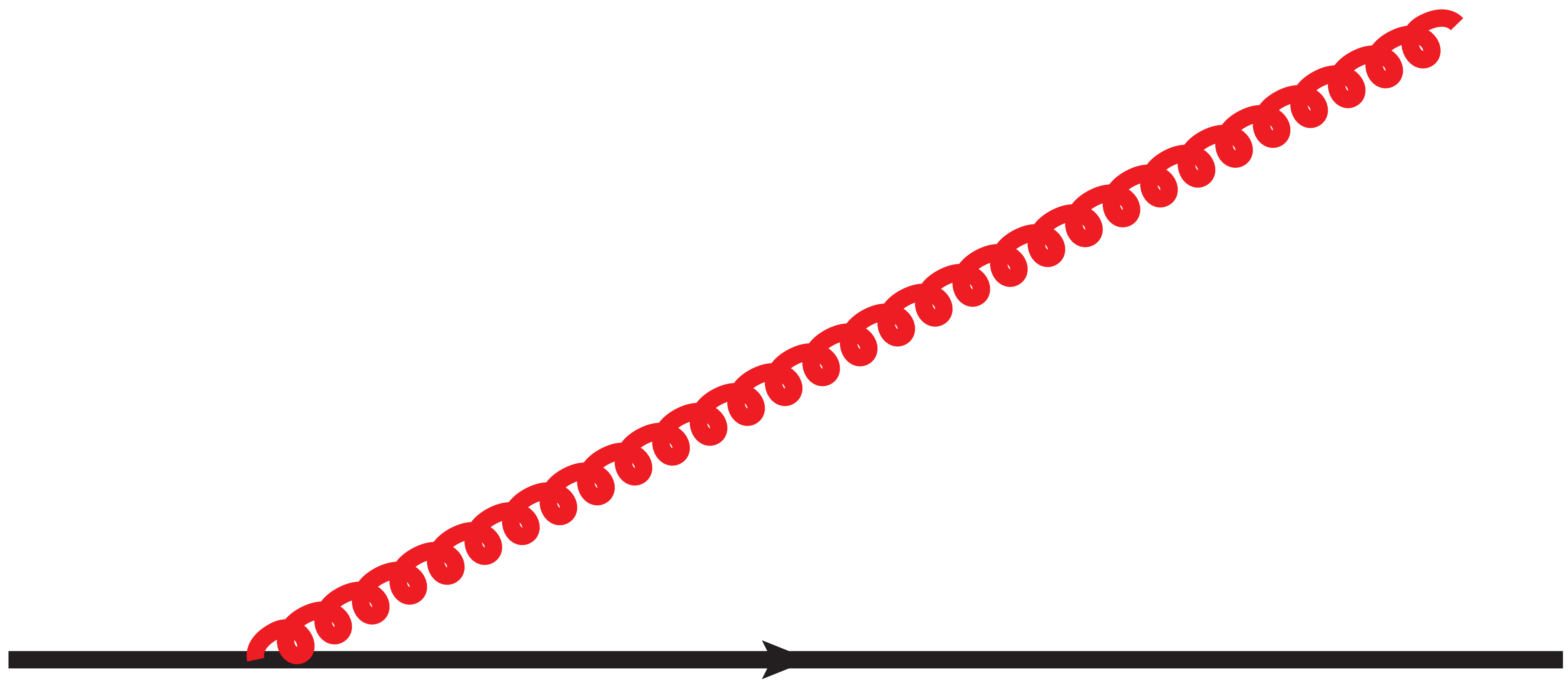
in collaboration with D. Pablos and K. Tywoniuk

UNIVERSITAT DE BARCELONA

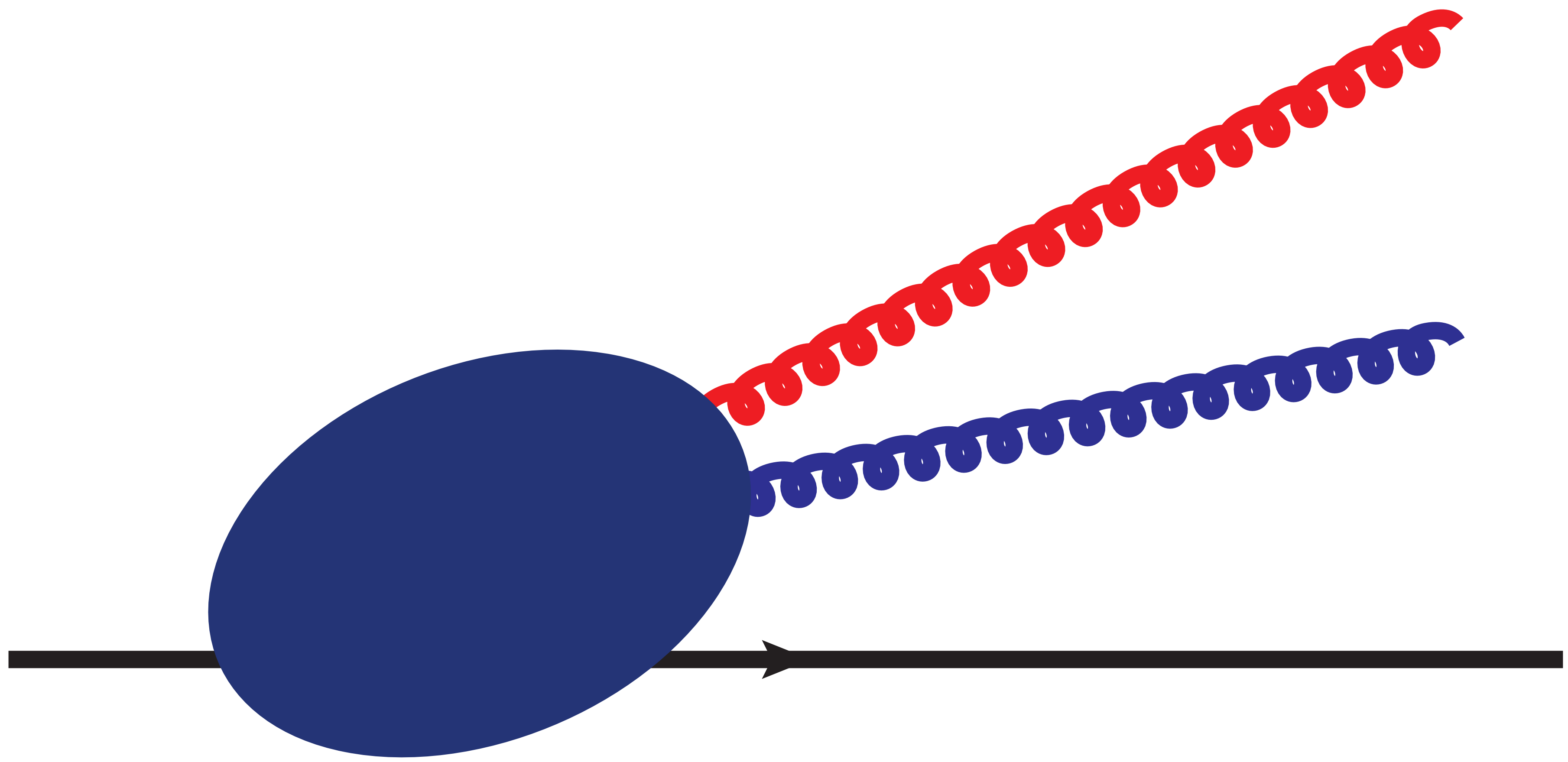
Jets



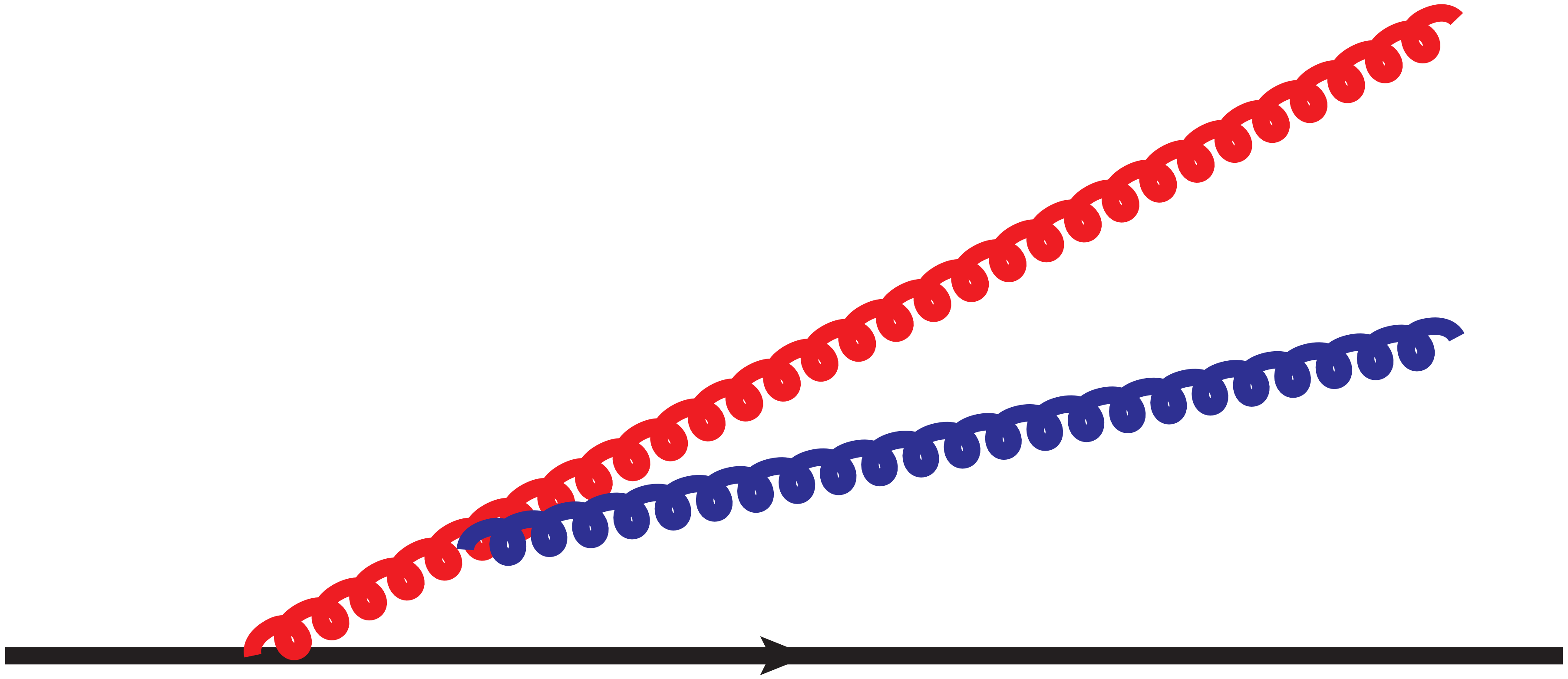
Single Gluon Emission



Two Gluon Emission



Interference



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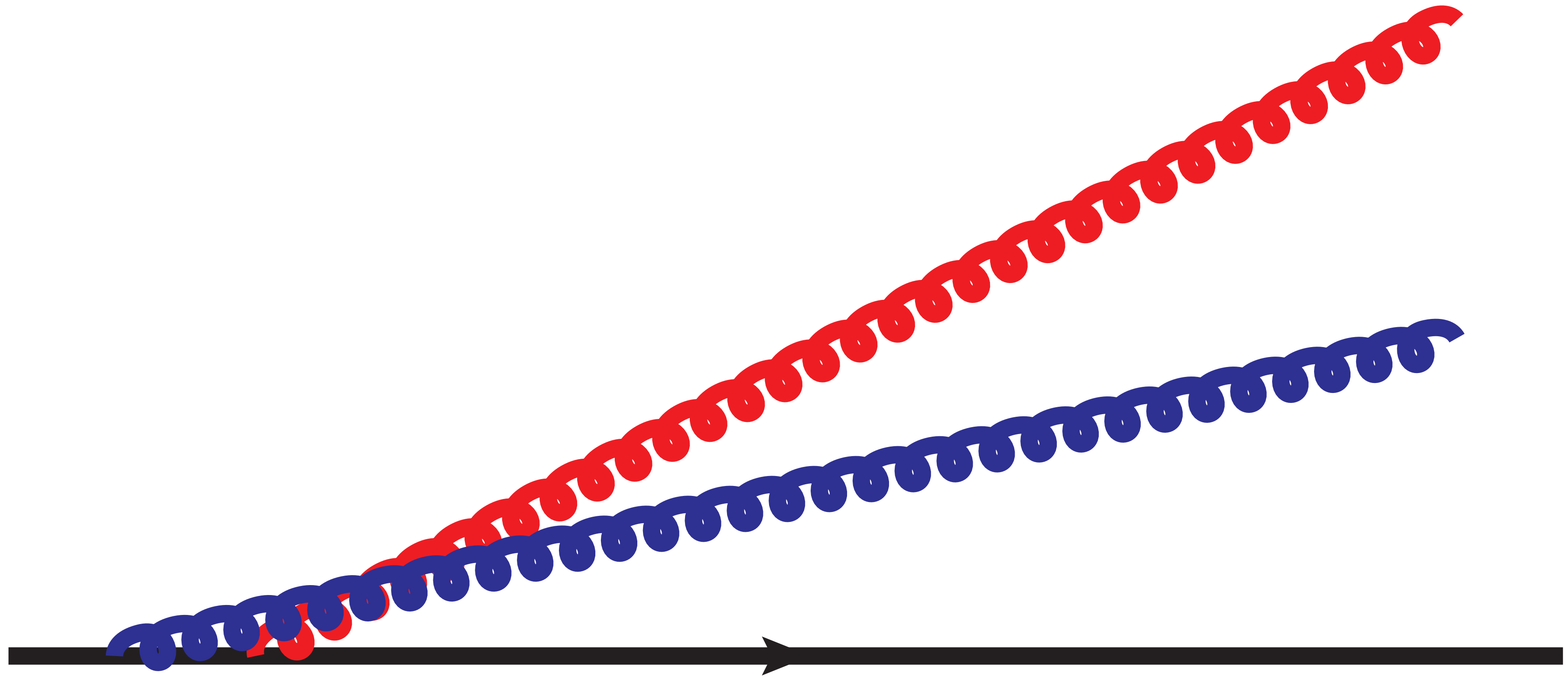

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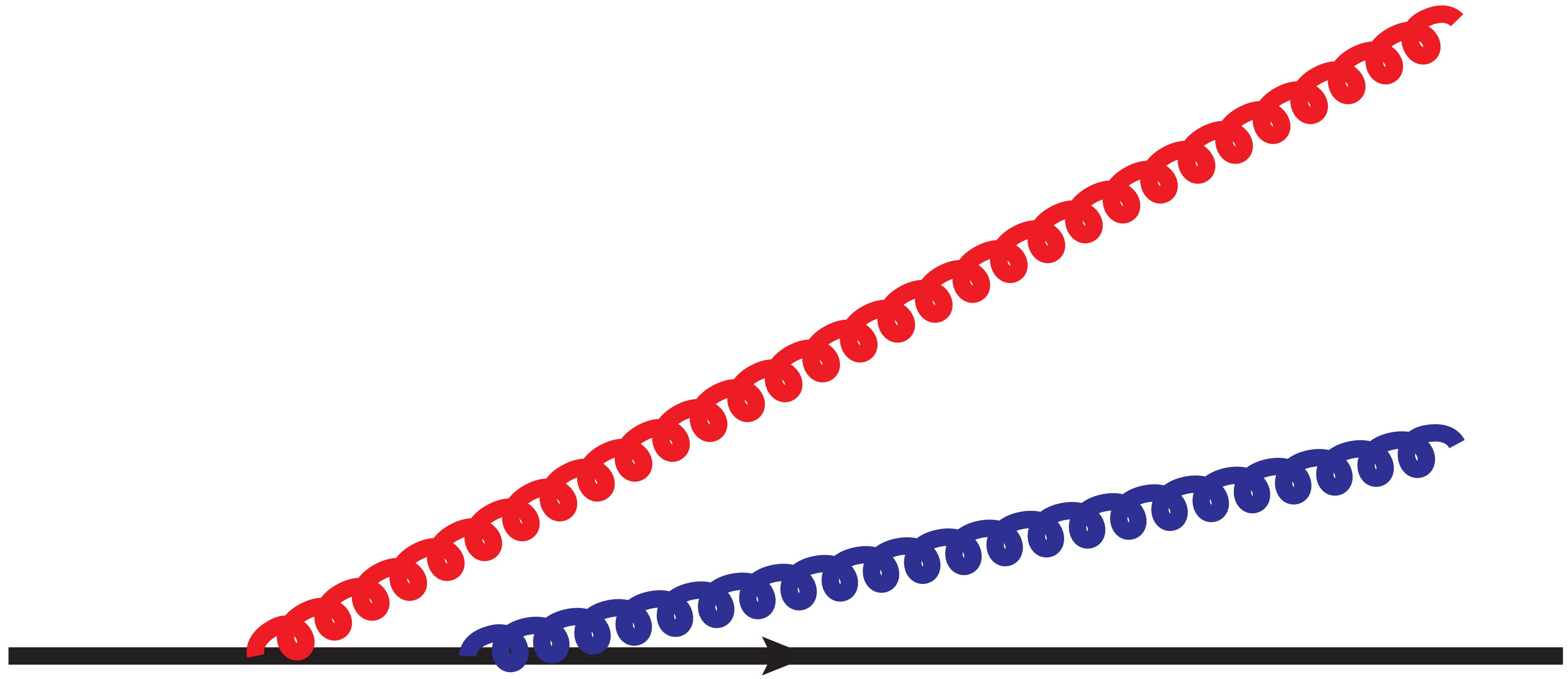
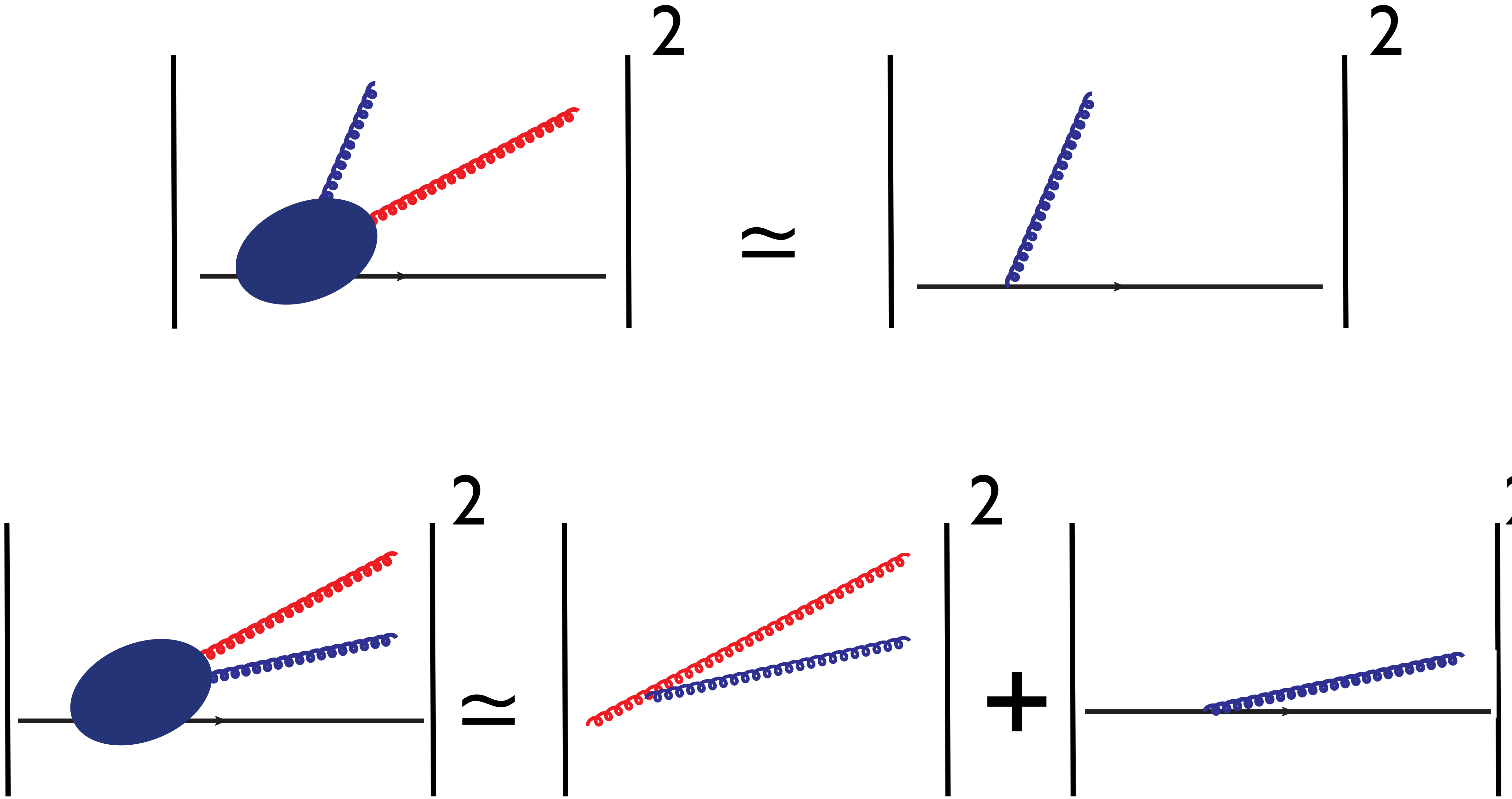
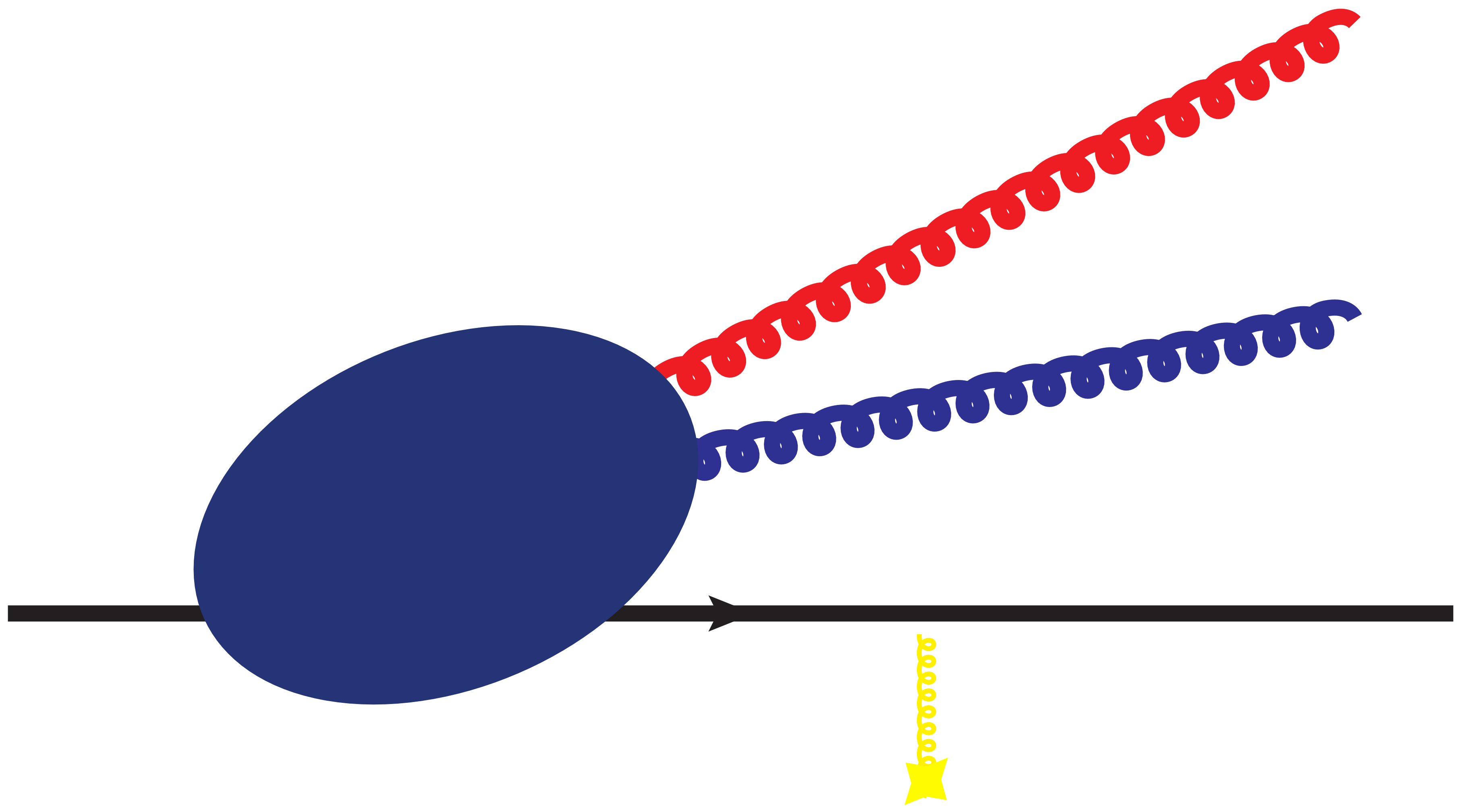


Coherent Branching



In-Medium Interferences



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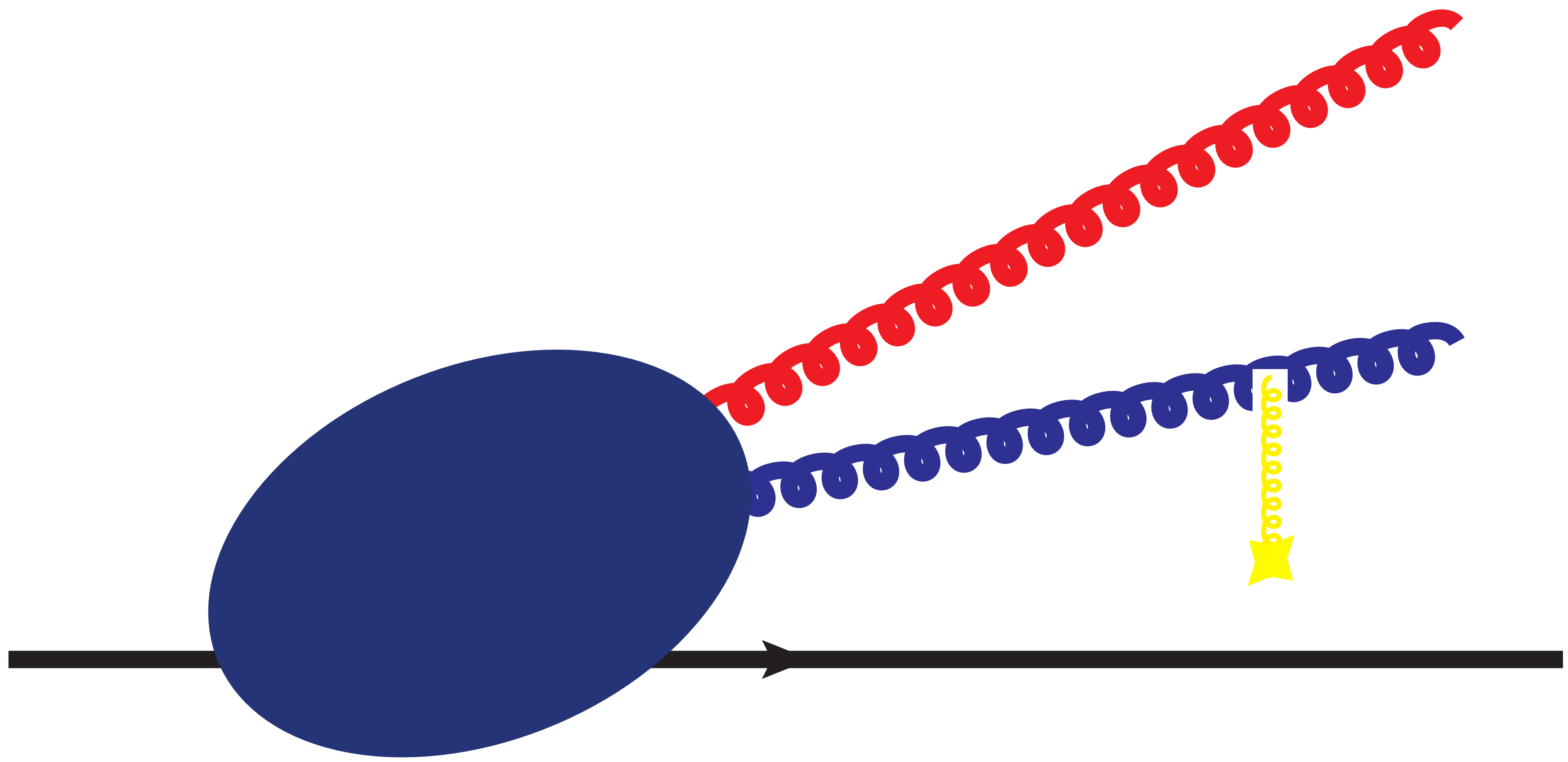
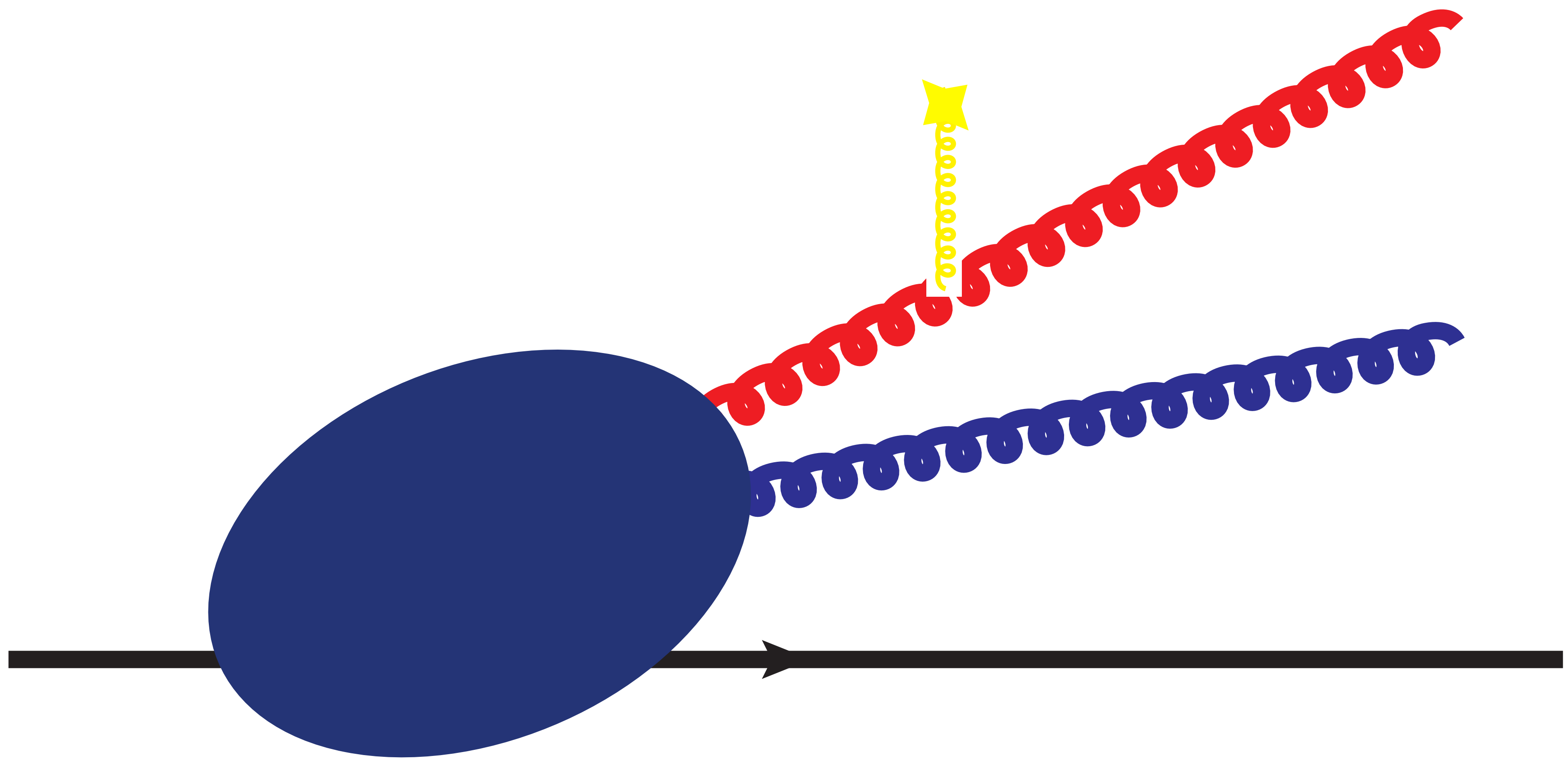


Antenna



- ➤ In-medium antenna problem

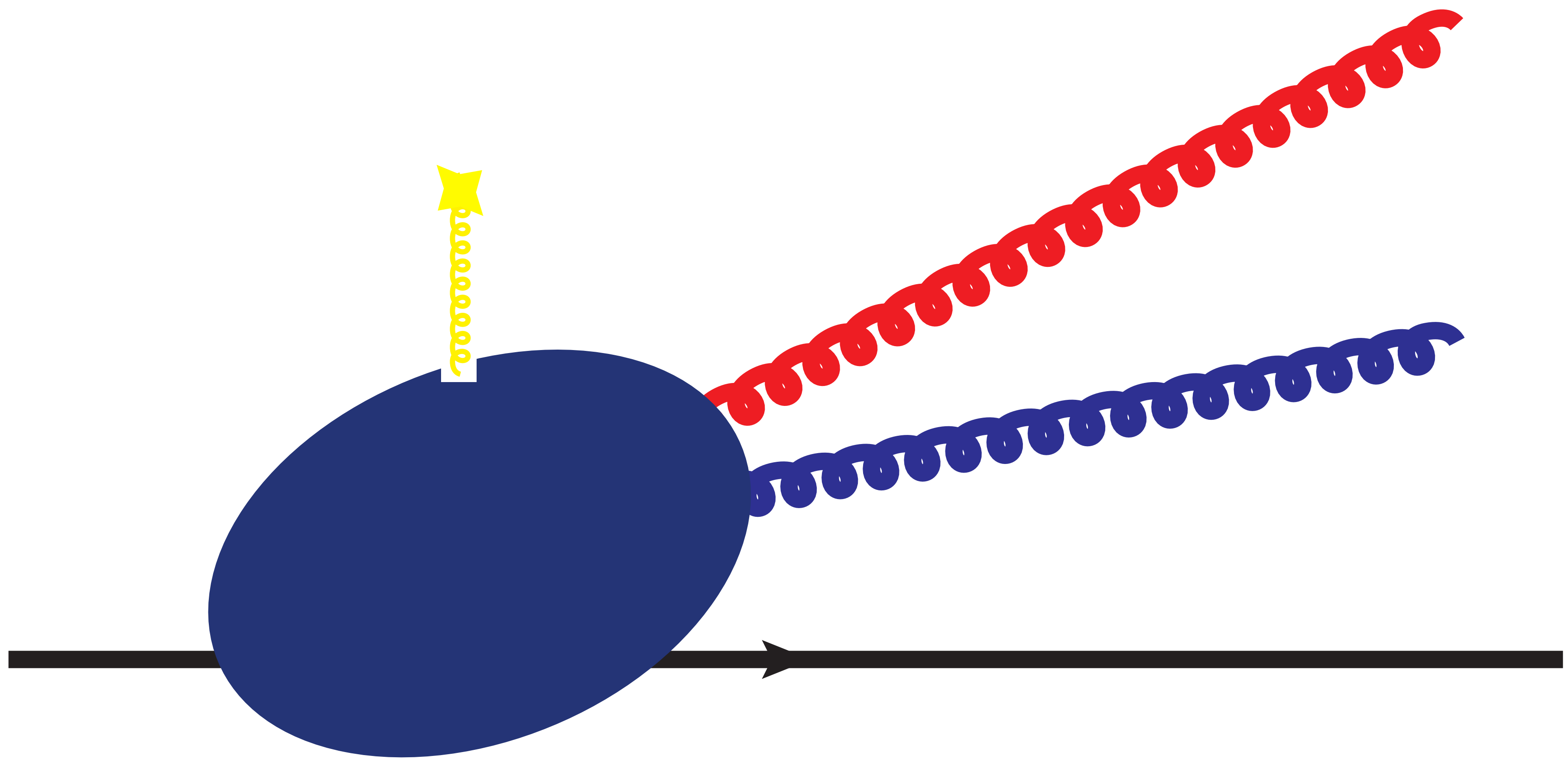
Mehtar-Tani, Salgado Tywoniuk 10,11,12

JCS, Iancu 11

Blaizot, Dominguez, Mehtar-Tani, Iancu, 12

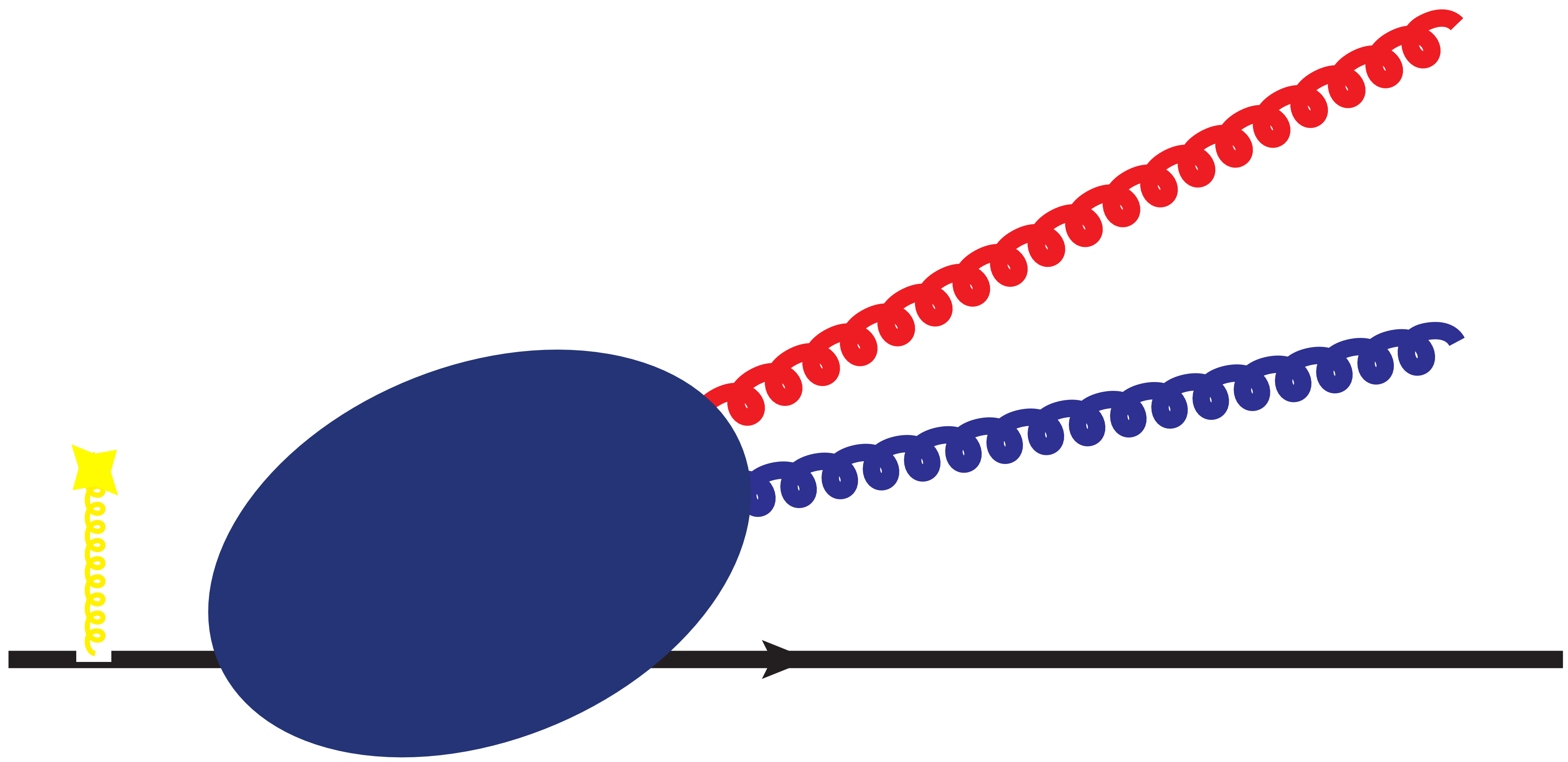
Armesto, Ma, Martinez, Mehtar-Tani,Salgado 13

Dynamical Antenna



➤ How does the formation of antenna affect interferences?

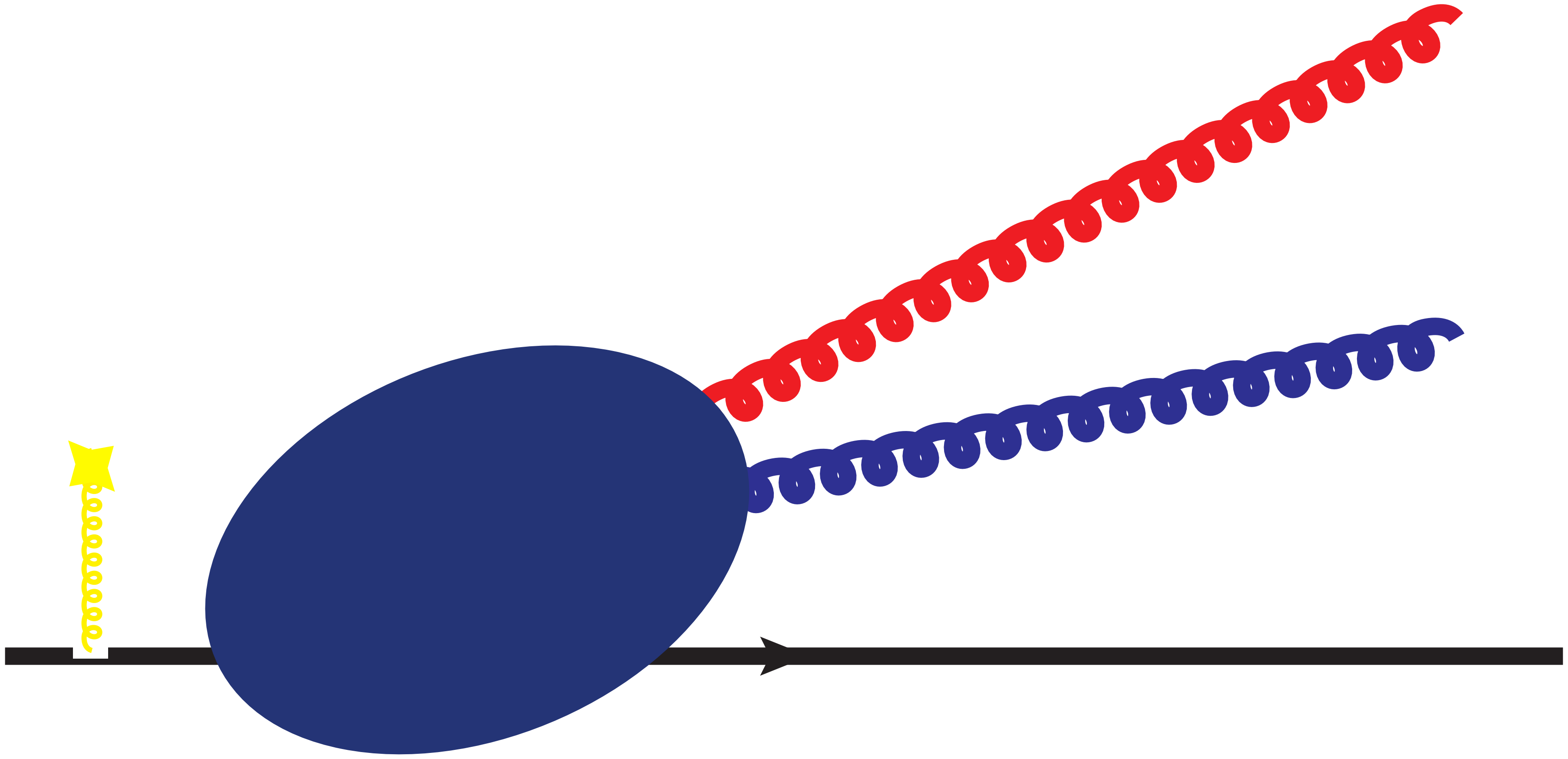
Dynamical Antenna



➤ How does the formation of antenna affect interferences?

➤ And the interactions prior to the formation?

Dynamical Antenna

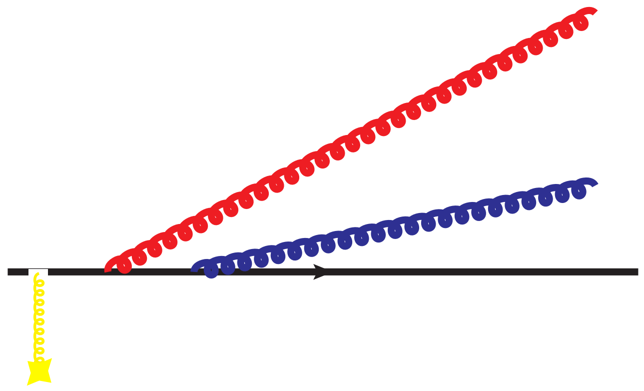


➤ How does the formation of antenna affect interferences?

➤ And the interactions prior to the formation?

Two gluon emission rate!

Diagrams, Diagrams, Diagrams



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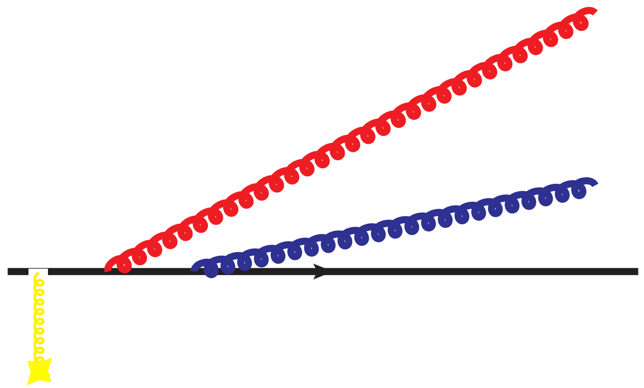

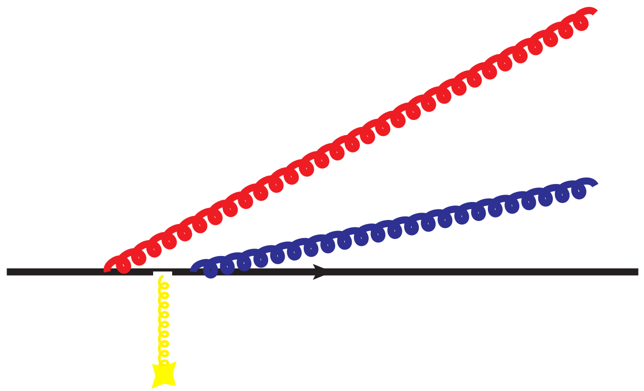

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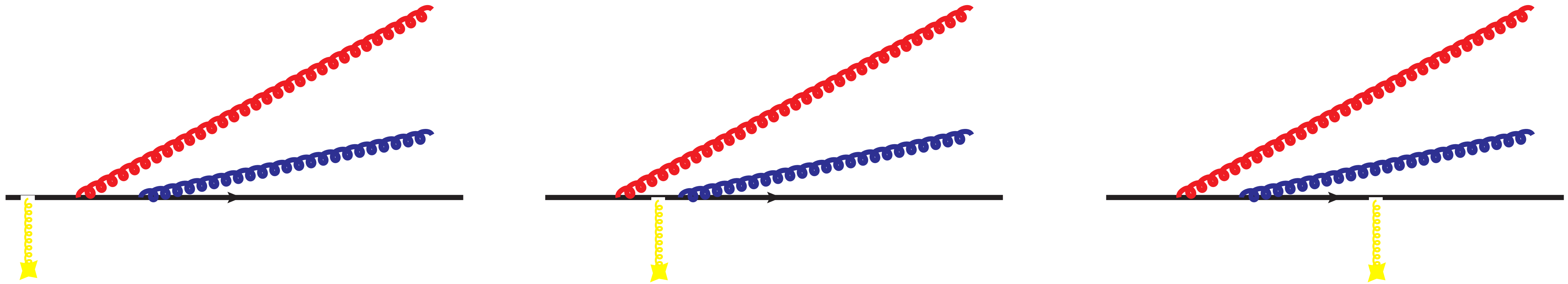

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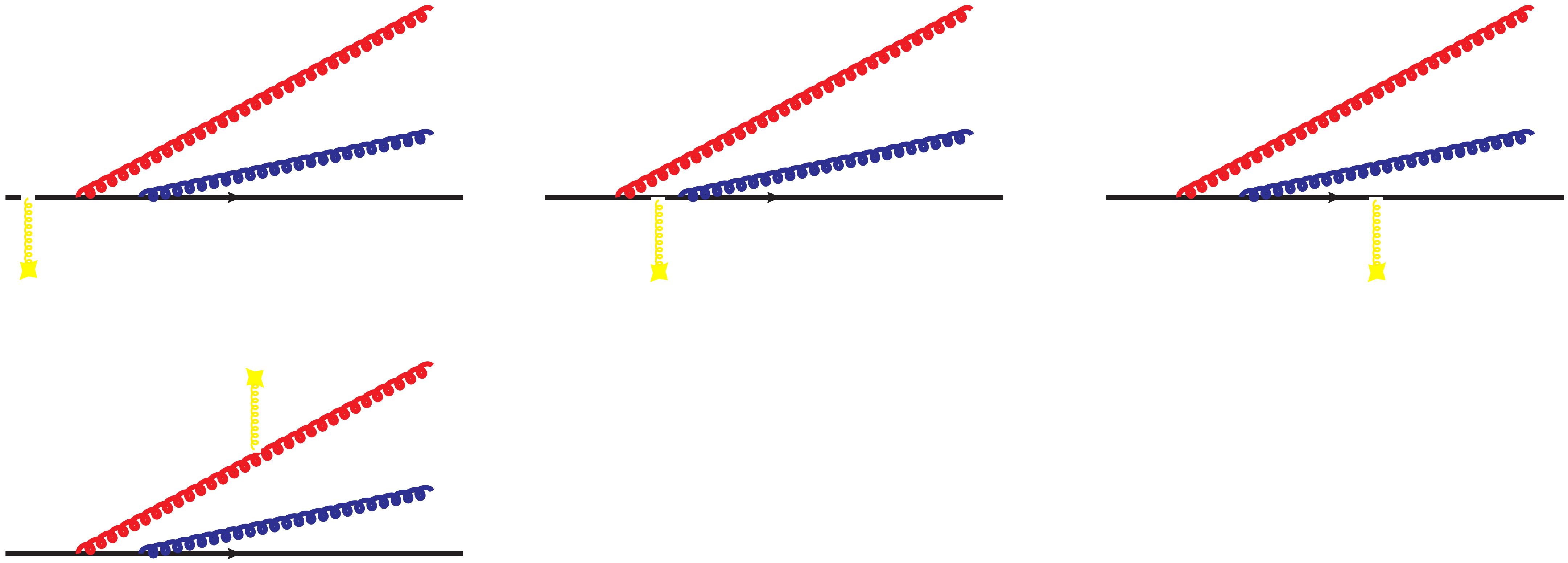

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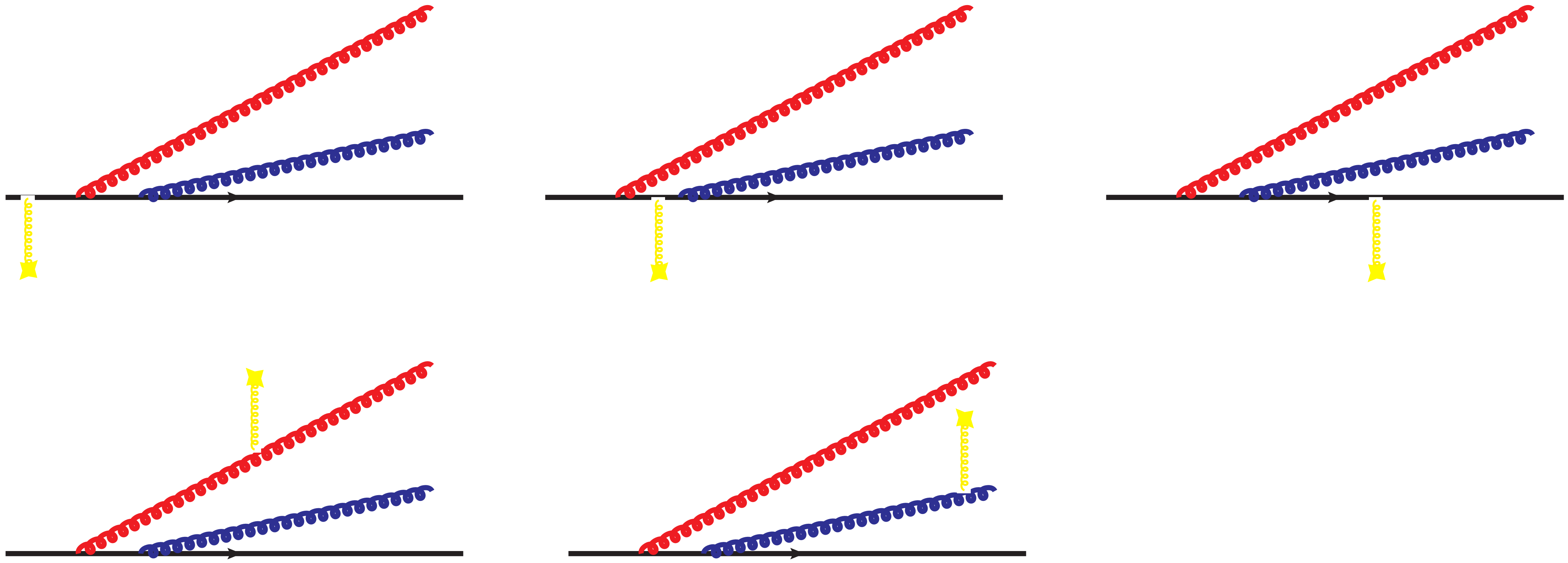
Diagrams, Diagrams, Diagrams



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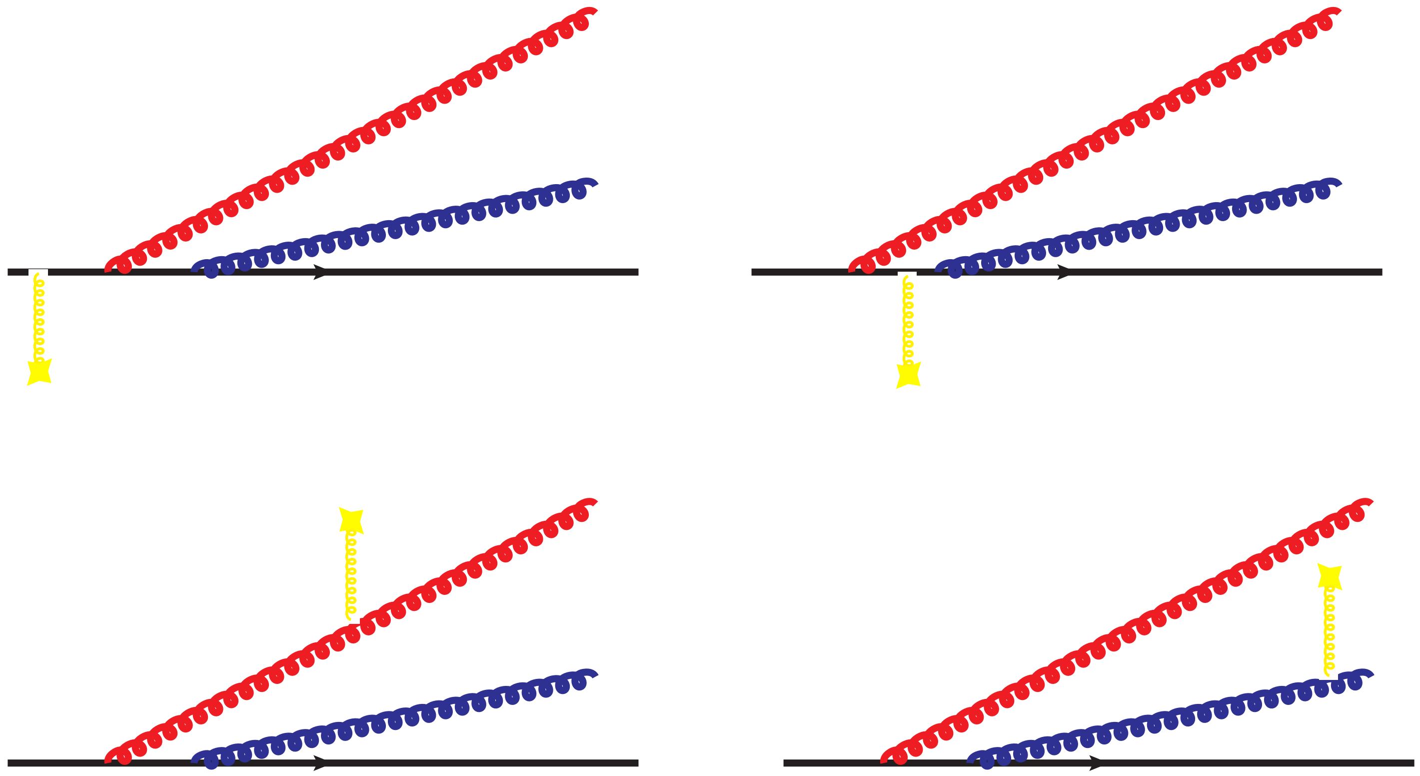
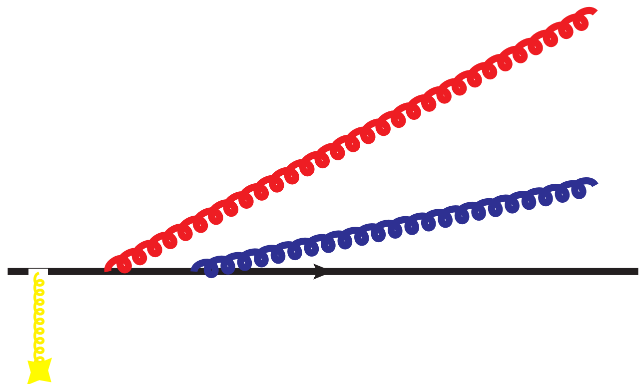
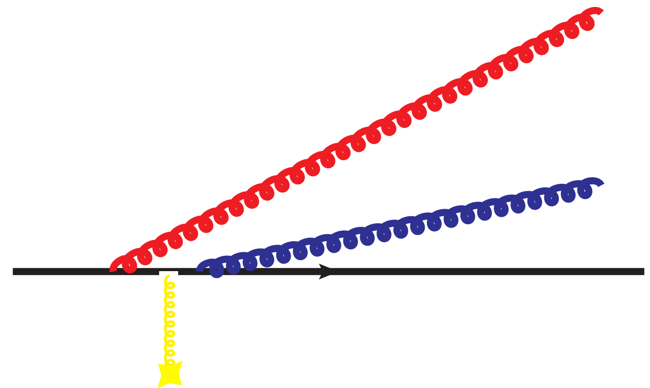
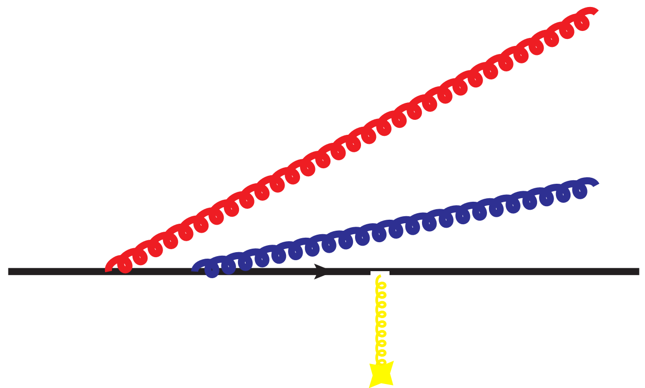


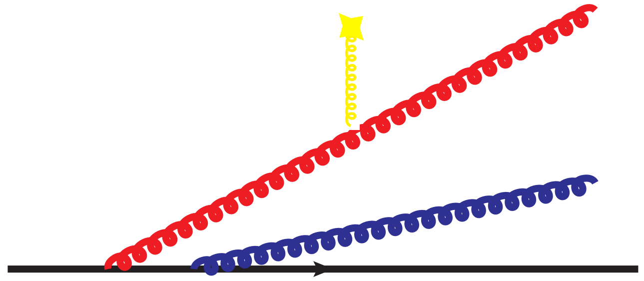
+ 10 real diagram

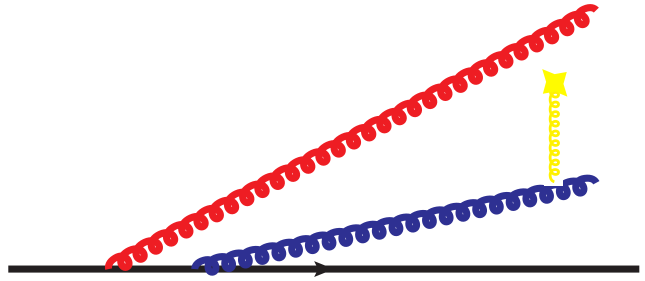
Diagrams, Diagrams, Diagrams







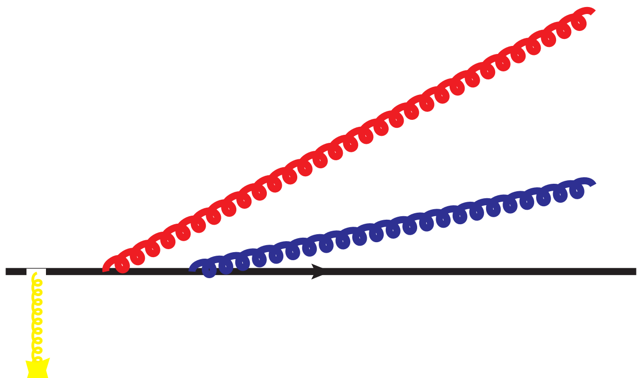


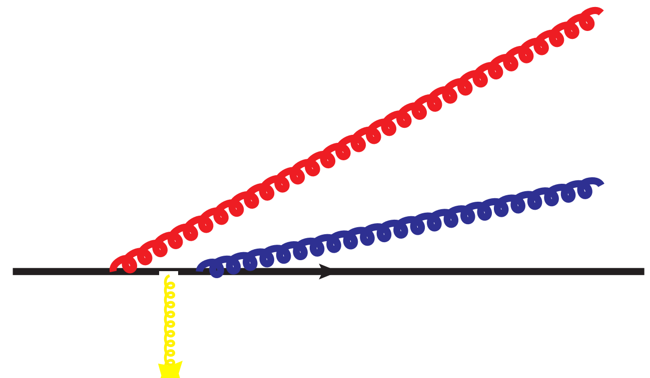


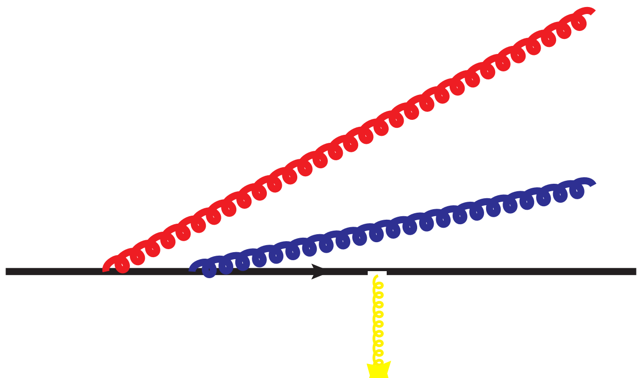
+ 10 real diagram

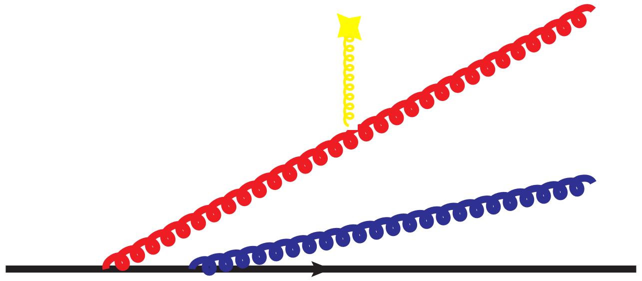
+ 15 virtual contributions

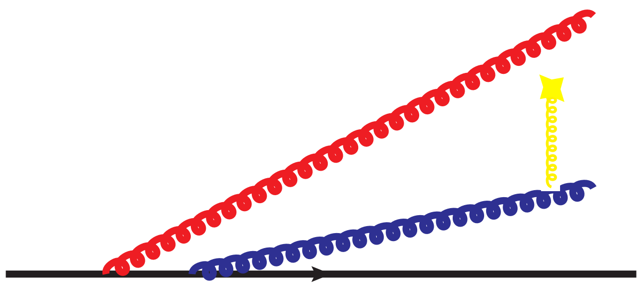
Diagrams, Diagrams, Diagrams











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... a mess....

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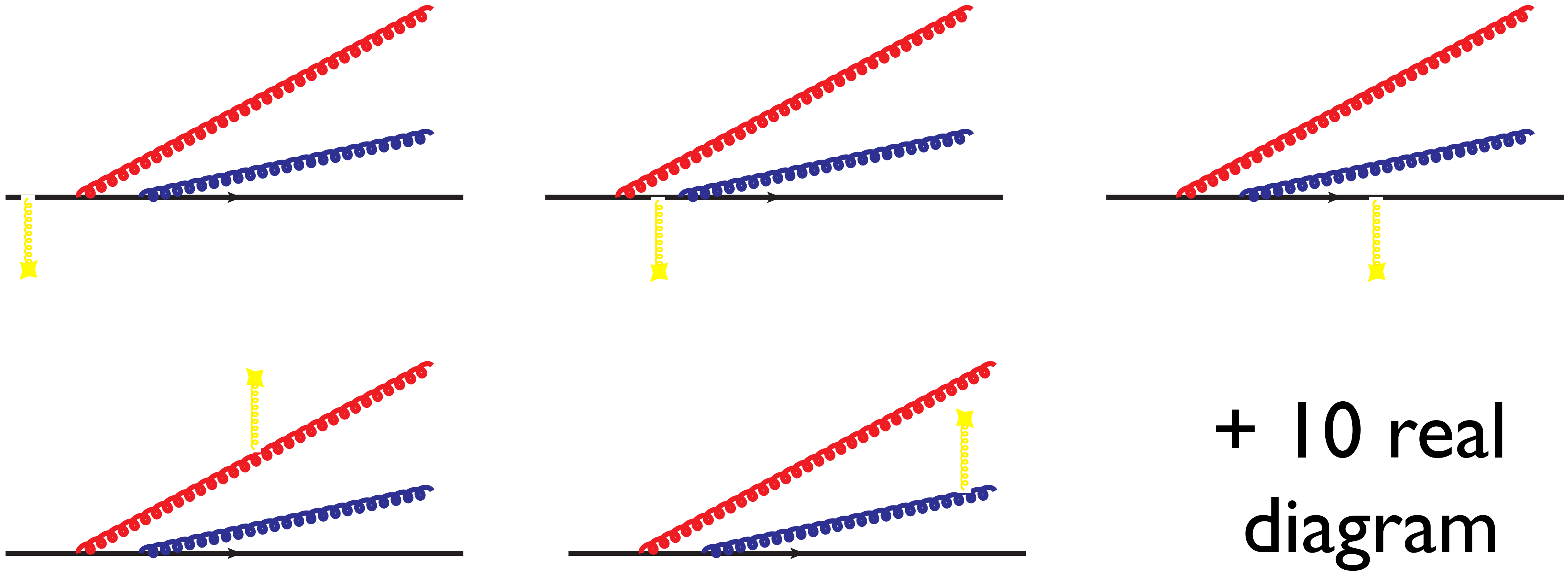

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... a mess....

Fickinger, Ovanesyan, Vitev 13

Arnold and Iqbal 15

Limits

- Strong energy ordering: $E_q \gg \omega_H \gg \omega_S \quad \Longleftrightarrow \quad z = \frac{\omega_S}{\omega_H} \ll 1$
- Small emission angles: $\theta_H \ll 1, \theta_S \ll 1$, but $r = \frac{\theta_H}{\theta_S}$ arbitrary
- Hard gluon from vacuum shower; soft gluon medium induced

$$K_H^{\perp} \gg K_S^{\perp} \sim q_{medium}$$

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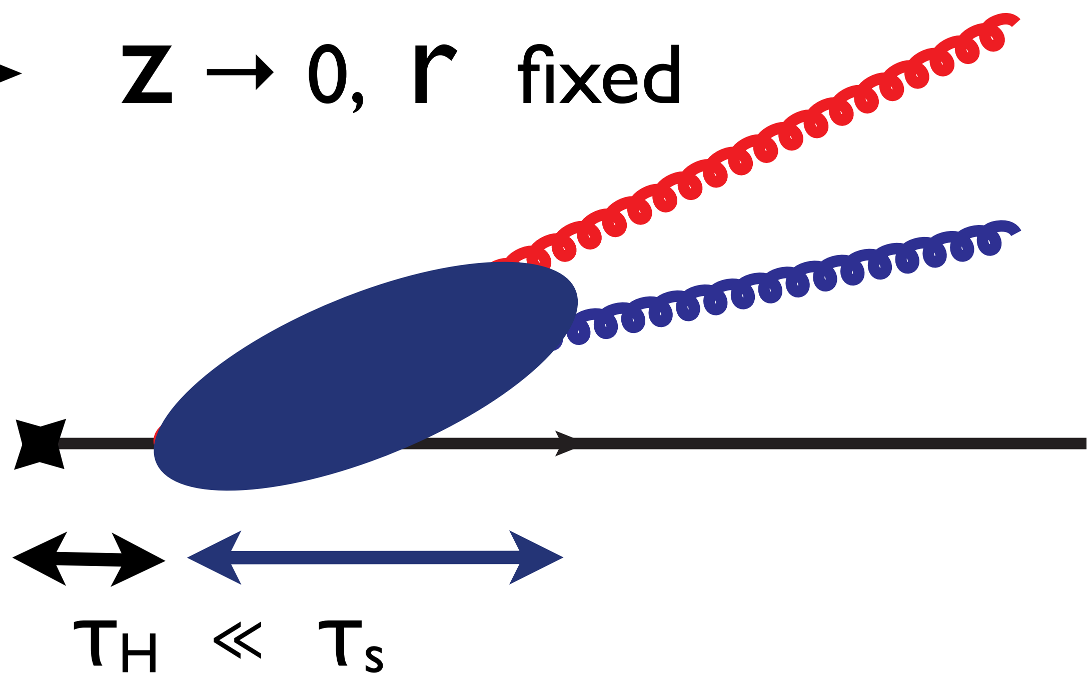
Two different order of limits

- $z \to 0, \ r$ fixed



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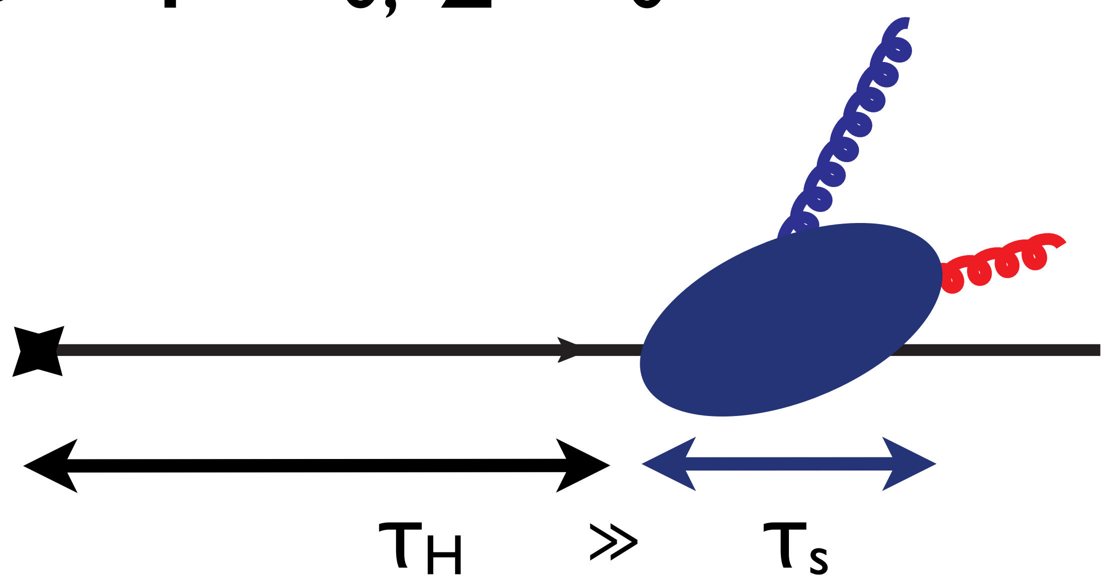

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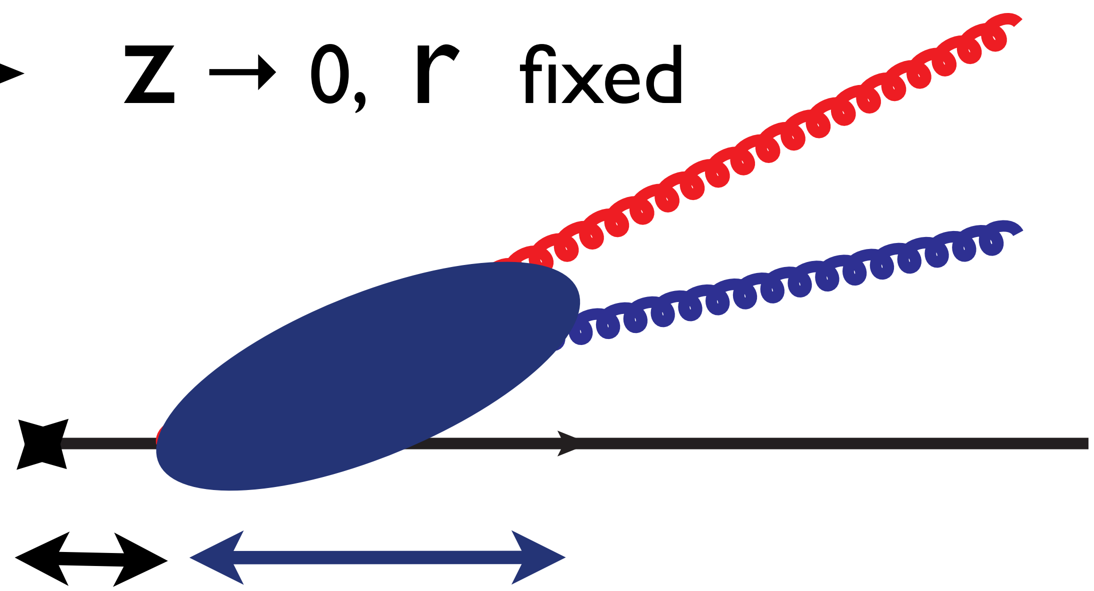
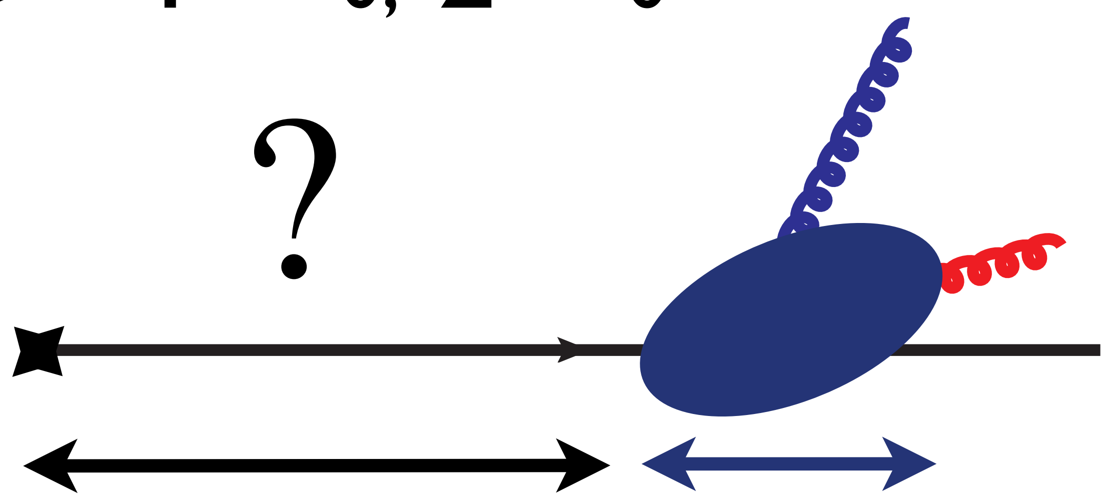


$\tau_H \ll \tau_s$

- $r \to 0$, $z \to 0$



$\tau_H \gg \tau_s$

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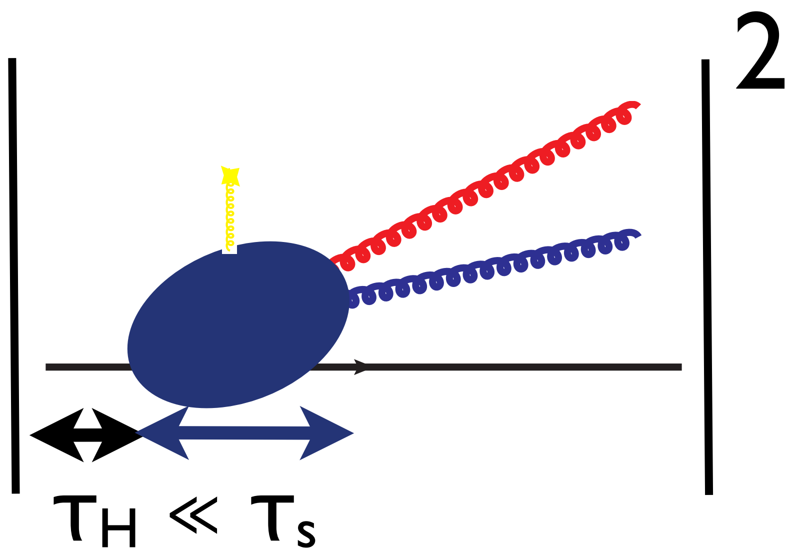
Early Antenna

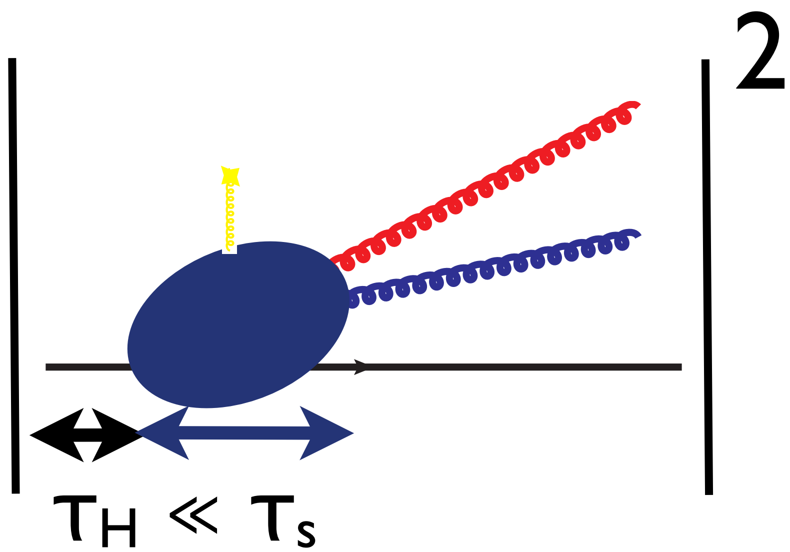


$$\left| \;\cdots\; \right|^2 = P_{vac}(K_H^{\perp}) \times \text{Antenna}(\theta_H)$$

$$+ \;\; 2\, x \text{ Prefactor } \sin(t_s/\tau_{long})\, \sin(t_s/\tau_{short})$$

\+ Out-of-cone term that vanishes for isotropic kicks

Early Antenna



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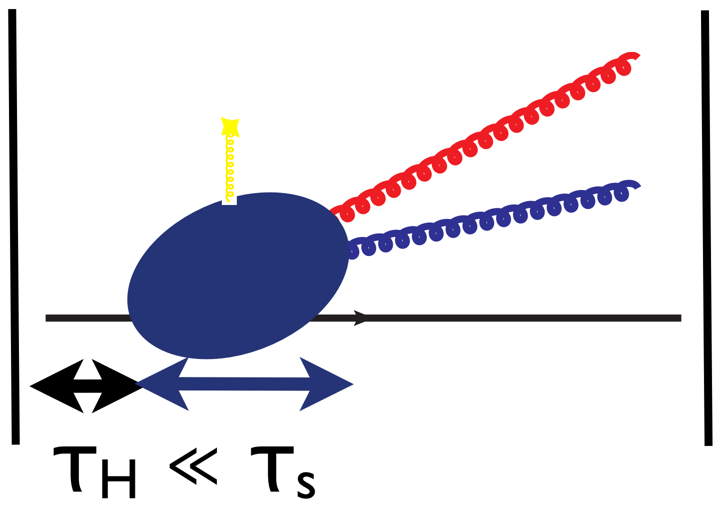

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$\tau_{short} \sim z\,\tau_{long}$

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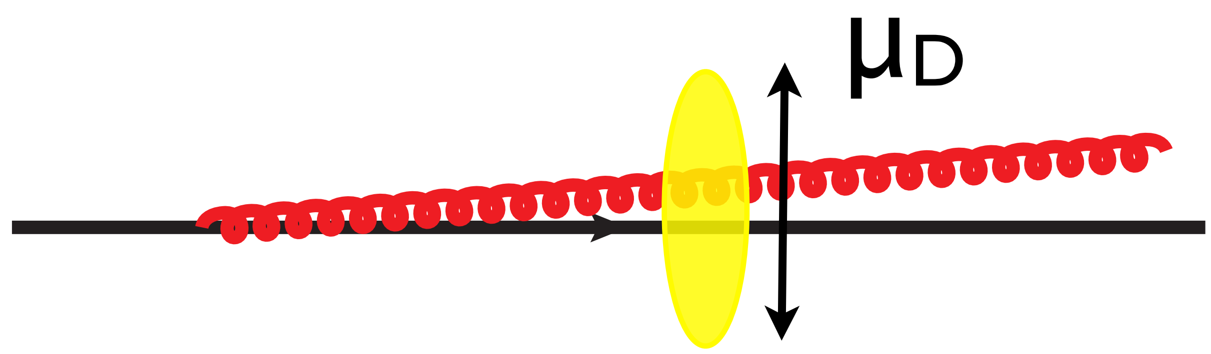
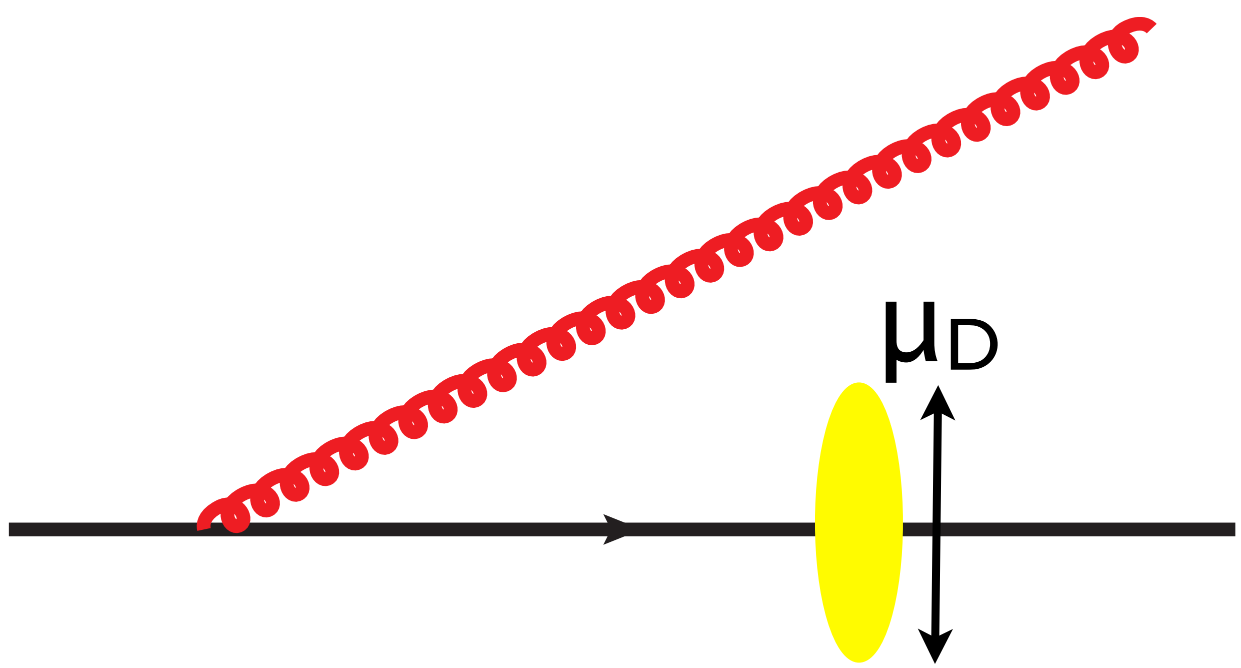
Antenna Spectrum

Mehtar-Tani, Salgado Tywoniuk 11

- Unresolved antenna



- Resolved antenna



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Mehtar-Tani, Salgado Tywoniuk 11

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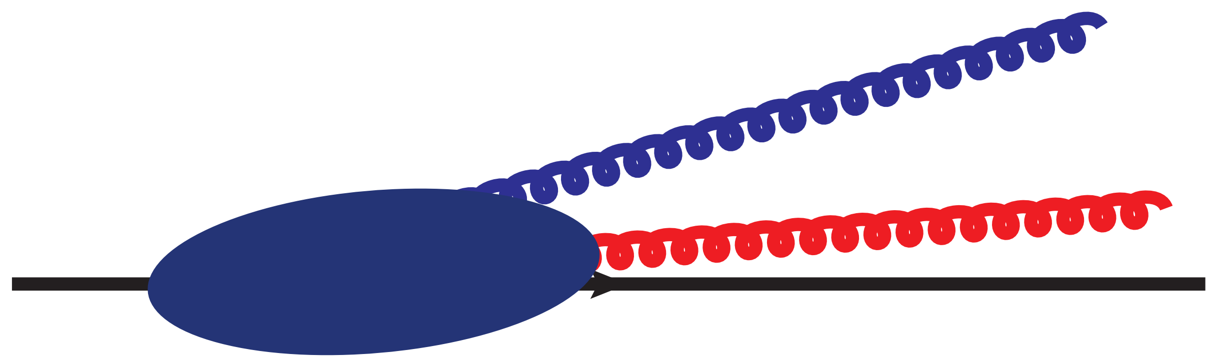

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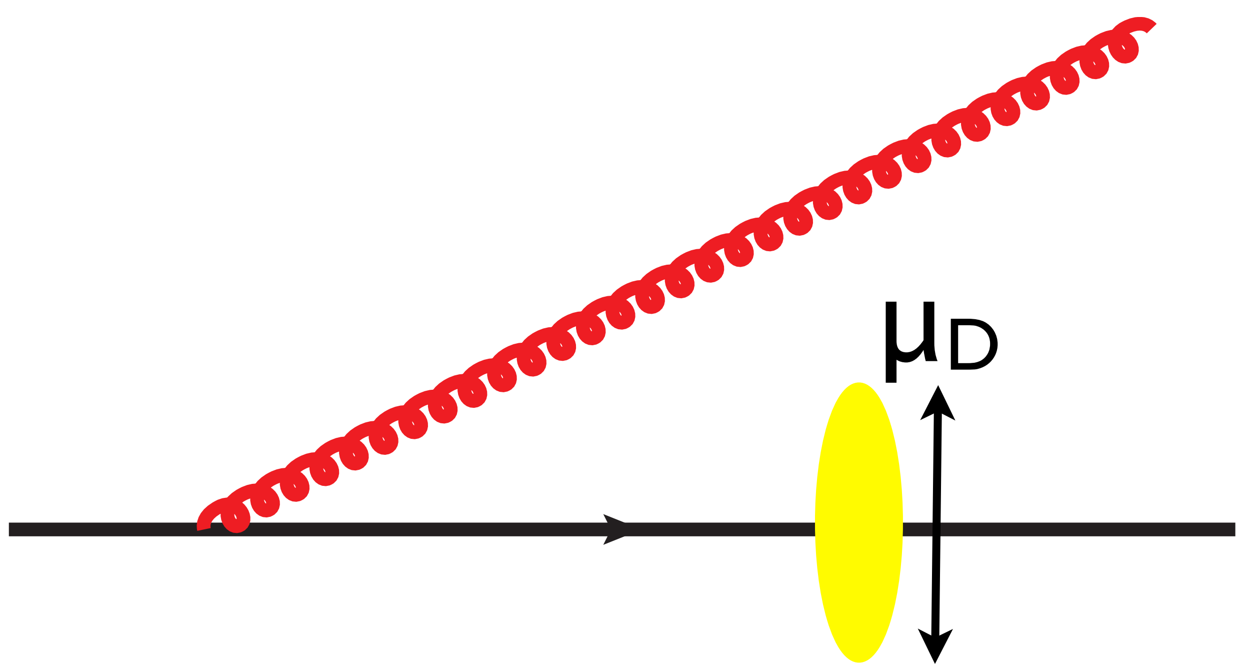

- N=1 opacity spectrum off a single quark
- Medium blind to the hard gluon

Antenna Spectrum

Mehtar-Tani, Salgado Tywoniuk 11

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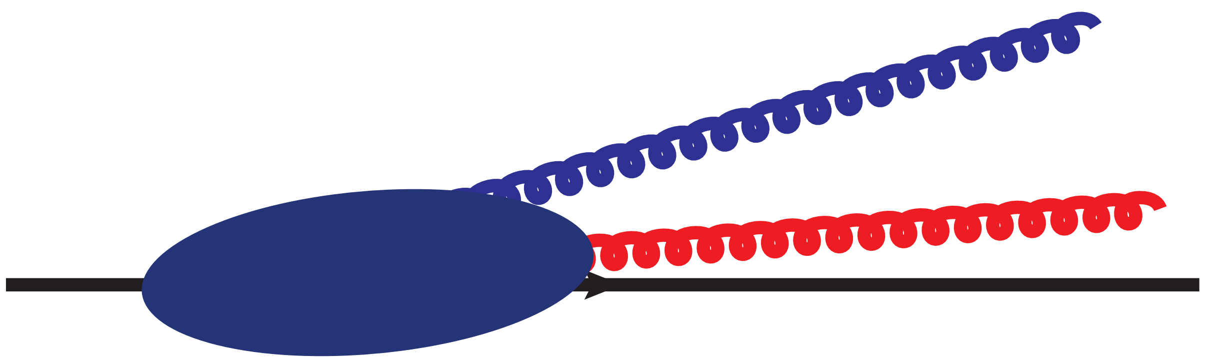

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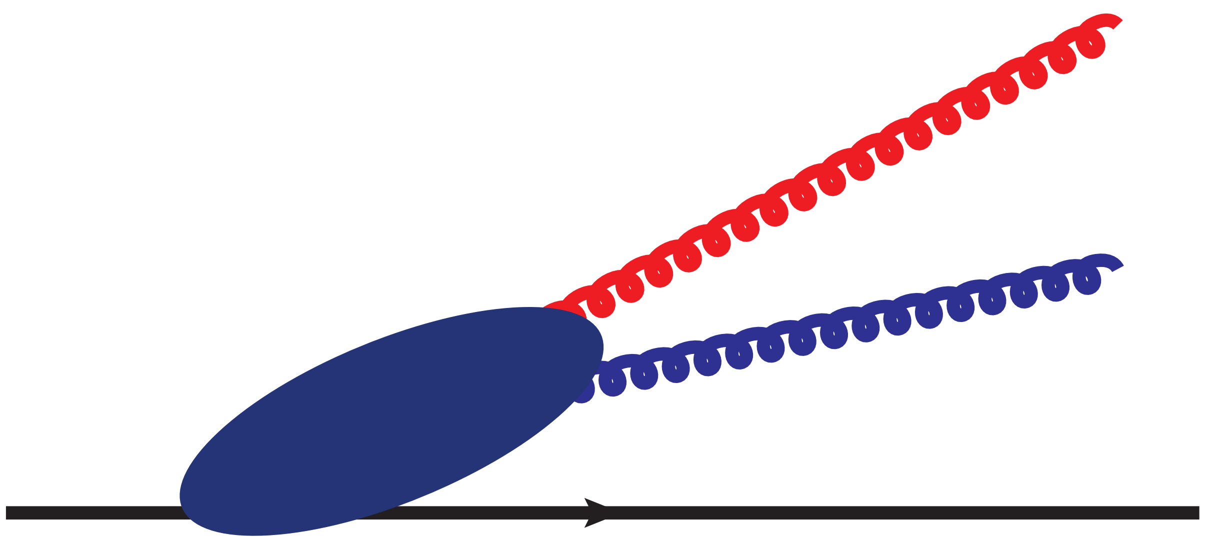
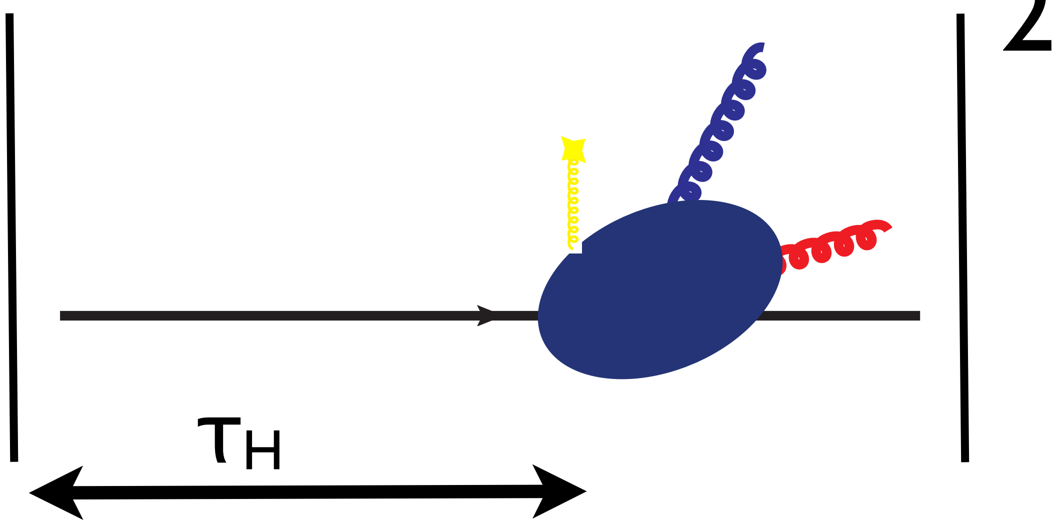


- Gunion-Bertsch of quark
  \+ Gunion-Bertsch of gluon
  \+ Broadeing of vac antenna
  \- Vac antenna
- Medium interacts with the hard gluon

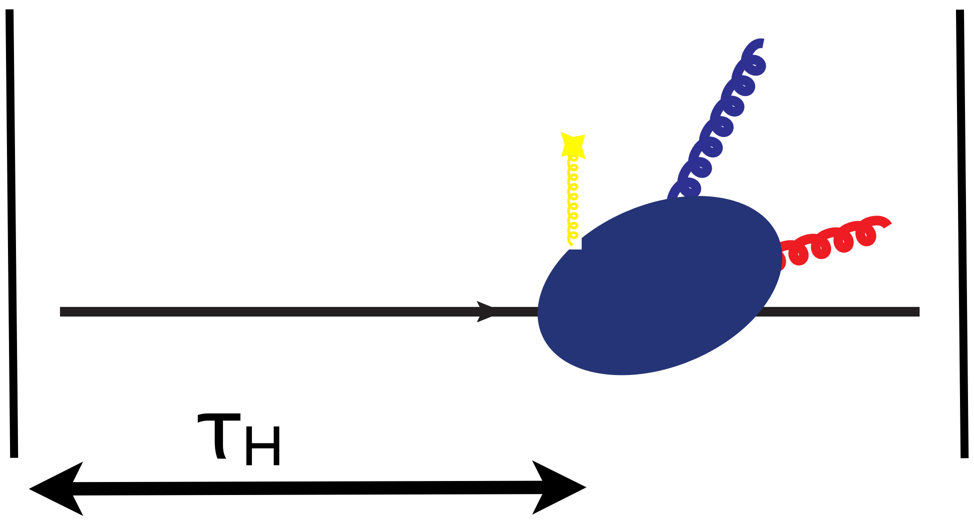
Late Time Antenna



$= $ N=1 opacity spectrum off a single quark

$$+ \left(\begin{matrix}\text{Gunion-Bertsch} \\ \text{off gluon}\end{matrix}\right)\left(1-\cos(t_s/\tau_H)\right)$$

Late Time Antenna



$|\ldots|^2$ = N=1 opacity spectrum off a single quark

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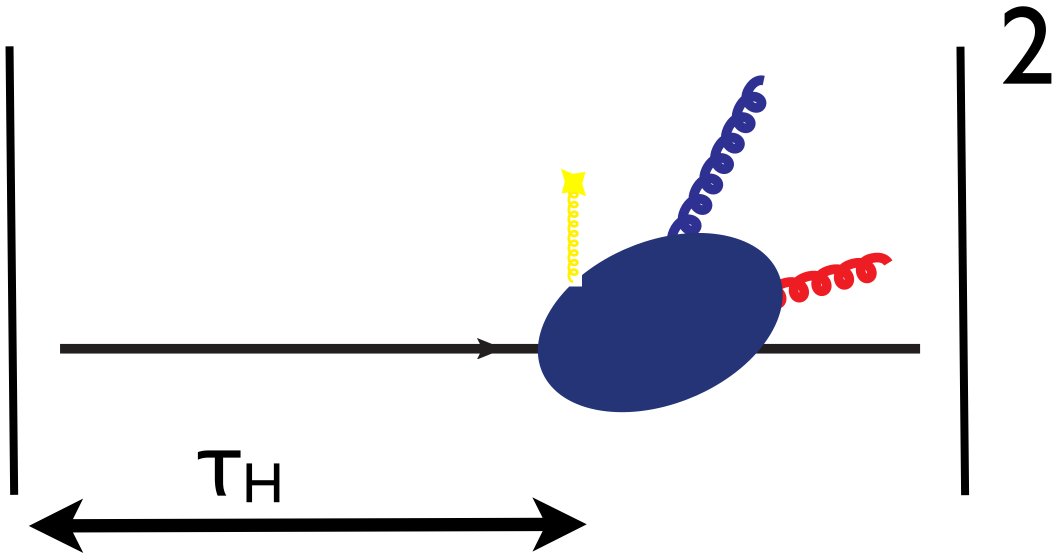
- An q-g antenna is formed after a time τ_H
- Once the antenna is formed, it is totally resolved

Late Time Antenna



= N=1 opacity spectrum off a single quark

+ (Gunion-Bertsch off gluon) $\left(1-\cos(t_s/\tau_H)\right)$

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Note: In this limit $\dfrac{\tau_{resolv}}{\tau_H} \to 0$

Conclusions

Organizing principle for jets in medium:

Simple space-time picture for in-medium interferences

(completes JCS, Mehtar-Tani,Tywoniuk, Salgado 12)

- ➤ Consider jets as a succession of antennas
  - ➤ Each antenna appears after formation time
- ➤ Narrow antennas ($r_\perp < \mu_D$) are invisible to the medium
  - ➤ They Lose energy as a colored parton with overall charge
- ➤ Wide antennas ($r_\perp > \mu_D$) are resolved
  - ➤ Independent E-loss of each parton

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(in a dense medium replace μ_D with $\hat{q}$ L)

(JCS, Mehtar-Tani,Tywoniuk, Salgado 12)