Next-to-leading order QCD corrections to the $e^+e^- \to t\bar{t}$ total cross section

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WHAT IS **QED**?

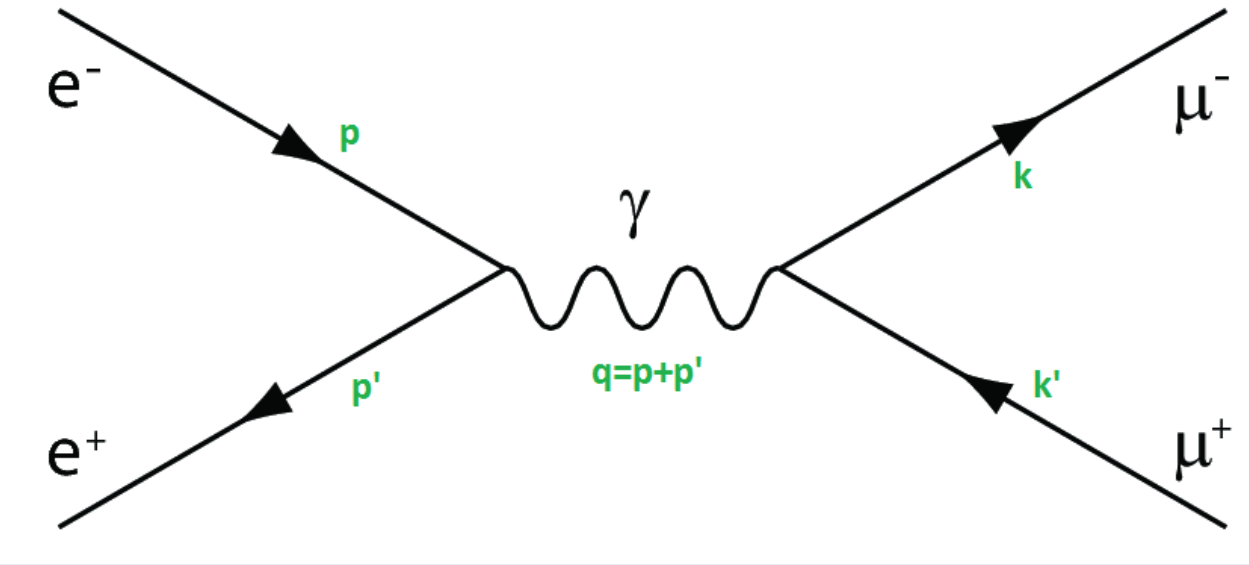
QED

QED (*Quantum Electrodynamics*)- part of SM, powerful tool for calculating decay rates and cross sections by means of the perturbation theory.

HOW DOES IT WORK?

- Initial state $|\Phi(-\infty)>=|i>$: not interacting particles
- All final states are contained in $|\Phi(\infty)>=\mathbf{S}|i>$
- Transition probability: $|<f|\Phi(\infty)>|^2=|<f|S|i>|^2$
- Conservation of probabilities$\rightarrow$ matrix **S** must be unitary

Basic process in QED



Using Feynman rules one can write the amplitude for the following process:

$$S_{fi} = \delta_{fi} + i(2\pi)^4 \delta(pi - pf)\mathbf{M}$$

$$\mathbf{M} = \bar{v}(p')(-ie\gamma^{\mu})u(p)(\frac{-ig_{\mu\nu}}{q^2})\bar{u}(k)(-ie\gamma^{\nu})v(k')$$

Our process-cross section

Our process is very similar to the previous one-we only need:

- to take t quark color into account
- to change the charge (μ has different charge than quark)

CROSS SECTION?

General formula for cross section:

$$d\sigma = \frac{|M|^2}{initial\ flux}(2 - body\ phase\ space)$$

After calculation we get:

$$\sigma = \frac{4\pi\alpha^2}{E_{CM}^2} q^2 \sqrt{1 - \frac{4m^2}{E_{CM}^2}} (1 + \frac{m^2}{E_{CM}^2})$$

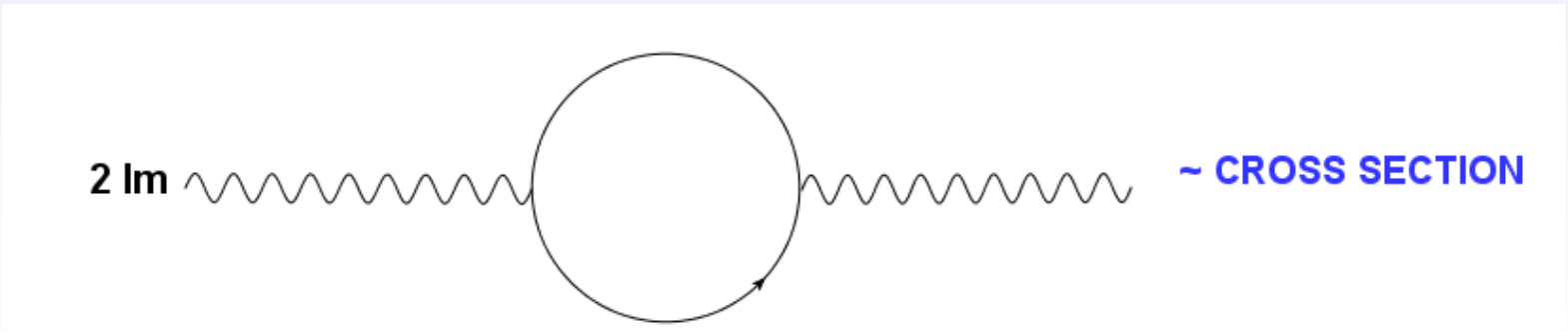
THE OPTICAL THEOREM

The total cross section can be obtained also by applying the so-called **optical theorem**.

The optical theorem

Imainary part of the propagator is equal to the sum of cross section to every possible particle:

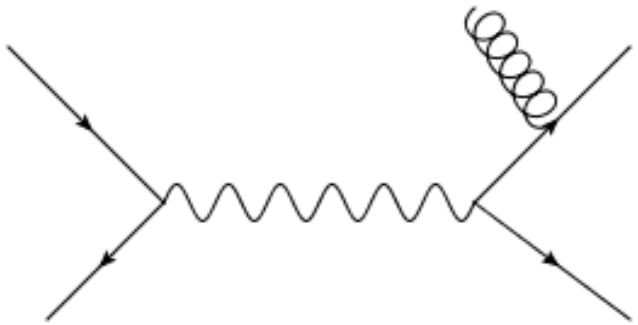
$$Im\ M(A \to A) = 2E_{CM}\, p_{CM} \sum_X \sigma(A \to X)$$

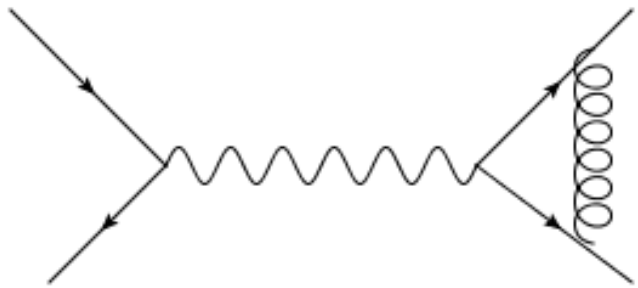


NEXT-TO LEADING ORDER QCD

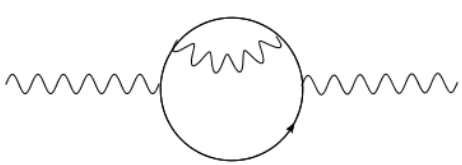
Calculation in the next-to-leading order S-matrix expansion are more complicated:(

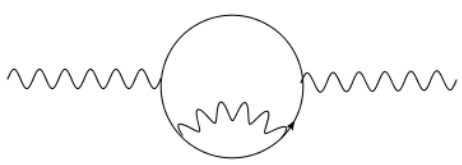
In order to calculate the diagrams:

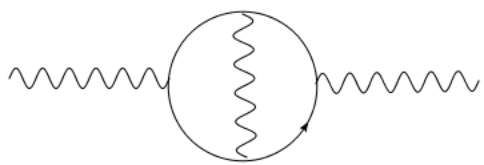




Using **optical theorem** we will calcuate *Im* part of:







What has been done:

- The cross section calculation for leading order (direct calculation)
- The cross section calculation for leading order (by the optical theorem):
  1. One loop calculation
  2. D-dimensional regularization method (amplitude was divergent)
  3. Method of **IBP** relations and differential equation

What we are planning to do:

- The cross section for next to leading order (using optical theorem)