Calculating Scattering Amplitudes and Form Factors

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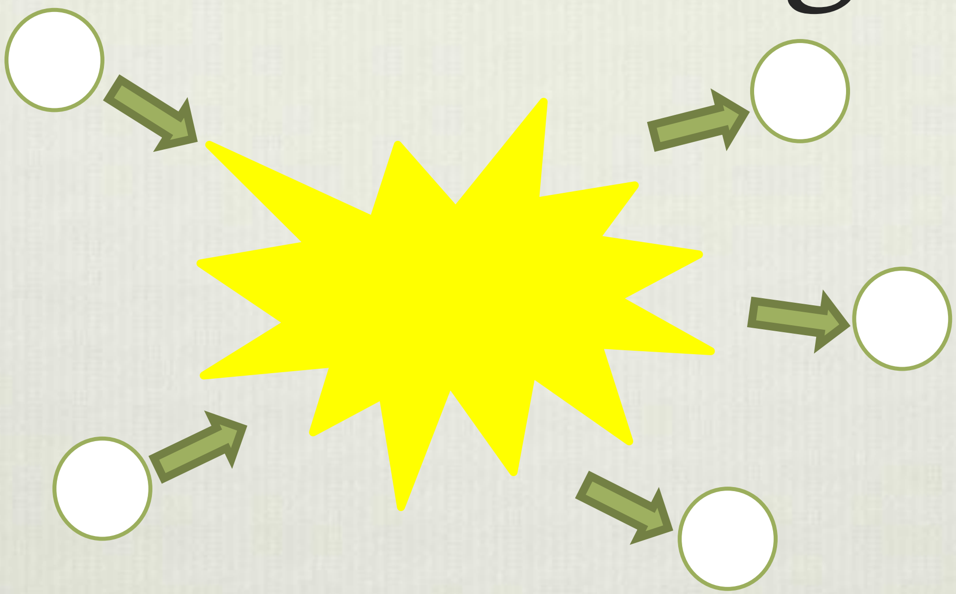
Scattering



Scattering Amplitude: Probability of scattering particles as functions of angles and energy.

Quantum Field Theory and Feynman Rules

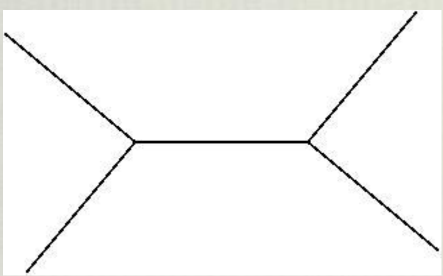
Quantum Field Theory is a mathematical framework for particle physics.

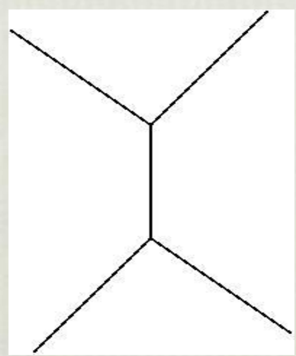
Quantum Chromodynamics – Theory of the strong interactions, describing the interactions between quarks and gluons .

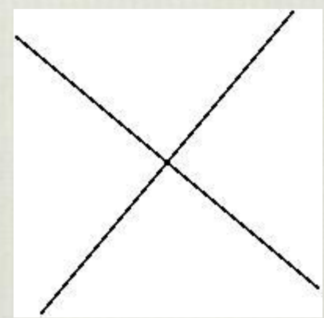
Gluons can interact with each other!

Gluon Diagram 

Gluon Scattering : gg → gg







gg→ ggg 10 Diagrams

gg→ gggg 38 Diagrams

The number of diagrams increase!

Parke-Taylor Formula

Calculated amplitude for gg→gggg scattering (1985) and developed an amplitude for n gluon scattering:

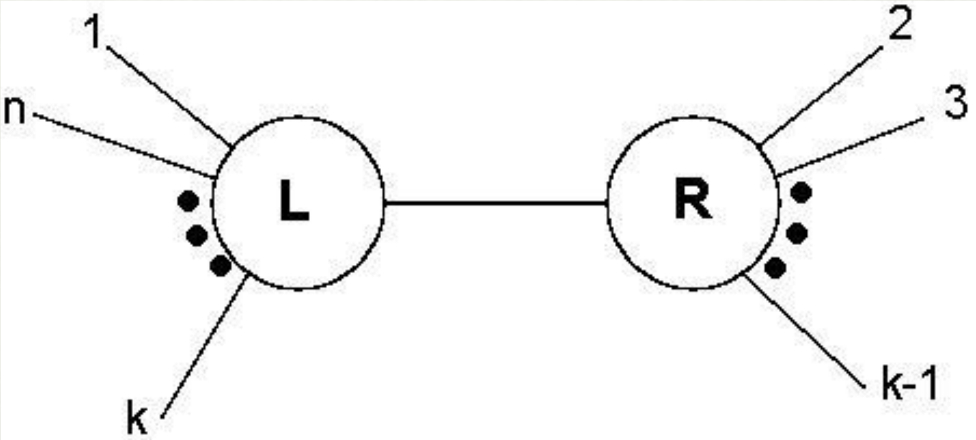
$$A_n[g_{1-}\ g_{2-}\ g_{3+}\ g_{4+}\cdots g_{n+}] = \frac{\langle 12\rangle^4}{\langle 12\rangle\langle 23\rangle\langle 34\rangle\ldots.\langle n1\rangle}$$

Each of the bracket expressions are compact forms of an expression that is a function of momentum and energy.

i.e. $\langle 12\rangle \sim \sqrt{2E_1E_2 - 2\vec{p}_1\vec{p}_2}\ e^{i\phi}$

(Why?) BCFW Recursion Relations

- **B**ritto, **C**achazo, **F**eng, and **W**itten (2005)
- Recursion relations provide an efficient way of calculating higher point amplitudes.
- The diagrams are not Feynman diagrams, but serve the same purpose.



My Project

- To apply BCFW recursion techniques to “form factors”

- Form Factors give probabilities of particle interactions in terms of the final momenta.

- Form factors are similar to amplitudes, but involve an operator that is not on-shell.

On- shell are momenta that obey $E^2 - p^2c^2 = m^2c^4$

- For gluons m = 0.

Simplest Example

Operator that gives g_+g_+ state.

(A. J. Larkoski and M. E. Peskin, Phys. Rev. D 81, 054010 (2010).)

- For this operator we have

$$\mathcal{A}(\mathcal{O} \to g_{1+}g_{2+}g_{3+}) = \frac{(p_1+p_2+p_3)^4}{\langle 12\rangle\langle 23\rangle\langle 31\rangle}$$

- With BCFW only one diagram contributes

- Extend to n particles:

$$\mathcal{A}(\mathcal{O} \to g_{1+}g_{2+}g_{3+}\cdots g_{n+}) = (-1)^{n-1}\frac{(p_1+p_2+p_3+p_4+\ldots p_n)^4}{\langle 12\rangle\langle 23\rangle\langle 34\rangle\ldots\langle n1\rangle}$$

Conclusion and Future Goals

- BCFW Recursion Relations is a modern approach to calculating scattering amplitudes.
- BCFW Method is effective!
- Applied BCFW to Form Factors
- Goal:

-Study form factors with different operators and same final states.

-Same Operator and different final states.

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- YOU (Audience)