Queen Mary
University of London

Scattering Amplitudes

Samuel Overington | ID 170431121

11-03-2020

General outline

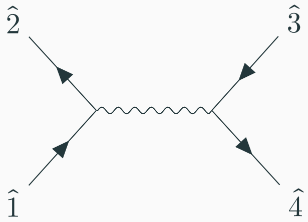
- Scattering amplitudes
- Feynman diagrams
- difference between On-shell and Off-shell
- Current methods using Gauge theories:
    - BCFW recursion / Yang Mills
    - loop level / tree level recursion

- Predicting and measuring fundamental particle interactions.
- Map Energy and momentum.
- Preserve Einstein Energy momentum relation.

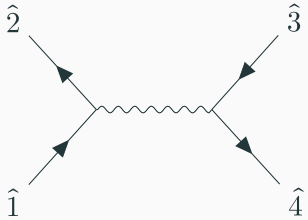
Einsteins Energy momentum relationship.

$$E^2 = (\vec{p}c)^2 + (mc^2)^2$$

A Feynman Diagram



Feynman diagrams



Feynman Diagrams:

- Set boundary conditions.
- Energy Momentum Conservation law.
- Virtual Particles (Off Shell)

$$E^2 = (\vec{p}c)^2 + (mc^2)^2 \quad \text{, "Shell" radius} \quad = \sqrt{mE}$$

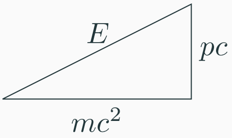
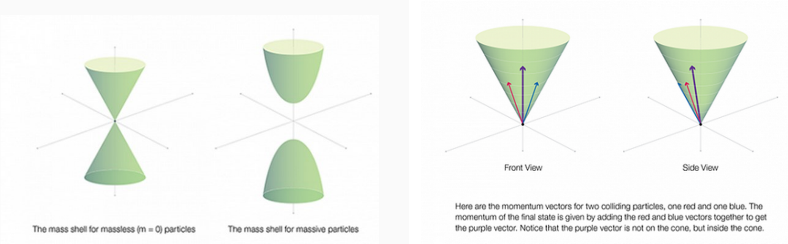


Figure 1: Einstein Energy momentum relationship

On and Off Shell Particles

- Massless particles produce parabolic surface
- Massive particles produce a cone shape
- Real particles momentum vectors along “Shell surface”



(a) Parabolic surface for massive particles Conic surface for massless particles

(b) Interaction of two massive particles on the Mass Shell

Figure 2: Source: Perimeter Institute

Problem with current method of computation (using Feynman diagrams)

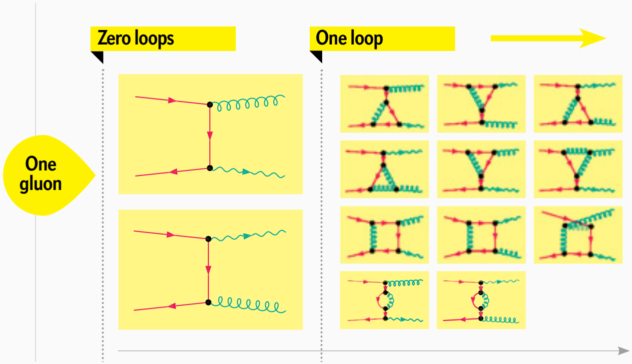


Figure 3: Source: Scientific American

Feynman diagrams help visualise one possible way particles interact.

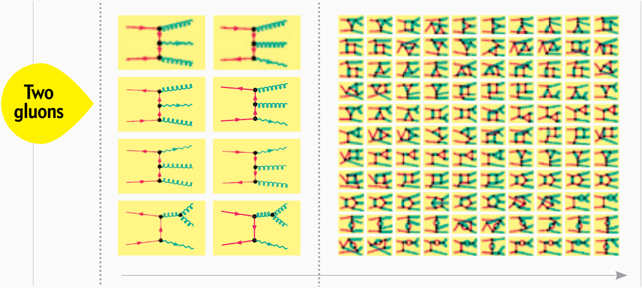


Figure 4: Source: Scientific American

Problem with current method of computation (using Feynman diagrams)

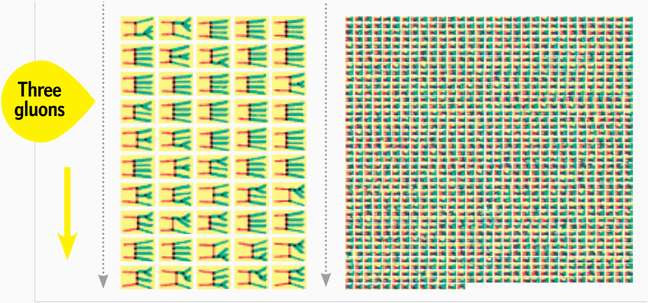
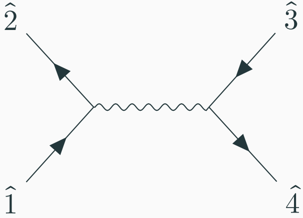
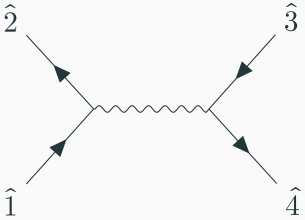


Figure 5: Source: Scientific American

Britto-Cachazo-Feng-Witten (BCFW) approach:

- Allows us to calculate with ease any tree level amplitude.
- two gluon into n = 8 gluon, 10,525,9000 contributing Feynman diagrams.
- Particles have complex momentum.





$$\lambda_1 \to \hat{\lambda}_1(z) = \lambda_1 - z\lambda_n$$
$$\tilde{\lambda}_1 \to \hat{\tilde{\lambda}}_1(z) = \tilde{\lambda}_1 - z\tilde{\lambda}_n$$