8.701

Introduction to Nuclear and Particle Physics

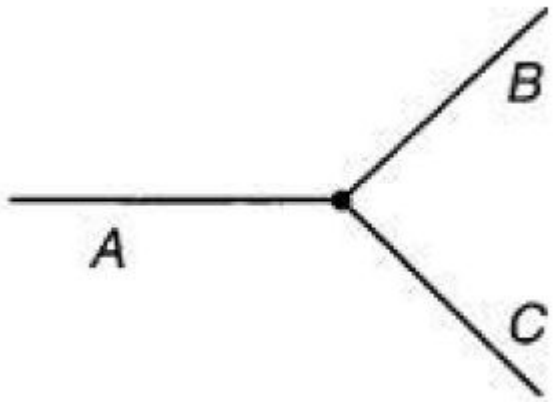
Markus Klute - MIT

3. Feynman Calculus

3.3 Toy Theory

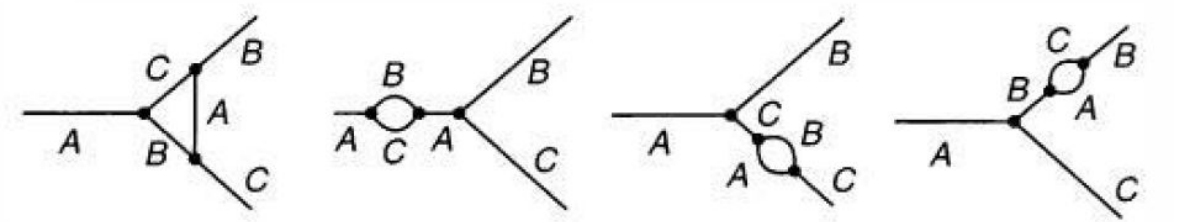
Calculating the Amplitude

- Starting from a toy theory and leaving out spin for now to illustrate the method
- Suppose we have three kinds of particles: A, B, and C
- Primitive vertex with all three particles interacting

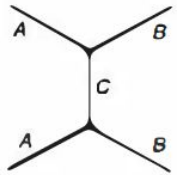


Calculating the Amplitude

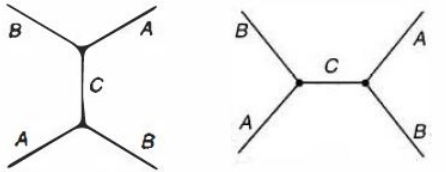
- Corrections like



- What is the lifetime of A?



- Scattering processes



Feynman Rules

- **Notation:** label incoming and outgoing four-momenta p_1, p_2, … p_n. Label the internal momenta q_1, q_2, … Add an arrow to each line to keep track of the positive direction.

- **Vertex faction:** for each vertex, write down a factor $-ig$ with g being the coupling constant

- **Propagator:** for each internal line, write a factor $\frac{i}{q_j^2 - m_j^2 c^2}$ where q_j is the 4-momenta of the line and m_j the mass of the particle. Note $q_j^2 \neq m_j^2 c^2$.

Feynman Rules

- Energy and momentum conservation: for each vertex write a delta function

$$(2\pi)^4\delta^4(k_1 + k_2 + k_3)$$

- Integration of internal momenta: for each internal line, write down a factor

$$\frac{1}{(2\pi)^4}\,\mathrm{d}^4 q_j$$

- The result will include a delta function. Erase it and multiply by i

$$(2\pi)^4\delta^4(p_1 + p_2 + \cdots - p_n)$$

- Voila, the result is M!

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