Feynman Rules - Self-Interacting Complex Scalar theory

The Lagrangian density for a self-interacting complex-scalar field theory is given by

$$\mathcal{L} = \partial_\mu \varphi^\dagger \, \partial^\mu \varphi - m^2 \varphi^\dagger \varphi - \lambda (\varphi^\dagger \varphi)^2$$

where m is the mass parameter and λ is the coupling.

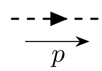
Feynman Rules

Here we give the Feynman rules for the scattering amplitude $\mathcal{M}$,

$$i\mathcal{M} = \text{sum of all connected, amputated diagrams}\,,$$

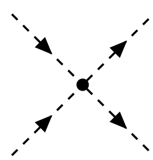
where the diagrams are evaluated according to the following rules:

- Draw all topologically distinct diagrams at a given order;
- For each internal scalar line, attach a propagator



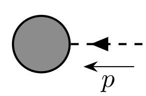
$$= \frac{i}{p^2 - m^2 + i\epsilon}\,;$$

- For each vertex, assign

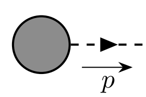


$$= -i\lambda\,;$$

- For each external line, place the particle on the mass-shell $p^2 = m^2$ and attach a wavefunction factor

"incoming scalar" 

$= 1\,;$

"outgoing scalar" 

$= 1\,;$

- Impose momentum conservation at each vertex;
- For each internal loop momentum k not fixed by momentum conservation, integrate $\displaystyle\int \frac{\mathrm{d}^4 k}{(2\pi)^4}$;
- Multiply the contribution for each diagram by an appropriate symmetry factor $\mathcal{S}^{-1}$.