

1 a

The denominator in Eq. (7.64) removes terms which have so-called “bubbles”, which are connected subgraphs of the feynmann diagram. The bubbles do not interact with the main part of the propagator, which in a two-point propagator connects x_1 to y_1 . They instead contribute to the normalization, which we factor out.

I don’t know why the bubbles don’t need to be removed in the first section. Since we’re interested in calculating correlators, which need to be evaluated at endpoints, then the only part of the diagram which can contribute to the endpoints is one which is connected to them?

2 b

Since the field is given by

$$\phi(x) = \int \frac{d^3p}{(2\pi)^3} \frac{1}{\sqrt{2\omega_p}} \left(a_p e^{-ip_\mu x^\mu} + a_p^\dagger e^{ip_\mu x^\mu} \right)$$

, when we are in momentum space, a derivative ∂_μ gives ip_μ if a particle is being destroyed, and $-ip_\mu$ if a particle is being created.

From the momentum-space feynmann rules, momentum is conserved at each vertex.

Consider an extra term in the lagrangian, $\mathcal{L}_d[\phi] = \partial_\mu (F^\mu(\phi_1 \dots \phi_n))$ for some F^μ . This is equal to $\sum_{i=1}^n \frac{\partial F^\mu}{\partial \phi_i} \partial_\mu \phi_i$. As stated before, in momentum space the derivatives of the fields become factors of the overall momentum. For this function F to be translation-invariant, it must not be different in its arguments. Therefore, we can factor out $\frac{\partial F^\mu}{\partial \phi_i}$, and replace it with:

$$\mathcal{L}_d[\phi] = \frac{\partial F^\mu}{\partial \phi} i \left(\sum p_{\mu, \text{incoming}} - \sum p_{\mu, \text{outgoing}} \right)$$

Note that this result only corresponds to the inherently perturbative feynmann rules, and says nothing about the exact interactions.

3 c

I’m going to give a nod to “By the way, this integral is infinite...”

It was somewhat surprising that we brushed over the difference between $|\Omega\rangle$ and $|0\rangle$ in the lagrangian derivation of the position-space feynmann rules.

It was also somewhat confusing for them to brush over interactions with derivatives until later, where they were treated as a special case.