Problem: Furry's Theorem

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Prelude

The Path Integral formalism and the canonical formalism are, as far as we're aware[1], equivalent. However, there are situations where one method is more intuitive, or simpler, than the other. To take advantage of this fact, it's important to build intuition on how to approach problems in either formalism in o. The idea of this problem is to build some.

Problem Statement

Prove, using Path Integrals, that in Quantum Electrodynamics, any Photon n-point function, where n is odd, vanishes to all orders of perturbation theory (this is also a hint, you don't need to draw Feynman diagrams to prove this theorem). This is what's referred to as a non-perturbative result.

Next, prove it again, this time using the canonical formalism.

Hint: Think about Charge Conjugation symmetry and how fields transform under it.

[1] This is not entirely true. There are problems in physics that are non-Lagrangian, so how to treat them via path integrals is not obvious. Perhaps the more precise statement is to say that there is a set of theories where we have computed observables in both formalisms, and they match.