Generation of Phi-4 Feynman Graphs Through a Recursive Algorithm

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Generating all possible Feynman diagrams is crucial in quantum field theory for computing interaction amplitudes. In scalar phi-4 theory, characterized by four-point interaction vertices, these diagrams can be translated into mathematical graphs, enabling a systematic graph-theoretic approach. This project aimed to develop an open-source program capable of generating and counting all phi-4 Feynman graphs with up to nine points of interaction. While previous work has generated graphs with few interaction vertices, this algorithm was designed to efficiently scale to more complex cases, and thus generate larger graphs. A family of graphs, known as vacuum graphs, was recursively generated and then systematically modified to create all valid phi-4 Feynman graphs with up to nine points of interaction. Each major component of the algorithm was timed individually, and the number of generated graphs was recorded. The algorithm successfully generated all phi-4 Feynman graphs with up to nine vertices. Preliminary results indicate that the most time-consuming part of the algorithm is the isomorphism check, and that the number of generated graphs grows combinatorially. Although the program currently performs efficiently, scalability could be improved by integrating more optimized isomorphism checks. The generated graphs are essential in particle physics, offering insight into particle interactions and potential new particles, but also relevant in statistical mechanics. Further development, such as implementing new operators to produce other kinds of Feynman graphs, would broaden the program's applicability even more.

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