For the first time, scientists rigorously calculate three-particle scattering from theory

January 19 2022

A new method uses supercomputers to calculate interactions among three particles. It may help physicists learn more about the building blocks of our universe. Credit: Jefferson Lab

The goal of nuclear physics is to describe all matter from its simplest building blocks: quarks and gluons. Found deep inside protons and neutrons, quarks and gluons also combine in less common configurations to make other subatomic particles of matter. For scientists, producing these less-common particles in experiments is an interesting challenge. A new theory method aids in those efforts by predicting which less-common particles an experiment will produce.

The theory that describes how particles interact is well established but extremely complicated. Applying that theory to experiments becomes more and more challenging as the number of particles in an experiment increases. This is why scientists' previous theory predictions from rigorous calculations were limited to two-particle systems. Now, nuclear physicists have made the first complete numerical prediction from theory for a three-particle system. Researchers successfully applied the new method to a relatively simple case of three positively charged pions. Pions are a type of subatomic particle made of quarks and antiquarks. This work is proof of principle that sets the stage for more complex calculations and more detailed knowledge of the particles that build our universe.

Nuclear physicists aim to produce and study the full spectrum of particles built of light quarks and gluons at the Continuous Electron Beam Accelerator Facility, a Department of Energy (DOE) user facility. These experiments help scientists understand quarks and gluons, the building blocks of our visible universe. Nuclear physicists predict the experiment results with rigorous calculations using the theory of quantum chromodynamics. These calculations have previously been limited to two-particle systems, and the theory has described many experiments well. Nuclear theorists recently developed a new method for computing the physical scattering amplitudes, or strengths, of interactions for systems with three particles. The method uses supercomputers for the first set of calculations. Afterwards, theorists apply a well-established formalism and an integration technique to convert the computation. The method yields data for comparison with experimental results. The new method was successfully applied to a simple case of three positively charged pions. Nuclear physicists aim to apply the new method to increasingly sophisticated three-particle systems.

The research was published in *Physical Review Letters*.

More information: Maxwell T. Hansen et al, Energy-Dependent $\pi^+\pi^+\pi^+$ Scattering Amplitude from QCD, *Physical Review Letters* (2021). DOI: 10.1103/PhysRevLett.126.012001

Provided by US Department of Energy