

S-Matrix Encyclopedia Article

S-Matrix

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S-Matrix

The S-matrix is a quantity related to the probability of events occurring in quantum mechanical **scattering** processes. In scattering, two or more particles collide, and the resulting mass-energy can be converted to other particles. The particles that exist before the collision, as well as their energies, momenta, spins, etc., are called the *initial state*, while the particles and their energies, momenta, etc. after the collision are called the *final state*. The S-matrix contains the probability information for all scattering processes.

Mathematically, a matrix is a two dimensional array of numbers arranged in rows and columns. Individual numbers are called matrix elements. Each row of the S-matrix corresponds to a specific initial state, and each column corresponds to a specific final state. The S-matrix element at row i , column j is the probability that initial state i becomes final state j after the scattering occurs. If an S-matrix element is zero, then the scattering process corresponding to its initial and final states cannot occur.

The advantage of the S-matrix formalism is that if the underlying physical theory obeys any symmetry principles, then the S-matrix also obeys those principles. For example, all quantum field theories must be invariant under **Lorentz transformations**. Therefore, the S-matrix is also invariant under Lorentz transformations. It is often easier to evaluate S-matrix elements in a specific reference frame, and then use Lorentz transformations to generalize the answer to any reference frame for use in other situations.