2. Symmetries

2.1 Introduction
Importance of Symmetries

Symmetries and conservation laws are central to the development of the Standard Model of particle physics.

Noether’s theorem:
(informal) If a system has a continuous symmetry property, then there are corresponding properties whose values do not change with time.
(more sophisticated) To every differentiable symmetry generated by local action there corresponds a conserved current
Emmy Noether

1882-1935

Erlangen

Göttingen

Bryn Mawr

Princeton

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# Symmetries and Conservation Laws

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Noether’s Theorem: Symmetries $\leftrightarrow$ Conservation laws
Symmetry Operations

Identity: there is an element \( I \) such that \( R_i I = R_i I = R_i \)

Closure: if \( R_i \) and \( R_j \) are in a set, then there exists \( R_k = R_i R_j \)

Inverse: for every element, there is an inverse \( R_i R_i^{-1} = I \)

Associativity: \( R_i (R_j R_i) = (R_i R_j) R_k \)

Abelian \( R_j R_i = R_i R_j \) and non-Abelian \( R_j R_i \neq R_i R_j \) groups