

Gauge Symmetry Encyclopedia Article

Gauge Symmetry

The following sections of this BookRags Literature Study Guide is offprint from Gale's For Students Series: Presenting Analysis, Context, and Criticism on Commonly Studied Works: Introduction, Author Biography, Plot Summary, Characters, Themes, Style, Historical Context, Critical Overview, Criticism and Critical Essays, Media Adaptations, Topics for Further Study, Compare & Contrast, What Do I Read Next?, For Further Study, and Sources.

(c)1998-2002; (c)2002 by Gale. Gale is an imprint of The Gale Group, Inc., a division of Thomson Learning, Inc. Gale and Design and Thomson Learning are trademarks used herein under license.

The following sections, if they exist, are offprint from Beacham's Encyclopedia of Popular Fiction: "Social Concerns", "Thematic Overview", "Techniques", "Literary Precedents", "Key Questions", "Related Titles", "Adaptations", "Related Web Sites". (c)1994-2005, by Walton Beacham.

The following sections, if they exist, are offprint from Beacham's Guide to Literature for Young Adults: "About the Author", "Overview", "Setting", "Literary Qualities", "Social Sensitivity", "Topics for Discussion", "Ideas for Reports and Papers". (c)1994-2005, by Walton Beacham.

All other sections in this Literature Study Guide are owned and copyrighted by BookRags, Inc.

Contents

Gauge Symmetry Encyclopedia Article.....	1
Contents.....	2
Gauge Symmetry.....	3

Gauge Symmetry

If a field theory possesses a gauge symmetry, then the theory is invariant under certain local transformations of the fields. The description of the system has a built-in redundancy corresponding to the action of a gauge transformation, which is typically thought of as an element of an algebraic group. By choosing a particular gauge, the redundancy can be eliminated. Measurements that are made of any physical quantities are independent of the precise choice of gauge.

An example serves to illustrate the point. The **quantum field theory** that describes the interactions of charged point particles and **radiation** is **quantum electrodynamics (QED)**. This theory encodes the quantum mechanical properties of electrons and photons in a manner that is consistent with the theories of special relativity and classical **electrodynamics**. The electrons and photons are thought of as fields, an extension of the notion of wave functions from quantum **mechanics**. QED possesses a $U(1)$ gauge symmetry. The group $U(1)$ can be represented as the unit circle in the complex plane, or the collection of complex numbers $z = x + iy$ whose modulus $|z|$ equals 1. Such numbers are called phases. The opportunity to redefine the fields in QED by a local phase without affecting the theory in any way is possible. Multiplying the **electron** field by a phase is compensated for by a corresponding shift in the **photon** field. The Lagrangian of the theory, which encodes all the **dynamics** of QED, remains invariant under this combined operation. Because it is impossible to add a **mass** term for the photon to the QED Lagrangian that respects the $U(1)$ gauge symmetry, the photon must be massless. A continuous symmetry, such as a gauge symmetry, leads to a conserved current as a consequence of Amalie Noether's theorem.

The theory of the particles observed in nature and their interactions (excluding **gravity**) is a gauge theory with gauge group $SU(3) \times SU(2) \times U(1)$. This is called the standard model. Yang-Mills theory is the general name given to a model with a gauge group that is non-Abelian (the product of elements in the group does not commute).