

# Symmetry and symmetry breaking

## Examples of symmetry and invariance in science

### Physics:

- translation symmetry: conservation of momentum;
- rotational symmetry: conservation of angular momentum;
- time invariance: conservation of energy;
- invariance for Lorentz transformations of the speed of light, Einstein's relativity principle: special theory of relativity;
- independence of units: dimensional homogeneity, dimensional analysis, Buckingham's pi theorem, similarity theory;
- independence of systems of units (basic units).

### Quantum mechanics:

- symmetry under change of parity (P), particle-antiparticle reversal (C) and time inversion (T);
- gauge symmetry: charge conservation, quantum electrodynamics (QED);
- conservation of total electrical charge, baryon number, hypercharge, iso-spin,...;
- baryon octet, baryon decuplet, meson-octet,...;
- invariance for the (space-time) resolution of the measurement equipment, "relativity of scale state": most important axioms of quantum mechanics.

### Mathematics:

- scale invariance: homogeneous functions, power laws ("universality"), fractals;
- base invariance (binary, decimal,...);

### Miscellaneous:

- symmetries in overall biological forms (morphology);
- translation, mirror, rotation and spiral symmetry in plants;
- symmetry in family relationships (anthropology).

## Interesting links

- Katherine A. Brading and Elena Castellani, *Symmetries in physics: philosophical reflections*, Cambridge University Press, 2003. Contents and Introduction: <http://arxiv.org/ftp/quant-ph/papers/0301/0301097.pdf>
- John Earman, *Laws, Symmetry, and Symmetry Breaking; Invariance, Conservation Principles, and Objectivity*, 2002: <http://philsci-archive.pitt.edu/878/1/PSA2002.pdf>
- Leon M. Lederman and Christopher T. Hill, *Symmetry and the Beautiful Universe*, 2004: [http://www.amazon.com/exec/obidos/tg/detail/-/1591022428/qid=1096764325/sr=1-1/ref=sr\\_1\\_1/104-2867667-9349535?v=glance&s=books](http://www.amazon.com/exec/obidos/tg/detail/-/1591022428/qid=1096764325/sr=1-1/ref=sr_1_1/104-2867667-9349535?v=glance&s=books)
- International Symmetry Association (ISA) and Symmetrion: <http://symmetry.hu>
- Wikipedia:
  - Symmetry: <http://en.wikipedia.org/wiki/Symmetry>
  - Invariance: <http://en.wikipedia.org/wiki/Invariant>
  - Conservation laws: [http://en.wikipedia.org/wiki/Conservation\\_law](http://en.wikipedia.org/wiki/Conservation_law)
  - Symmetry breaking: [http://en.wikipedia.org/wiki/Symmetry\\_breaking](http://en.wikipedia.org/wiki/Symmetry_breaking)
  - Noether's theorem: [http://en.wikipedia.org/wiki/Noether's\\_theorem](http://en.wikipedia.org/wiki/Noether's_theorem)