Symmetry of STRUCTURE

an interdisciplinary Symposium

Abstracts

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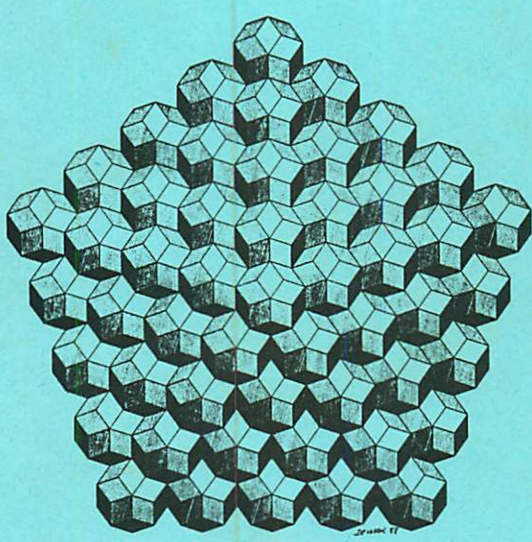

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SYMMETRIES AND THEIR BREAKING

Henning Genz
Institut für theoretische Kernphysik der Universität Karlsruhe
D7500 Karlsruhe, Germany

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Symmetry of objects in space as defined by Hermann Weyl is closely related to unobservability. The concept is extended to the laws of nature. Absolute values of variables that are modified by symmetry transformations of these laws are unobservable. Symmetries imply conservation laws. Symmetric laws of nature are not inconsistent with asymmetric phenomena since in addition to the laws initial conditions are required to fix the phenomena. Symmetry in the mean as well as explicit and spontaneous symmetry breaking are described. Unified theories such as Newton's mechanics, Maxwell's electrodynamics and the standard model of elementary particle physics have a larger domain of applicability and thus a higher symmetry than the individual laws they unite in a modified form. As an extension of the rotation symmetry of their predecessors, the Maxwell equations are symmetric under velocity changes according to the rules of special relativity. They furthermore possess a certain local symmetry. Both symmetries, which are of utmost importance in present-day elementary particle physics, appeared in Maxwell's equations for the first time. Their validity is tested by these equations themselves and their quantum-mechanical version, quantum electrodynamics, with overwhelming success.

The laws of Maxwell and the standard model may furthermore almost uniquely be derived from the symmetries they possess. According to E. P. Wigner, the relation of the symmetries of the laws of nature to these laws is the same as the relation of the laws to the phenomena. Known and supposed symmetries therefore may help in the search for more general laws of nature than are presently known. The symmetry group of these laws presumably combines internal and space-time symmetries in a non-trivial way. The prominent role played by the requirement of local symmetry for the derivation of interactions is explained with the help of examples.

Outside of physics, symmetries are mainly used for the classification of objects. The laws of chemistry and biology leading to (or allowing) the breaking of mirror symmetry observed in living systems, serve as an example for the spontaneous breaking of symmetries.

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