

The principle of general tovariance

Heunen, Chris and Landsman, Klaas and Spitters, Bas (2008) The principle of general tovariance.

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Abstract

We tentatively propose two guiding principles for the construction of theories of physics, which should be satisfied by a possible future theory of quantum gravity. These principles are inspired by those that led Einstein to his theory of general relativity, viz. his principle of general covariance and his equivalence principle, as well as by the two mysterious dogmas of Bohr's interpretation of quantum mechanics, i.e. his doctrine of classical concepts and his principle of complementarity. An appropriate mathematical language for combining these ideas is topos theory, a framework earlier proposed for physics by Isham and collaborators.

Our "Principle of general tovariance" states that any mathematical structure appearing in the laws of physics must be definable in an arbitrary topos (with natural numbers object) and must be preserved under so-called geometric morphisms. This principle identifies geometric logic as the mathematical language of physics and restricts the constructions and theorems to those valid in intuitionism: neither Aristotle's principle of the excluded third nor Zermelo's Axiom of Choice may be invoked. Subsequently, our "Equivalence principle" states that any algebra of observables (initially defined in the topos Sets) is empirically equivalent to a commutative one in some other topos.

Subjects: [Specific Sciences: Physics: Quantum Mechanics](#)

ID Code: 3931

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Deposited On: 16 March 2008