Physics on Noncommutative Spaces

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We have constructed field theories and gauge theories for arbitrary gauge groups on noncommutative spaces that are deformations of the usual commutative space. These theories can be formulated in terms of fields of commuting variables; the noncommutativity appears in the product of such fields as differential operators. The number of fields corresponds exactly to the number of fields in the commutative theory; the noncommutativity shows itself as additional couplings. These couplings change the field theoretical behaviour especially of the corresponding quantum theory but it changes the phenomenology of such a model as well.

The Θ-deformed space has been treated extensively. The Lagrangians for arbitrary gauge groups have been constructed in a power series expansion in Θ up to second order. The results agree with string theoretical models for appropriate gauge groups. The deformation of the Standard Model leads to new phenomenological processes. They are of special interest if the process does not occur in the undeformed theory. An example is the Standard Model-forbidden decay of a Z°-gauge boson to two photons.

We treat the new couplings perturbatively in Θ. This is a good approximation for processes that appear at very short distances and we believe that the models should be tested there. It is also a way to avoid infrared difficulties.

We systematically developed this approach for any gauge group and have a formalism that can be applied to all deformations of space-time.

We have systematically studied the Θ-deformation for an arbitrary gauge group and have studied the Standard Model for SU(3) x SU(2) x U(1) in great detail. An explicit Lagrangian up to second order in Θ has been constructed. Phenomenological implications of this theory have been investigated as well.

One of the next projects will be the construction of κ-supersymmetric theories and the deformation of gravity theory. A more ambitious project will be the investigation of the quantum aspects of these models as quantum field theories. At present we know very little about the renormalization aspects.