Quantum Field Theory in Curved Space-Time.

Quantum field theory in curved space-time deals with second quantized fields on the background, which is not the Minkowski space-time but some general curved space-time. This can be viewed as some interaction of the quantized field with gravitational field, being treated classically as some this or that geometrical property of the space-time. It is generally believed that such treatment is possible in absence of the consistent quantization of gravity when one can neglect Planckean values of space or time intervals. There is a lot of applications of such treatment in modern astrophysics in situations when the gravitation is strong enough but still is classical, the well known examples being physics of black holes and cosmology of the early Universe.

In quantum field theory in curved space-time there are developed special methods of quantization which make possible calculations of quantum effects in curved space-time, different from those known in Minkowski space-time. Here one solves two problems. The first is the construction of the Hilbert space and Fock quantization of the field making possible some particle interpretation. Differently from Minkowski space-time in curved space-time one does not have Poincare group as the symmetry. This makes the classification of particles rather ambiguous. However in quasiclassical approximation one can speak about particles as some pointlike objects moving along geodesics of curved space-time, in neglect of the curvature treated according to classification in Minkowski space-time. So the main problem is to find for this or that curved space the Fock quantization leading to correct quasiclassical behaviour.

The second problem is calculation of physical observables as some expectation values of operators, usually being bilinear in field operators using states as some vectors in Hilbert space, constructed before. Here one must struggle with new infinities arising in curved space-time in order to obtain finite regularized values for physical observables and find the interpretation of the regularization procedure in terms of renormalization of some physical constants.

Both problems were solved for the special case of Friedmann models in cosmology, describing isotropic nonstationary early Universe. In papers of A.A.Grib, S.G.Mamayev, V.M.Mostepanenko finite values for observables, describing vacuum polarization and particle creation were obtained. It was shown that the effects lead to observable consequences for creation of heavy particles with the mass of the order of Grand Unification, new terms to Einstein equations due to vacuum polarization, dependent on the mass of particle were also obtained. Due to the special symmetry of Friedmann's model the method of the Hamiltonian diagonalization for defining the Fock quantization was widely used. However in more general case of anisotropic space-time more sophisticated methods, directly taking into account regularization procedure with counter terms in the Lagrangian must be used in order to obtain consistent interpretation.

Problems of the role of interactions, possibilities of spontaneous breaking of gauge symmetries due to nontrivial geometry as well as role of nontrivial topology for quantum effects are also investigated.

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