The goal of the project consists of further studies, and therefore better understanding of quantum chromodynamics (QCD). It is generally established as the theory of strong (hence also of nuclear) interactions. QCD was born in fifties of the previous century as a generalisation of quantum electrodynamics (QED) - historically the first field theory which successfully describes our world (more precisely: the world of electrons, photons and their interactions) on the most fundamental level. QED owns its triumph to the small value of the elementary electric charge. This allows for the precise calculations of the experimental predictions by the perturbative methods. Analogically QCD describes hadrons (proton, neutron, mesons, etc.) and their interactions. However the situation here is much more subtle. Hadrons turn out to be bound states of quarks and gluons, and those are equivalents of electrons and photons. Second, while photons do not carry electric charge, their counterparts - gluons - do. They have colour charge responsible for strong interactions. In the consequence gluons have a complicated (non-abelian) pattern of interactions among themselves as well as with quarks. Moreover, in contradistinction to an atom, for example, hadrons cannot be ionised in order to observe free quarks and gluons. The latters are permanently confined similarly to two ends of a lace - cutting a lace gives two laces each with its two ends again. Already these examples show that QCD is much more complicated than QED. It is not surprising then, that experimental verifications of QCD are still ongoing. This applies also to the nuclear forces, which are van der Waals forces of colour interactions. Contrary to the effective electric charge, which very weakly depends on the size of the occurring process, the effective colour charge strongly varies with the scale of the described phenomenon. Therefore one distinguishes two regimes of applications of QCD. High energy scattering of hadrons with large momentum transfer is well described by perturbative methods, since it occurs at small distances and colour charge decreases with the distance. On the other hand, in bigger regions (of the order of 1 fm) the non-perturbative description is necessary.

Studies of QCD in its non-perturbative regime, are precisely the subject of proposed grant. In general, one is interested in hadronic masses, their wave functions in terms of constituents, and low energy interactions. More concretely, the project deals with non-perturbative calculations of hadronic amplitudes which enter description of the weak interactions between hadrons and leptons. Such amplitudes are necessary while searching for new, i.e. beyond the Standard Model physics. Above amplitudes are calculated within the lattice formulation of QCD. It consists of Monte Carlo computations of Feynman path integrals which define the theory *ab initio*. In practice these are Monte Carlo simulations on a very large computational scale (with c.a. 10^9 variables, at present). The main challenge, however, consists of construction of state of art methods, which can copy with the complicated mathematical structure of the field theory. A good example is provided by the recent, non-perturbative renormalisation algorithms. Participants of our grant are well recognised specialists in this field.

A second task of the project consists of continuing non-perturbative studies of QCD, and its modifcations, with more analytic and intuitive techniques. One is, derived from lattice formulation, dimensional reduction - another, complementary to the lattice, light cone approach. Also in this area our investigators have important and valuable results which are promising interesting outcome.