**NATIONAL SCIENCE FUND**
MINISTRY OF EDUCATION AND SCIENCE

# SUMMARY

(FNSF-2004)

**Reg. No.:**

**Project Leader** Title, Rank, Degrees, Family Name, First Name, Middle Name:

Full Member of BAS, Professor, Doctor of Sciences TODOROV Ivan Todorov

**Project Title:**

QUANTUM STRUCTURE AND GEOMETRIC NATURE OF FUNDAMENTAL FORCES

**Summary ( 1800 characters)**

Our project is motivated by the advent of string theory as a central and most promising model of a unified theory of all fundamental forces in Nature on the one hand, and by the unsolved challenges of this theory, on the other hand. String theory encompasses the achievements of many branches of theoretical physics, at the same time applying the tools of modern pure and applied mathematics and inspiring new progress in these most advanced fields. The aim of this project is to get further insights into the structure and behaviour of matter at very short distances, to advance research and facilitate training at the interface of physics and mathematics. The main emphases is to put strings into the context of particle physics and cosmology. Hence the project will contribute to address some of the core questions on the structure, origin and future of our Universe.

The main objectives of the project are:

(a) Gauge/gravity duality and integrability in string theory relevant for the AdS/CFT correspondence.

(b) Globally conformal invariant field models.

(c) Models of supersymmetric vertex algebras within the axiomatic approach to globally conformally QFT.

(d) Lightlike branes in the physics of black holes, elementary particle physics and cosmology, in particular, new cosmological brane-world scenarios with lightlike brane "universes".

(e) Black holes in higher-dimensional general relativity.

(f) Two-dimensional non-critical string models **-** obtaining exact results in Liouville gravity with matter in the presence of boundaries.

(g) Applications of quantum group and conformal invariance to integrable models – generalized Hopf-type internal symmetries and superselection rules.

(h) Conformal (super-)algebras in various dimensions - construction of Minkowskian bulk-to-boundary intertwining operators in (super-)AdS/CFT correspondence.

(i) Topological quantum computation with non-abelian anyons - applications of braid group representations to quantum computers.

(j) Applications of non-standard quantum statistics to strongly correlated systems.

(k) Geometric structures related to string theory - studying properties and structures of quaternionic contact manifolds.

**Keywords:**

M-theory, superstrings, AdS/CFT duality, integrablility, Bethe ansatz, (supersymmetric) spin-chain models, p-branes, brane tension, black holes, black rings, wormholes, (super-)conformal algebras, vertex algebras, quantum groups, WZNW models, Liouville gravity, boundary operators, braid groups, quantum Hall effect, Pfaffian state, quantum computers, non-standard quantum statistics, quaternionic manifolds, Riemann problem, CR-Yamabe problem, (para-) Sasakian manifolds