The group for
Gravitation, Particles and Fields

http://www.gravity.ipb.ac.rs

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History: The group is founded in the 1980s; first activities - gauge theories and gravity

Members: 11 PhDs + 4 PhD students = 15

Research activities

– Gauge theories of gravity (the motion of matter, symmetries, dynamics in 3D)
– Strings and branes (boundary conditions and noncomutativity)
– Noncommutative field theories (standard model, gravity)

1. Gauge theories of gravity

Motivation

GR with Riemannian geometry:
- problems with classical singularities and quantization

Gauge theories of gravity:
- based on more general geometries of spacetime (Riemann-Cartan, Weyl, affine, . . .)
- might lead to a consistent unification at the quantum level

(a) The motion of extended objects in Riemann-Cartan geometry

RC geometry: spacetime with torsion and curvature
Conservation laws of P^μ, $M^{\mu\nu}$ $\Rightarrow$ eqs. of motion for matter
– only the motion of matter with spin is influenced by torsion $\Rightarrow$
spinless matter in "Gravity Probe B" cannot detect torsion
– membrane in RC geometry + dim. reduction $\Rightarrow$ eqs. of motion of fundamental string
(with background fields: $B_{\mu\nu} \sim$ torsion, $g_{\mu\nu} \sim$ metric of spacetime)
– 3D branes $\Rightarrow$ cosmological models

(b) Spacetime symmetries of modified gravity and p-branes

Local spacetime symmetries based on: SL(D,R), Affine(D,R) and Diff(D,R)
- infinite dim. representations, Dirac spinors $\rightarrow$ world spinors
- construction of the generalized Dirac equation for world spinors
- the coupling of matter to affine gravity
- study of the particle content of p-branes

(c) 3D gravity with torsion

Einstein's 3D gravity—a theoretical lab for studying gravitational dynamics: no propagating modes, but BTZ black hole solution

3D gravity with torsion:
- BTZ-like black hole solution
- canonical derivation of central charges
- the 1st law of BH thermodynamics still holds, but entropy depends on torsion
- extension to more realistic models with propagating graviton: TMG, NMG,. . .

Extension to 4D cosmology

2. Strings and branes

Motivation

- Search for a consistent quantum gravity (and unified theory of fundamental interactions)

Geometric interpretation of the background fields $B_{\mu\nu}$ and ϕ

- Test string "feels" $B_{\mu\nu}$ as torsion and the dilaton ϕ as nonmetricity of spacetime.

String, branes and noncommutativity

Noncommutativity can be derived from boundary conditions:
- Open bosonic string (with $B_{\mu\nu}$ and ϕ) ending on a brane $\Rightarrow$ noncomutativity of the brane manifold
- Weakly curved background $\Rightarrow$ noncommutativity on the world sheet boundary

For $(\nabla\phi)^2 = 0 \Rightarrow$ extra gauge symmetries $\Rightarrow$ dimension of the brane decreases

3. Noncommutative field theories and gravity

Motivation

Noncommutativity (NC) implies uncertainty relations between coordinates.
One hopes that such relations might
- improve singularity behavior of GR (black holes, cosmological singularity)
- resolve UV divergences in quantum field theory.

NC gauge field theories, Standard model

- definition of the NC standard model (field content), investigation of renormalizability
- phenomenological consequences and estimates of the noncommutativity parameters

NC gravity

- NC theories of gravity in the moving frame formalism
- properties of curved NC spaces

4. Collaboration

- We have a collaboration with similar groups in:
 Lisbon, Munich, Koeln, Vienna, Zagreb

- Our group is a member of the Southeastern European Network in Mathematical and Theoretical Physics (SEENET-MTP)

- We have a joint international project with a group in Zagreb:
"Theory of modified gravity and the accelerated expansion of Universe"