Overview of scientific research for 2004–2007

Node no. 24, University of Craiova

Constituents, Fundamental Forces and Symmetries of the Universe

Valencia, October 1–5, 2007

1 Main research topics

- Interactions in topological BF models;

- Indirect cross-couplings among different gravitons;

- Mixed symmetry-type tensor fields;

- Cohomological aspects of $N = 1$, $D = 11$SUGRA — in progress;

- Reducible second-class constraints — in progress.

2 Brief description of the emerging results

2.1 Interactions in topological BF models

Method: construction of consistent interactions in gauge theories based on the cohomological reformulation of the BRST symmetry.

Working hypotheses: locality, smoothness in the coupling constant, Poincaré invariance, Lorentz covariance, preservation of the number of derivatives on each field with respect to the free theory (derivative order assumption).

Results:

(i) PT-breaking interactions for a collection of topological BF models;

(ii) special couplings in $D = 5$;

(iii) interactions between a collection of BF models and arbitrary matter theories;

(iv) couplings between a collection of BF models and p-forms (so far for $p = 1, 2, 3$).

Young researchers involved: E. M. Cioroianu; S. C. Sararu.

Recent papers:

[1] E. M. Cioroianu, S. C. Sararu, *PT-symmetry breaking Hamiltonian interactions in BF models*, Int. J. Mod. Phys. **A21** (2006) 2573 [arXiv:hep-th/0606164];

[2] E. M. Cioroianu, S. C. Sararu, *Self-interactions in a topological BF-type model in $D = 5$*, JHEP **0507** (2005) 056 [arXiv:hep-th/0508035];

[3] C. Bizdadea, E. M. Cioroianu, S. O. Saliu, S. C. Sararu, *Couplings of a collection of BF models to matter theories*, Eur. Phys. J. **C41** (2005) 401 [arXiv:hep-th/0508037];

[4] E. M. Cioroianu, S. C. Sararu, *Two-dimensional interactions between a BF-type theory and a collection of vector fields*, Int. J. Mod. Phys. **A19** (2004) 4101 [arXiv:hep-th/0501056];

[5] C. Bizdadea, E. M. Cioroianu, I. Negru, S. O. Saliu, S. C. Sararu, *On the generalized Freedman-Townsend model*, JHEP **0610** (2006) 004 [arXiv:0704.3407];

[6] C. Bizdadea, E. M. Cioroianu, S. C. Sararu, *Couplings between a collection of BF models and a set of three-form gauge fields*, Int. J. Mod. Phys. **A21** (2006) 6477 [arXiv:0704.2656].

2.2 Indirect cross-couplings among different gravitons

Method: construction of interactions in gauge theories from BRST cohomology.

Working hypotheses: previous + positively defined metric in internal space.

Results:

(i) interactions between a single spin-two field and a Dirac spinor: uniqueness of General Relativity prescriptions;

(ii) couplings between a single spin-two field and a massive Rarita-Schwinger spinor: more than the well-known minimal coupling;

(iii) interactions between a single spin-two field and a massless p-form: (a) General Relativity prescriptions; (b) new, nontrivial couplings in $D = 2p + 2$;

(iv) no-go results on the cross-couplings between different Einstein gravitons in the presence of a Dirac field, a massive Rarita-Schwinger spinor and respectively of a massless p-form (assuming a positively defined metric in internal space induced by the Pauli-Fierz Lagrangian);

(v) no-go results on the existence of cross-couplings between different Weyl gravitons intermediated by a scalar field (assuming a positively defined metric in internal space induced by the linearized Weyl Lagrangian).

Young researchers involved: E. M. Cioroianu; D. Cornea; E. Diaconu; A. C. Lungu; S. C. Sararu.

Recent papers:

[1] C. Bizdadea, E. M. Cioroianu, A. C. Lungu, S. O. Saliu, *No multi-graviton theories in the presence of a Dirac field*, JHEP **0502** (2005) 016 [arXiv:0704.2321];

[2] C. Bizdadea, E. M. Cioroianu, D. Cornea, S. O. Saliu, S. C. Sararu, *No interactions for a collection of spin-two fields intermediated by a massive Rarita-Schwinger field*, Eur. Phys. J. **C48** (2006) 265 [arXiv:0704.2334];

[3] C. Bizdadea, E. M. Cioroianu, D. Cornea, E. Diaconu, S. O. Saliu, S. C. Sararu, *Interactions for a collection of spin-two fields intermediated by a massless vector field: no-go and yes-go results*, arXiv:0705.3210;

[4] C. Bizdadea, E. M. Cioroianu, A. C. Lungu, *No interactions for a collection of Weyl gravitons intermediated by a scalar field* , Int. J. Mod. Phys. **A19** (2004) 4101A21 (2006) 4083 [arXiv:0705.2926];

[5] C. Bizdadea, E. M. Cioroianu, A. C. Lungu, S. C. Sararu, *No cross-interactions between the Weyl graviton and the massless Rarita-Schwinger field*, Annalen Phys. **15** (2006) 416 [arXiv:0704.2658].

2.3 Mixed symmetry-type tensor fields

Method: deformation of the solution to the master equation.

Working hypotheses: locality, smoothness, Poincaré invariance, Lorentz covariance, derivative order assumption.

Results:

(i) computation of the local BRST symmetry for the massless tensor field with the mixed symmetry (k, k);

(ii) construction of self-interactions for the massless tensor field with the mixed symmetry $(2, 2)$ and also of its couplings to matter fields, a spin-two field, and respectively a massless vector field: no-go results;

(iii) building of couplings between the massless tensor field with the mixed symmetry $(3, 1)$ and a massless vector field: new results. Generalization to an arbitrary massless p-form.

Young researchers involved: C. C. Ciobirca; E. M. Cioroianu; S. C. Sararu.

Recent papers:

[1] C. C. Ciobirca, E. M. Cioroianu, S. O. Saliu, *Cohomological BRST aspects of the massless tensor field with the mixed symmetry* (k, k), Int. J. Mod. Phys. **A19** (2004) 4579 [arXiv:hep-th/0403017];

[2] C. Bizdadea, C. C. Ciobirca, E. M. Cioroianu, S. O. Saliu, S. C. Sararu, *Interactions of a massless tensor field with the mixed symmetry of the Riemann tensor. No-go results*, Eur. Phys. J. **C36** (2004) 253 [arXiv:hep-th/0306154];

[3] C. Bizdadea, C. C. Ciobirca, E. M. Cioroianu, S. O. Saliu, S. C. Sararu, *BRST cohomological results on the massless tensor field with the mixed symmetry of the Riemann tensor*, Int. J. Geom. Meth. Mod. Phys. **1** (2004) 335 [arXiv:hep-th/0402099];

[4] C. Bizdadea, C. C. Ciobirca, E. M. Cioroianu, S. O. Saliu, *Interactions between a massless tensor field with the mixed symmetry of the Riemann tensor and a massless vector field*, J. Phys. A: Math. Gen. **39** (2006) 10549 [arXiv:0705.1054];

[5] C. Bizdadea, C. C. Ciobirca, I. Negru, S. O. Saliu, *Couplings between a single massless tensor field with the mixed symmetry* $(3, 1)$ *and one vector field* , Phys. Rev. **D74** (2006) 045031 [arXiv:0705.1048];

[6] C. C. Ciobirca, S. O. Saliu, *Generalized couplings between an Abelian p-form and a* $(3, 1)$ *mixed symmetry tensor field*, arXiv:hep-th/0702018.

2.4 Cohomological aspects of $N = 1$, $D = 11$ SUGRA (in progress)

Method: interactions in gauge field theories from local BRST cohomology.

Working hypotheses: locality, smoothness, Poincaré invariance, Lorentz covariance, derivative order assumption.

Results:
(i) computation of two-field vertices (Pauli-Fierz–Rarita-Schwinger, Pauli-Fierz–3-form, Rarita-Schwinger–3-form);

(ii) analysis of vertices mixing all the three types of fields at order one in the couplings constant: no-go results;

(iii) consistency of the first-order deformation of the solution to the master equation: vanishing of the cosmological constant, null Rarita-Schwinger mass term, establishing the standard relations among the various coupling constants.

Young researchers involved: E. M. Cioroianu; E. Diaconu; S. C. Sararu.

Recent papers: in progress.

2.5 Reducible second-class constraints (in progress)

Method: general methods of constrained dynamics.

Working hypotheses: reducibility of second-class constraints, fulfillment of general regularity conditions.

Results:
(i) irreducible approach to second and respectively three-order reducible second-class constraints: reducible Dirac bracket expressed in terms of an invertible matrix, introduction of an intermediate system subject to a set of reducible second-class constraints whose Dirac bracket is weakly equal to the original one, construction of a theory subject to an irreducible set of second-class constraints whose Dirac bracket coincides weakly with that of the intermediate system. This three-step procedure implies the weak equality between the Dirac bracket of the irreducible system and the starting reducible theory.

Young researchers involved: O. Balus; E. M. Cioroianu; S. C. Sararu.

Recent papers: in progress.

3 Further research topics

- Cohomological approach to dual formulations of linearized gravity;

- Higher spin field theories;

- Topological BF theories;

- Cohomological aspects of supergravity theories;

- Constrained dynamics.