XXth Oporto meetting

on

Geometry, Topology and Physics,

Main theme:

NONCOMMUTATIVE GEOMETRY AND CONFORMAL FIELD THEORY

Dept. of Mathematics, Faculty of Sciences, Univ. of Oporto
July 19–22, 2012

Schedule

	July 19 Thursday	July 20 Friday	July 21 Saturday	July 22 Sunday
8h45-9h00	Opening			
9h00-10h00	**Gannon**	**Longo**	**Kawahigashi**	**Fuchs**
10h10-11h10	**Longo**	**Kawahigashi**	**Fuchs**	**Kawahigashi**
	Coffee break	Coffee break	Coffee break	Coffee break
11h40-12h40	El Harti	**Fuchs**	**Gannon**	**Longo**
	Lunch	Lunch		
14h30-15h00	Hahn	**Gannon** (14h30-15h30)	social program (15:00—19:00)	
15h10-15h40	Castelo Ferreira			
15h50-16h20	Mikovic	Mendes		
16h50 -17h20	Guttenberg	Hillier (16h50-17h50)		
17h30-18h00	Mayburov			
18h10-18h40	Chryssomalakos	Popov		
18h50-19h20	Druta-Romaniuc	Martins Ferreira		
20h30			Conf. Dinner	

Mini Course Titles

Jürgen Fuchs (Karlstad, Sweden): *Characters and coends in conformal field theory*

Terry Gannon (Alberta, Canada): *Postcards from the edge: modularity, K-theory and subfactors in 21st century CFT*

Yasuyuki Kawahigashi (Tokyo, Japan): *Superconformal Field Theory and Operator Algebras*

Roberto Longo (Rome, Italy): *Operator Algebras and Boundary Quantum Field Theory*

Abstracts

Main Speakers/Mini courses

1. **Jürgen Fuchs (Karlstad, Sweden)**
   Characters and coends in conformal field theory

   Abstract: Lecture 1: The bulk state space in conformal field theory

   In this lecture I start by reviewing, as a motivation, various general results in CFT (two-dimensional conformal quantum field theory). In particular the relation between chiral CFT and full local CFT is made precise and some pertinent aspects of the so-called TFT-approach to rational CFT are described. Afterwards I discuss in detail algebraic properties of the space of bulk states of a CFT, as well as aspects of its character, which is the torus partition function.

   Lecture 2: Categories and coends

   In lecture 1 some informal knowledge about basic categorical notions is assumed. These as well as a few more advanced notions are now described in some detail. In particular the notions of ribbon category, modular tensor category, algebra and coalgebra objects, module of a monoidal category, finite tensor category, and factorizable finite tensor category are explained. The definition of the latter involves a certain Hopf algebra object L (introduced by Majid and Lyubashenko), which can be constructed as a coend; accordingly the concept of a coend and related issues are also presented. Finally I discuss properties of the coend L as well of another coend F that turns out to be relevant in CFT. An important tool in the discussion is the graphical calculus for morphisms in strict monoidal categories.

   Lecture 3: The Cardy-Cartan torus partition function

   The categories of modules and bimodules over a finite-dimensional factorizable ribbon Hopf algebra H are considered as models for the categories that arise in CFT. It is shown that the coend F possesses all properties needed for the bulk state space of a CFT, and that the character of F as a module over the coend L for the H-bimodule category has the modular invariance properties needed for the torus partition function. A chiral decomposition of this character is described, which involves the Cartan matrix of the category of H-modules. Finally an outlook is given on how these results can be generalized to correlation functions of (not necessarily rational) CFT at higher genus.

   Preparation material:
   Appendices A and B.1-B.3 of hep-th/0503194
   http://arxiv.org/abs/hep-th/0503194
   Appendices of 1106.0210
   http://arxiv.org/abs/1106.0210
   Sections 2 and 4 and appendix A.1 of 1004.3405
   http://arxiv.org/abs/1004.3405

2. **Terry Gannon (Alberta, Canada)**
   Postcards from the edge: modularity, K-theory and subfactors in 21st century CFT

   Abstract: We begin by reviewing the blood and guts of conformal field theory: a tower of mapping class group representations, and with it the fusion rules, partition functions, etc. We'll probably digress at some point and dabble in Mathieu Moonshine, just because it's there. Then I'll tell a story, about K-theory and CFT. I'll finish by explaining that subfactors predicts that there are many many well-behaved CFTs out there, waiting to be discovered!

3. **Yasuyuki Kawahigashi (Tokyo, Japan)**
Superconformal Field Theory and Operator Algebras

Abstract: We will present operator algebraic approach to superconformal field theory. It is a certain quantum field theory on the one-dimensional circle. We emphasize representation theoretic aspects, classification theory and connections to noncommutative geometry.

Our method is functional analytic, and there is another object called a vertex operator algebra, which studies the same physical structure with an algebraic method. We also make a comparison of the two approaches.

4. **Roberto Longo (Univ. Rome Tor Vergata, Italy)**
Operator Algebras and Boundary Quantum Field Theory

Abstract: TBA

Contributed talks

1. **Speaker**: Chryssomalis Chryssomalakos (Instituto de Ciencias Nucleares UNAM, Mexico)
Title: Operational Geometry on de Sitter Spacetime

Abstract: Traditional geometry employs concepts like that of a point or a curve, the operational definition of which relies on the availability of classical point particles as probes. Such particles seem to not exist in nature, forcing us to consider here the effects of the use of realistic probes on the effective geometry of classical manifolds. As an example, we consider de Sitter spacetime, and employ various composite probes to measure its sectional curvature " we compute the effects of the probes internal energy, spatial extension, and spin, on the measurement. Implications of our results for various approaches to quantum gravity are outlined.

2. **Speaker**: Pedro Castelo Ferreira (Univ. of Lisbon, Lisbon, Portugal)
Title: D-branes description from 2+1D topological field theory

Abstract: Are derived the world sheet D-branes vertex operators from the orbifolding of 2+1D topological massive gauge theories coupled to a dynamical scalar field. It is shown that the boundary conformal field theory states corresponding to D-branes are described by the vacuum states of the bulk theory and the brane tension is set by the bulk mass scales.

3. **Speaker**: Simona-Luiza Druta-Romaniuc (Univ. "Alexandru Ioan Cuza" din Iasi, Romania)
Title: Magnetic curves corresponding to Killing magnetic fields on 3D spaces

Abstract: We find all the magnetic trajectories of the Killing magnetic fields on the three-dimensional Euclidian and Minkowksi spaces. While in the Euclidian case all the three vector fields corresponding to the canonical coordinates play the same role, in a three-dimensional Minkowksi space, only two of the mentioned vector fields play similar roles. So, in the second case is relevant to consider the Killing vector fields which are combinations of the three vector fields, with real coefficients, and to determine their associated magnetic curves.

References:
[1] Barros, M., Cabrerizo, J. L., Fernandez, M., and Romero, A., Magnetic vortex filament flows, J. Math. Phys. 48 (2007) 8, 082904:1–27.

[2] Barros, M. and Ferrandez, A., A conformal variational approach for helices in nature, J. Math. Phys. 50(2009) 10, 103529:1–20.
[3] Barros, M., Romero, A., Cabrerizo, J. L., and Fernandez, M., The Gauss-Landau-Hall problem on Riemannian surfaces, J. Math. Phys. 46 (2005), 112905:1–15.
[4] Barros, M. and Romero, A., Magnetic vortices, EPL 77 (2007), 34002:1–5.
[5] Cabrerizo, J. L., Fernandez, M., and Gomez, J. S., The contact magnetic flow in 3D Sasakian manifolds,J. Phys. A: Math. Theor., 42(2009), 19, 195201:1–10.
[6] Druta-Romaniuc S. L., Munteanu M. I., Magnetic curves corresponding to Killing magnetic fields in E3, J. Math. Phys. 52 (2011), 113506.
[7] Munteanu, M. I. and Nistor, A. I., The classification of Killing magnetic curves in S2 R, J. Geom. Phys. (accepted).
[8] Sunada, T., Magnetic flows on a Riemann surface, Proceedings of KAIST Mathematics Workshop, 1993, 93–108.

4. **Speaker**: Sebastian Guttenberg (CAMGSD and Instituto Superior Técnico, Lisbon, Portugal)
Title: The quantum Siegel algebra

Abstract: Siegel's algebra is the constraint algebra generated by the Virasoro constraints and the kappa-symmetry current of the Green Schwarz superstring. It was discussed in the literature mainly at classical level. In the context of the composite b-ghost of Berkovits' pure spinor string, these Siegel generators reappeared. The talk will present the Siegel algebra at quantum level (in terms of OPE's) with all its anomalies and discuss how these can be canceled and how it is related to Berkovits' b-ghost operators.

5. **Speaker**: Atle Hahn (Univ. of Lisbon, Lisbon, Portugal)
Title: A simplicial approach to the non-Abelian Chern-Simons path integral

Abstract: In my talk I will sketch a simplicial approach for giving a rigorous meaning to the path integral expressions for the Wilson loop observables of non-Abelian Chern-Simons theory. (The base manifold M is assumed to be of the form M = Sigma x S1). This approach is based on the so-called "torus gauge fixing procedure" by Blau and Thompson. At the end of my talk I will show that - at least for links of the simplest type - the explicit evaluation of the (rigorously defined) Wilson loop observables leads to the state sum expressions appearing in the "shadow world" approach to Quantum Topology due to Turaev.

6. **Speaker**: Rachid El Harti (Univ. Hassan I, Settat, Morocco)
Title: C*-unitarisable groups and Kadison problem

Abstract: We explain the notion of C*-unitarisable locally compact group. This allows us to relate Dixmier's conjecture (is a unitarisable group amenable?) and Kadison's similarity problem (is every continuous representation of a C*-algebra A similar to a *-representation of A?).

7. **Speaker**: Robin Hillier (Univ. of Rome Tor Vergata, Italy)
Title: On super-KMS functionals for graded-local conformal nets

Abstract: We introduce super-KMS functionals for graded-local conformal nets with superderivations, roughly speaking as a certain supersymmetric modification of classical KMS states on local conformal nets. Although we are able to make several surprising statements concerning their general structure, most properties will be studied in the setting of individual models. In particular, we provide a constructive existence and partial uniqueness proof of super-KMS functionals for the supersymmetric free field in d dimensions, for its rational extensions, and for the super-Virasoro

net. Moreover, we show that super-KMS functionals - as one of their main applications - give rise to generalized perturbation-invariant entire cyclic (JLO) cocycles and thus to a connection with noncommutative geometry.

8. **Speaker**: Nelson Martins Ferreira (Instituto Politécnico de Leiria, Portugal)
Title: Topological spaces via neighbourhood relations and an appropriate notion of a base

Abstract: In the beginning of twentieth century, motivated by the works on functional analysis and in particular by the work of Riemann and the work of Poincaré, several attempts were made to give, as general as possible, the notion of space. Today we have many equivalent formulations for the notion of what is called a topological space. In fact one of the most standard ones, that dominated the second and third quartets of the last century, is the definition of topology by means of open sets: a set equipped with a collection of subsets, called opens, such that it contains the empty set, the whole set, and is closed under finite intersections and arbitrary unions. This is indeed the most general notion of a space in the sense that finite intersections, together with the whole set are used to form product spaces, while arbitrary unions are used to establish the connection with the more intuitive idea of neighbourhood. The alternative definition via a system of neighbourhoods is also well established and in practice it is used as much as open sets, or, for that matter, closed sets, closure operators, etc. Nevertheless, to this author's knowledge, apart from the book [1], and their sequels, there is no other place where the notion of neighbourhood is primitive. This is somehow surprising since in the Hilbert's proposal, from 1902, one of the first ones in this direction, even before Frechet and Riesz ([2], p.211), the notion of neighbourhood is central. In this work we follow Hilbert's intuition and introduce an alternative definition of a space, based on the notion of a neighbourhood relation. It turns out that this equivalent definition of a topological space is suitable to be internalized, as a categorical structure, and furthermore it makes sense in an arbitrary topos. As a consequence of this approach we can easily derive the notion for a base and consider the category of bases for neighbourhood relations, obtaining thus a setting which is both intuitive and efficient.

References:
[1] R. Brown, *Topology: A Geometric Account of General Topology Homotopy Types and the Fundamental Groupoid*, Ellis Horwood, 1988
[2] I. M. James, *History of Topology*, North-Holland, 1999

9. **Speaker**: Sergey Mayburov (Lebedev Inst. of Physics, Moscow)
Title: Fuzzy Topology, Quantization and Gauge Invariance

Abstract: Dodson-Zeeman fuzzy topology (FT) is studied as possible quantum space-time formalism [1]. FT elements are fuzzy points (FP) $\{a_i\}$, beside standard orderimg relation $a_j \leq a_k$, they admit also the incomparability relation (IR) between them: $a_j \sim a_k$, so $\{a_i\}$ set A^P is partial-ordered set (Poset)[2]. For 1-dimensional geometry Universe is supposedly Poset $U = A^P \cup X$, where X - standard coordinate axe R^1, so that $a_j \sim x_b$ permitted for some $x_b \in X$. a_i properties are detalized relative to X by the introduction of fuzzy weight $w_i(x) \geq 0$ with norm $||w|| = 1$ [3]. If $w_i(x) \neq 0$ on some X interval $\{x_c, x_d\}$, then a_i coordinate relative to X is principally uncertain [2]. It supposed that FP $a_i(t) \in A^P$ describes massive particle m_i, its fuzzy state $\varphi_i(t)$ evolves relative to X. It's shown that other φ free parameter is w flow velocity $\vec{v}(x)$, so that in $x-$representation: $\varphi(x) = \sqrt{w}e^{i\alpha}$ where $\alpha(x)$ defined via: $grad(\alpha) = m\vec{v}(x)$. Assuming space-time shift invariance, it follows that $\varphi(t)$ evolution obeys to free Schroedinger equation [4, 5], it fulfilled also for 3-dimensional case. In relativistic case free m_i evolution corresponds to Dirac equation with spin $\frac{1}{2}$. In this approach the commutation relations can be derived from topological premises; basing on them, lorentz-covariant noncommutative geometry is considered. Massive particle's interactions are studied, it's shown that

FT demands them to be gauge invariant. In particular, the interactions of fermion muliplets are performed by the corresponding Yang-Mills fields [4, 5].

References

[1] Dodson, C.J.T. (1975), *J. London Math. Soc.* **11**, 465

[2] Mayburov, S. (2008), *J. Phys. A* **41**, 164071 ; Eprint hep-th / 0711.0129

[3] Bandmeyer, H. and Gottwald, S. (1993), *Introduction in Fuzzy Sets.* (Akademie Verlag, Berlin)

[4] Mayburov S. (2010) *Int. J. Theor. Phys.* **49** 3192

[5] Mayburov S. (2012) *Phys. Part. Nucl.* To be published, hep-th:1205.3019

10. **Speaker**: Sérgio Mendes (ISCTE-IUL, Lisbon, Portugal)
Title: The Aubert-Baum-Plymen conjecture and the principal series of $SL(2)$

Abstract: We use the Artin-Schreier symbol to create countably many quadratic characters of $F_2((x))$. Such characters induce countably many, nonequivalent reducible principal series representations of $SL(2)$ over $F_2((x))$, and are used to give a neat parametrization of L-packets. Then, we investigate the Aubert-Baum-Plymen (ABP) conjecture in the framework of noncommutative geometry, through the example of $SL(2)$.

11. **Speaker**: Aleksandar Mikovic (Lusófona Univ. and GFMUL, Lisbon, Portugal)
Title: Spin cube models of quantum gravity

Abstract: Spin cube models represent a categorification of spin foam models, in the sense that spin foam models are path integrals for BF theories, while spin cube models are path integrals for 2-BF theories. These are theories of fake-flat 2-connections for 2-groups, and for General Relativity the relevant 2-group is the Poincare 2-group.

References:

[1] arXiv:1110.4694, Poincare 2-group and quantum gravity, A. Mikovic and M. Vojinovic.

[2] arXiv:1006.0903, Lie crossed modules and gauge-invariant actions for 2-BF theories, J. F. Martins and A. Mikovic, Adv. Theor. Math. Phys. vol. 15, nr 4 (2011).

12. **Speaker**: Todor Popov (INRNE, Bulgarian Academy of Sciences, Bulgaria)
Title: Homotopy commutative algebra and 2-nilpotent Lie algebra

Abstract: We consider the universal enveloping algebra U of the 2-nilpotent free Lie algebra. It is a model of the general linear group $GL(V)$, i.e., a representation which contains each irreducible finite dimensional representation of $GL(V)$, once and exactly once. We use the Kadeishvili's Homotopy transfer theorem to the Yoneda algebra of U and prove that it is a homotopy commutative and associative algebra generated in degree one thus providing a natural generalization of the Koszul dual for non-quadratic algebras. (in collaboration with Michel Dubois-Violette)