

# Report on the workshop Higher Structures in Topology and Geometry V

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## 1 Summary

The workshop “Higher structures in Topology and Geometry V” took place at the University of Hamburg from May 25, 2011 to May 27, 2011. More than 40 participants, including PhD students, postdocs and both junior and senior faculty met to discuss new developments concerning higher structures and their use in topology, algebra and mathematical physics.

There have been a total of 16 talks. Some of them were organized in the form of a series of lectures to review and to introduce new developments in greater detail:

- André Henriques (Utrecht):  
Defects between conformal nets (3 lectures)
- Alan Carey (Münster and Adelaide)  
Twisted geometric cycles (2 lectures)
- and Ping Xu (Penn State and Luxembourg)  
String Topology for Stacks (2 lectures)

The program on Thursday afternoon was also integrated in the bi-weekly seminar of Hamburg’s Center of Mathematical Physics. The corresponding talks served at the same talk to expose a larger audience of mathematical physicists to ideas and new developments in the field of higher structures.

## 2 Scientific content

### 2.1 Scientific content

The workshop focussed on three major circles of interest:

- **String Topology**

In a series of two lectures, Ping Xu and Gregory Ginot introduced string topology in the framework of smooth stacks. As prominent examples, mapping stacks and the classifying stacks  $[*/G]$  of a compact Lie group were discussed. Bernardo Uribe explained orbifold string topology and the relation to Hochschild cohomology. Janko Latschev reviewed Fukaya's idea about the relation between Lagrangian submanifolds and string topology and outlined his program based on algebraic structures from holomorphic curves to implement these ideas.

Even within the community of string topologists, the workshop has contributed to new exchange, in particular concerning string topology on spaces more general than manifolds.

- **Extended topological field theories** Extended topological field theories in the sense of Lurie have been of central interest and have been discussed in various contributions:

- André Henriques has discussed the construction of a three-category of conformal nets in terms of von Neumann algebras, providing thus a rigorous mathematical framework for the physical idea of a chiral conformal field theory.
- Jeffrey Morton has discussed an explicit geometric construction of an extended topological field theory in three dimensions that is based on the stack of  $G$ -bundles. He also included a discussion of some aspects of theories for which  $G$  is a compact Lie group.
- Benjamin Balsam has described the Turaev-Viro theory based on a spherical fusion category as an extended topological field theory. In this framework, he is able to show its equivalence to the Turaev-Reshetikhin theory based on the Drinfeld center of the fusion category.
- Chris Schommer-Pries has finally explained how the structure of fusion categories is related to the structure of 3-dimensional topological quantum field theories. This identifies, in particular, fusion categories as fully-dualizable objects in a certain natural 3-category and provides natural geometric insight in algebraic results, e.g. about powers of the antipode of a Hopf algebra.

- **Infinite-dimensional aspects**

Higher structures are typically classified by (generalized, differential, twisted) cohomology theories. To realize the cycles of such cohomology theory explicitly, it is frequently helpful and sometimes even indispensable to make use of infinite-dimensional structures.

Alan Carey has explained in this context his recent work with Bai-Ling Wang on using twisted Baum-Douglas geometric cycles to construct twisted K-homology, including an index formula that can be interpreted as formula for D-brane charges in string theory.

Andrew Stacey has explained the construction of Dirac operators in infinite dimensions, paying particular attention to the vital ingredient of a co-Riemannian structure. In Karl-Hermann Neeb's contribution, the classical theory of loop groups and their representations has been generalized to the situation where the compact target Lie algebra is replaced by a real Hilbert-Lie algebra with an Ad-invariant scalar product.

## 2.2 Results and impact

The conference has considerably added to the visibility of the field in Germany and beyond. Indications are the relatively large number of participants from overseas, coming even at their own expense, and some spontaneous unregistered participants from neighbouring universities.

The effect was even strengthened by the presence of Alan Carey who, as a Humboldt research price winner, holds a distinguished place in the German mathematical community.

Apart from the series of lectures, many informal discussions have contributed to an atmosphere of common learning that is, by now, characteristic for this series of workshops. It seems to be clear that this series will be continued.

Finally, several ideas for applications for support of common research projects have been discussed, including ideas to strengthen the networking among younger participants. One such application is presently prepared.

## A List of talks and program

### Wednesday, May 25

09:50 - 10:20	Registration	
10:20 - 11:20	Bernardo Uribe	Orbifold string topology and Hochschild cohomology
11:30 - 12:30	Janko Latschev	An application of string topology in symplectic topology
12:30 - 14:00	Lunch break	
14:00 - 15:00	Andrew Stacey	How to construct a Dirac operator in infinite dimensions
15:10 - 15:55	André Henriques	Defects between conformal nets I
15:55 - 16:30	Coffee break	
16:30 - 17:15	Jeffrey Morton	Extended TQFT from Gauge Theory
17:25 - 18:10	Benjamin Balsam	Turaev-Viro theory and Extended TQFTs
19:30	Conference dinner at Fischerhaus	

### Wednesday, May 25

09:00 - 09:45	André Henriques	Defects between conformal nets II
09:45 - 10:30	Coffee break	
10:30 - 11:15	André Henriques	Defects between conformal nets III
11:25 - 12:10	Alex Hoffnung	A groupoid approach to Hecke algebras
12:10 - 14:00	Lunch break	
14:00 - 14:45	Alan Carey	Twisted geometric cycles I
14:45 - 15:30	Coffee break	
15:30 - 16:30	Ping Xu	String Topology for Stacks I
16:40 - 17:40	Liang Kong	Conformal field theories and a new geometry

### Friday, May 27

09:00 - 10:00	Gregory Ginot	String Topology for Stacks II
10:10 - 11:10	Karl-Hermann Neeb	Loop groups with infinite dimensional targets and unitary representations
11:10 - 11:50	Coffee break	
11:50 - 12:35	Chris Schommer-Pries	The Structure of Fusion Categories via Topological Quantum Field Theories
12:45 - 13:30	Alan Carey	Twisted geometric cycles II

### Remark:

Slides for selected talks are available at the conference's webpage at

[http://www.crcg.de/wiki/Higher\\_Structures\\_in\\_Topology\\_and\\_Geometry\\_V](http://www.crcg.de/wiki/Higher_Structures_in_Topology_and_Geometry_V)

## B List of participants

Attached is the list of participants. Speakers are marked with an asterisk:

- Albert, Hinnerk
- Balsam, Benjamin (Stony Brook)(\*)
- Blohmann, Christian (MPI Bonn)
- Callies, Martin (Göttingen)
- Carchedi, David (Utrecht)
- Carey, Alan (Münster/Canberra) (\*)
- Dehling, Malte (Göttingen)
- Dumitrescu, Florin (Hamburg)
- Fairbairn, Winston (Hamburg)
- Garcia-Raboso, Alberto (UPenn)
- Ginot, Gregory (Jussieu) (\*)
- Henriques, Andre (Utrecht)(\*)
- Hoffnung, Alex (Ottawa)
- Holtkamp, Ralf (Hamburg)
- Janssens, Bas (Hamburg)
- Khudaverdyan, David (Luxembourg)
- Kong, Liang (Beijing)
- Lahtinen, Anssi (Copenhagen)
- Latshev, Janko (Hamburg) (\*)
- Laures, Gerd (Bochum)
- Lean, Rohan (Göttingen)
- Li, Du (Göttingen)
- Morton, Jeffrey (Lisbon) (\*)
- Neeb, Karl-Hermann (Erlangen) (\*)
- Nikolaus, Thomas (Hamburg)
- Pennig, Ulrich (Münster)
- Richter, Birgit (Hamburg)
- Sachse, Christoph (Hamburg)
- Schneider, Ansgar (MPI Bonn)
- Schommer-Pries, Chris (MIT) (\*)
- Schweigert, Christoph (Hamburg)
- Shaikh, Zain (Köln)
- Stacey, Andrew (Trondheim) (\*)
- Stienon, Mathieu (Penn State)
- Trentinaglia, Giorgio (Göttingen)
- Upmeier, Markus (Göttingen)
- Uribe, Bernardo (Bogota) (\*)
- Valentino, Alessandro (Hamburg)
- Vasquez, José (Hamburg)
- Waldorf, Konrad (Regensburg)
- Wittkamp, Steffen (Bochum)
- Wockel, Christoph (Hamburg)
- Wolfson, Jesse (Northwestern)
- Xu, Ping (Penn State)
- Zambon, Marco (UA Madrid)
- Zhu, Chenchang (Göttingen)