Institut für Mathematik
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January 29, 2019

Organizers of the ACT2019 School

To whom it may concern

Arne Hoffmann is currently pursuing a master thesis project titled "Fractional Quantum Hall Effect and BV-BFV formalism" under my supervision. During this project he has acquainted himself with category theory both through the study of different categories of vector spaces and topological field theories.
Participating in ACT could be very valuable for him since it would allow him to deepen his knowledge of category theory and its applications. Today, category theory is one of the main tools for the study of topological field theories, an important branch of mathematical physics. Coming in touch with other applications of category theory will certainly be very helpful to his interests in mathematical physics and to his further career. I also think the school will provide a valuable possibility for exchanging with other researches interested in applying category theory.
During his master's thesis he has shown very strong indepedent research skills that led to some interesting new results, as well as a strong interest in putting the basics of the project on a solid category-theoretical footing.
I can strongly recommend Arne Hoffmann for participation in the ACT2019 school.

Yours sincerely

Dr. Konstantin Wernli

Application for ACT 2019.
Arne Hofmann, January 30, 2019

1 Background. My familiarity with category theory comes from studying mathematical physics. I was enticed into the world of describing *generalized spaces* using category theory by studying classical and quantum field theory for my Master's thesis (*Abelian Chern-Simons Theory and Fractional Quantum Hall Effect in the BV-BFV Formalism*). In field theory, one needs differential calculus on mapping spaces, and therefore smooth spaces more general than manifolds. For fermionic field theory, or in quantization schemes such a BV quantization, one also requires *supermanifolds*. These are perhaps the simplest examples of spaces which cannot be described by their $\mathbb{R}$-valued points alone; *odd* points are also necessary. In my thesis I also make use of the string diagram calculus for closed monoidal categories to derive Feynman diagrams for a version of Wick's lemma on super vector spaces.

Since my first choice is David Spivak's course on autopoiesis, I should also mention my interest in philosophy in general and Luhmann in particular. My familiarity with Niklas Luhmann comes primarily from his *Zettelkasten*, or slip-box system of organizing notes. I have tried implementing an electronic version of his system for myself. Before doing so, I thought a little about whether one could formalize such a system mathematically and looked around for literature on the subject. I came to the conclusion that any discussion would need to take place on a category-theoretical level, but was so far missing from the literature. Since Luhmann considered his *Zettelkasten* to be an independent system amenable to his theory of systems, I have wanted for the past year to study Luhmann more deeply, but have been distracted by other interests (not least my mathematical studies).

It seems to me that approaching philosophy from a mathematical background and with mathematicians can be very fruitful, and should not be neglected out of modesty or shyness on the part of our profession. Studying the philosophical writings of such mathematicians as Felix Hausdorff, Hermann Weyl, Gian-Carlo Rota and William Lawvere is a side project of mine, and I would be very excited to discuss Luhmann's philosophy with other mathematicians or mathematically-minded philosophers.

2 Current state of studies. I am in the last semester of my M.Sc. in Applied Mathematics at ETH Zurich. My thesis is on the BV-BFV formalism for the quantization of gauge theories on manifolds with boundary, and the application of this formalism to the fractional quantum Hall effect in condensed matter physics. I expect to begin a PhD programme in October 2019.

3 Project preference.

1. Toward a mathematical foundation for autopoiesis (David Spivak).
2. Formal and experimental methods to reason about dialogue and discourse using categorical models of vector spaces (Mehrnoosh Sadrzadeh).

3. Complexity classes, computation, and Turing categories (Pieter Hofstra).

4. Simplifying quantum circuits using the ZX-calculus (Miriam Backens).

5. Partial evaluations, the bar construction, and second-order stochastic dominance (Tobias Fritz).

6. Traversal optics and profunctors (Bartosz Milewski).

4 Commitment to attend. Should funding not be available, I can self-fund my attendance of ACT 2019, and can commit to coming to Oxford for the conference.

5 Statement. Although my background is primarily in mathematical physics, my interest in category theory has intensified over the past year. I am currently busy writing PhD applications, and my preferred position would be with Tom Leinster in Edinburgh to work directly on CT, even above other places closer to my physics background. However, I do not wish to give up physics. It is also with a view towards gaining a better understanding of the work of John Baez, Urs Schreiber and others who have used category theory in physics that I wish to dive deeper into this subject. I therefore expect that category theory, and in particular applied category theory, will play a central role in my research, whether it remains focused on mathematical physics or not.

I am also very interested in the relationship of mathematics to other sciences and humanities. In his 1942 manuscript *Ordnung der Wirklichkeit* (Order of Reality), Werner Heisenberg remarks that any scientist is confronted with the question of how his science relates to *the entirety of life and the world.* Of course mathematics has always had strong connections to such disciplines as engineering, physics, statistics and computer science, but in topics such as that of David Spivak's workshop, category theory shows promise of connecting it also to philosophy, with which relations have perhaps been more tenuous, and which is perhaps more directly related to *the entirety of life and the world.*

Umberto Eco once quipped that a polymath is someone *who is interested in everything and nothing else.* This is an attitude that, unfortunately, a modern scientist can hardly afford to take – to make progress, it is necessary to specialize to some degree. But studying category theory does have the refreshing feeling of specializing in generality. My studies in mathematical physics have trained on me two complementary reflexes: asking *how does this generalize?* and *how does this specialize – where can it be applied?* Applied category theory is precisely the right environment for these twin impulses.

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Arne Hofmann

Teaching Assistant Experience

2018 Mathematics for Physicists II (Giovanni Felder)
2017/18 Mathematics for Physicists I (Horst Knörrer)
2016/17 Exam preparation course, Physics for Environmental Scientists (ETH)
2015/16 Quantum Mechanics II (Karl-Henning Rehren)
2015 Quantum Mechanics I (Marcus Müller)
2014/15 Mathematics for Physicists II (Laura Covi)

Education

2016 – today ETH Zürich, M. Sc. Applied Mathematics
2015 – 2016 Georg-August-Universität Göttingen, B. Sc. Mathematics
2012 – 2015 Georg-August-Universität Göttingen, B. Sc. Physics
2007 – 2012 Abitur, Erzbischöfliches Suitbertus-Gymnasium, Düsseldorf-Kaiserswerth

Written work (unpublished)

2018 – 2019 Master's thesis *The Fractional Quantum Hall Effect and Abelian Chern-Simons Theory in the BV-BFV Formalism*, supervised by Alberto Cattaneo and Konstantin Wernli.
2017 – 2018 Semester paper *Mathematics and Physics of the Integer Quantum Hall Effect*, supervised by Gian Michele Graf.
2018 Seminar paper on Hans Blumenberg's *Die Lesbarkeit der Welt* (The Readability of the World). Seminar run by Michael Hagner. [History of ideas, history of science, "metaphorology"]
2017 *Classification of crystal symmetry groups.* Notes written up as preparation for an exam on *Group Theory in Solid State Theory.*
2016 Bachelor's thesis in Mathematics, *The Perturbation Semigroup in Noncommutative Geometry*, supervised by Dorothea Bahns.
2015 Bachelor's thesis in Physics, *The Feshbach Method in Quantum Mechanics*, supervised by Dorothea Bahns.

Selection of courses taken

2018 Algebraic Topology II (Will Merry).
2017 Applied Harmonic Analysis (Helmut Bölcskei)
2017 Representations of Lie Groups (Emmanuel Kowalski)
2017 Group Theory in Solid State Physics (Danilo Pescia)
2016 Representations of C^*-algebras, C^*-dynamical systems, representations of semidirect products (Dorothea Bahns).
2015/16 Intrinsic differential geometry and Cartan's moving frames (Victor Pidstrygach).
2015/16 Unitary representations of locally compact groups, harmonic analysis (Dorothea Bahns).
2014 Functional Analysis (Ralf Meyer).

Workshops

Nov. 2016	Autumn School on Mathematical Foundations of Physics, Munich
Jan. 2016	37th LQP Workshop "Foundations and Constructive Aspects of QFT", Göttingen

Languages

German	Native speaker
English	Native speaker competence (USA resident from 2002 – 2007)
French	Advanced (DELF C1 in 2012)

Programming

Python	Scripting language of choice – basic skills.
Matlab	Basics of numerical mathematics.
C++	Basic skills.
LaTeX	Untrained but experienced.

Projects/interests tangent to mathematics

- Editions (using LaTeX) of Felix Hausdorff's *Sant' Ilario* and Christoph Martin Wieland's *Oberon*.
- Miscellaneous studies of natural science metaphor in popular writing (e.g. *quantum leap*, *chemistry of a relationship* etc.), inspired by Hans Blumenberg.
- Sketches of philosophically inclined mathematicians: Felix Hausdorff, Hermann Weyl, Gian-Carlo Rota, William Lawvere.
- Literature and exact sciences in G. C. Lichtenberg's writings.