Application for ACT School 2019

Relevant Background:

During my Bachelor's I took a course on category theory, and since then I've always been interested in it as a universal language for describing mathematical structures. Although I have never really done any work on 'pure' category theory, much of the work I've done in my PhD touches on it in an applied way. In particular I have spent a considerable amount of time working with effectus theory. An effectus is a categorical framework for doing classical and quantum logic. Next to that, I'm well versed in the language of categorical quantum mechanics, having taught a Master's level course about it, and actively doing research on the topic, specifically using the ZX- and ZH-calculus to reason about quantum computation.

PhD summary:

While the first 1,5 years of my PhD were mostly spent doing research in quantum foundations, in particular investigating what kind of principles or structure can be used to derive the algebraic structure of quantum theory, this last year I have been doing more applied work by developing the theory and code for the open-source Python library *PyZX* that does quantum circuit optimization using the ZX-calculus and achieves state-of-the-art results on realistic benchmark circuits.
I still have 1,5 years to go on my PhD, as my contract runs until September 2020.

Project preference:

My preference goes out to Miriam Backens' project 'S*implifying quantum circuits using the ZX-calculus'* as I think this could really help me with my current research. Barring the possibility of joining that project, I would like to join the project of Pieter Hofstra. After that, my preference goes out to the project of Tobias Fritz, then to David Spivak, then Bartosz Milewski and finally Mehrnoosh Sadrzadeh.

Oxford availability:

I am available during the time period, and I'm pretty sure I can get funding to go there. I would be interested in going the full two weeks.

JOHN VAN DE WETERING

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EDUCATION

Radboud University Nijmegen *2011-2016*

Bachelor in Mathematics	*Cum laude*	*2011-2014*
Bachelor in Physics	*Cum laude*	*2011-2014*
Master in Mathematical Physics	*Bene meritum*	*2014-2016*

Master's Thesis February-July 2016
'Ordering information on distributions' *at Oxford University*

EXPERIENCE

PhD student September 2016 - Present
Radboud University *Nijmegen, the Netherlands*

· Hired as part of the *Quantum Computation, Logic and Security* ERC advanced grant for a 4 year PhD programme.
· Promoter: Bart Jacobs.
· Supervisor: Aleks Kissinger.

Teaching experience 2011 - Present
Radboud University *Nijmegen, the Netherlands*

· Co-lecturer for the 2018 Master's course *Quantum Processes and Computation*. Part of the duties were designing teachers materials and writing the lectures.
· During my Bachelor, Master and PhD I have worked as a teacher's assistant for a variety of mathematics courses concerning topics such as Linear algebra, Probability theory, Analysis, Differential equations and complex functions.

TALKS AND POSTERS

- Conference talk at the Symposium on Compositional Structures December 2018: *PyZX: Quantum circuit optimization using the ZX-calculus.*
- Conference talk at Foundations 2018: *Reconstruction of Quantum Theory from Universal Filters.*
- Conference talk at QPL 2018: *Sequential Measurement characterises Quantum Theory.*
- Conerence talk at QPL 2018: *Purity in Euclidean Jordan Algebras.*
- Poster at TQC 2017: *Universal measurement-based quantum computation with Mølmer-Sørensen interactions and just two measurement bases.*
- Conference talk at QPL 2017: *Quantum Theory is a Quasi-Stochastic Process Theory.*
- Workshop talk at the Workshop on Semantic Spaces at the Intersection of NLP, Physics and Cognitive Science 2016: *Entailment Relations on Distributions*

PUBLICATIONS

1. Abraham Westerbaan, Bas Westerbaan, and John van de Wetering. Pure maps between Euclidean Jordan Algebras. *To appear in the proceedings of QPL2018.* 2018.

2. John van de Wetering. Ordering quantum states and channels based on positive Bayesian evidence. *J. Math. Phys. Vol.59-10*, 2018.

3. John van de Wetering. Three characterisations of the sequential product. *J. Math. Phys. Vol.59-8*, 2018.

4. John van de Wetering. Quantum Theory is a Quasi-stochastic Process Theory. *Proceedings of the 14th International Conference on Quantum Physics and Logic, Nijmegen, The Netherlands, 3-7 July 2017*, volume 266 of EPTCS, 2017.

5. John van de Wetering. Entailment Relations on Distributions. *Proceedings of the 2016 Workshop on Semantic Spaces at the Intersection of NLP, Physics and Cognitive Science, Glasgow, Scotland. 11th June 2016*, volume 221 of EPTCS, 2016.

PREPRINTS

1. Aleks Kissinger and John van de Wetering. Universal MBQC with generalised parity-phase interactions and Pauli measurements. *arXiv preprint arXiv:1704.06504*, 2017.

2. John van de Wetering. Sequential Product Spaces are Jordan Algebras. *arXiv preprint arXiv:1803.11139*, 2018.

3. John van de Wetering. An effect-theoretic reconstruction of quantum theory. *arXiv preprint arXiv:1801.05798*, 2018.

SOFTWARE

PyZX April 2018 - Present

Co-creator `github.com/Quantomatic/pyzx`

· PyZX is an open-source Python library for doing quantum circuit optimization using the ZX-calculus.

· It's T-count minimization routine currently beats the state-of-the-art.

Radboud University

Aleks Kissinger
Assistant Professor
iCIS, Radboud University
aleks@cs.ru.nl

Dear ACT summer school organisers,

I'm happy to recommend my PhD student John van de Wetering for participation in the Applied Category Theory Summer School. He has been working with me for 2-1/2 years on topics in quantum foundations and quantum circuit optimisation. This is my own research area, as I have been working on the diagrammatic/categorical approach to quantum theory for a bit over a decade.

John is incredibly sharp, and one of the best PhD students I have had the joy of working with. He has contributed approximately 75% of the code for the PyZX tool, a ZX-calculus-based circuit optimiser which is currently out-performing just about anything else out there on the task of ancilla-free T-count reduction. Many of the theoretical ideas used in the core simplifier and circuit extraction routines are due to John. Clearly, the topic being led by Miriam Backens is pretty much tailor-made for John's PhD work, and he would be an excellent addition to the group. He has also been working extensively with my masters students on topics in graphical calculus and optimisation, and a think he would do well in a group with mixed levels of skills and experience.

If you need any more information or have any questions, don't hesitate to contact me.

Best,

Aleks Kissinger
Assistant Professor, Radboud University

I□m interested in the summer school for several reasons. The most important one being that the project of my preference, simplifying quantum circuits using the ZX-calculus, is precisely the subject that I have been working on for the last year. The specific methods we□ve been using will appear in the form of a paper pretty soon, and as a result I□m now thinking about new methods for future work. It will be very helpful to talk and discuss with other people about this subject in order to come up with new ideas and collaborations, and I□m curious to see what people coming from a different background have to offer in this interesting subject.

Another reason is that I□m looking forward to discussing and communicating with like-minded people and getting some idea of what other problems are being tackled right now by the applied category theory community, and maybe being inspired by them to contribute in some way.

Finally, as the amount of people in Nijmegen doing research in the area of applied category theory is quite small, it is also my hope that this summer school will connect me to people I would not otherwise come across.