

# Pieter Naaijkens

## CURRICULUM VITAE<sup>1</sup>

### PERSONAL INFORMATION

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*Contact details:*

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### ACADEMIC EMPLOYMENT

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9/2015 – 8/2018 *Marie Skłodowska-Curie Individual Fellow (Global Fellowship)*  
UC Davis (mentor Prof. Bruno Nachtergaele), 2015–2017  
RWTH Aachen University (mentor Prof. Barbara Terhal), 2017–2018

4/2012 – 8/2015 *Scientific assistant* (two years as Rubicon fellow)  
Leibniz University Hannover  
Mentors: Prof. Tobias Osborne and Prof. Reinhard Werner

10/2007 – 1/2012 *PhD Candidate*  
Radboud University Nijmegen  
Supervisors: Prof. Klaas Landsman and Dr. Michael Mürger

### EDUCATION

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10/2007 – 1/2012 *PhD*, Radboud University Nijmegen  
Thesis: *Anyons in infinite quantum systems: QFT in  $d=2+1$  and the Toric Code*  
Supervisors: Prof. Klaas Landsman and Dr. Michael Mürger  
Defended on May 15, 2012

9/2001 – 8/2012 *MSc Mathematics and MSc Theoretical Physics*, Utrecht University  
MSc Thesis: *Four-point functions of  $N = 4$  SYM<sub>4</sub> in the AdS/CFT correspondence*  
Supervisor: Dr. Gleb Arutyunov. Grade 8.5/10  
Kleine scriptie (~ BSc thesis): *Cartesisch gesloten deelcategorieën van **Top***  
[Cartesian closed subcategories of **Top**]  
Supervisor: Dr. Jaap van Oosten. Grade 9.5/10

### GRANTS AND AWARDS

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- AHP Prize 2016, for the most remarkable paper published in Annales Henri Poincaré
- EU Marie Skłodowska-Curie Actions-Individual Fellowship, 2015–2018. Project: *Operator Algebraic Approach to Topological Phases*
- Netherlands Organisation for Scientific Research (NWO) Rubicon, 2012–2014. Project: *Mathematical structure of anyons in planar quantum spin systems*

### RESEARCH INTERESTS

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I am interested in quantum spin systems and their applications to quantum information theory, with a focus on the use of functional analysis and operator algebraic techniques. I primarily study of quantum spin systems

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<sup>1</sup>Last updated: April 11, 2018

with topological order, and how one can obtain a full understanding of the (quasi)particle excitations of such systems. The properties of these excitations can be described by tensor categories, and a substantial part of my work is related to how one can obtain this tensor category by studying certain representations of the  $C^*$ -algebra of quasi-local observables. An important question is then how stable this structure is with respect to perturbations of the underlying dynamics defining the system, which also is relevant in the classification of topological phases.

## PUBLICATIONS

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### Refereed journals

1. M. Cha, P. Naaijken, B. Nachtergaele: The complete set of infinite volume ground states for Kitaev's abelian quantum double models, *Commun. Math. Phys.* **357**:125–157 (2018) [arXiv:1608.04449](#)
2. L. Fiedler, P. Naaijken, T.J. Osborne: Jones index, secret sharing and total quantum dimension, *New J. Phys.* **19**:023039 (2017) [arXiv:1608.02618](#)
3. S. Bachmann, W. Dybalski, P. Naaijken: Lieb-Robinson bounds, Arveson spectrum and Haag-Ruelle scattering theory for gapped quantum spin systems, *Ann. Henri Poincaré* **17**:1737–1791 (2016)  
**Note:** awarded with **AHP Prize 2016**. [arXiv:1412.2970](#).
4. L. Chang, M. Cheng, S.X. Cui, Y. Hu, W. Jin, R. Movassagh, P. Naaijken, Z. Wang, A. Young: On Enriching the Levin-Wen model with Symmetry, *J. Phys. A: Math. Theor.* **48**:12FT01 (2015)  
[arXiv:1412.6589](#)
5. L. Fiedler, P. Naaijken: Haag duality for Kitaev's quantum double model for abelian groups, *Rev. Math. Phys.* **27**:1550021:1–43 (2015) [arXiv:1406.1084](#)
6. P. Naaijken: Kosaki-Longo index and classification of charges in 2D quantum spin models, *J. Math. Phys.* **54**:081901-1–17 (2013). **Note:** selected as “**editor's pick**”. [arXiv:1303.4420](#)
7. P. Naaijken: Haag duality and the distal split property for cones in the toric code, *Lett. Math. Phys.* **101**:341–354 (2012) [arXiv:1106.4171](#)
8. P. Naaijken: Localized endomorphisms in Kitaev's toric code on the plane, *Rev. Math. Phys.* **23**:347–373 (2011) [arXiv:1012.3857](#)
9. P. Naaijken: On the extension of stringlike localised sectors in 2+1 dimensions, *Commun. Math. Phys.* **303**:385–420 (2011) [arXiv:1004.4775](#)
10. P. Naaijken: Topologische kwantumcomputers: rekenen met vlechten, *Nieuw Arch. Wiskd.* **11**:187–193 (sept. 2010)
11. L. Berdichevsky, P. Naaijken: Four-point functions of different-weight operators in the AdS/CFT correspondence, *JHEP* **0801**:071 (2008) [arXiv:0709.1365](#)

### Books and book chapters

12. Quantum Spin Systems on Infinite Lattices: A Concise Introduction, *Lecture Notes in Physics* **933**, Springer International Publishing (2017) [arXiv:1311.2717](#)
13. Kitaev's quantum double model from a local quantum physics point of view. In: R. Brunetti C. Dappiaggi, K. Fredenhagen, J. Yngvason (eds), *Advances in Algebraic Quantum Field Theory*, pp. 365–395, Springer (2015) [arXiv:1508.07170](#)

### Submitted

14. M. Cha, P. Naaijken, B. Nachtergaele: On the stability of charges in infinite quantum spin systems, preprint, [arXiv:1804.03203](#)
15. P. Naaijken: Subfactors and quantum information theory, submitted, [arXiv:1704.05562](#)

**As instructor:**

- *Quantum Information*, Summer semester 2018 (with David DiVincenzo)
- *MAT-22A (Introduction to Linear Algebra)*, Spring quarter 2016.
- *Quantum spin systems on infinite lattices*, Summer semester 2013.
- *Zomercursus wiskunde*. Crash course for prospective students not meeting admission requirements for mathematics and physics. I could recommend students for admission after successful completion of the course. Summer 2008.
- Various lectures (including preparing materials) for high school students aged 12–18 in the *Sprint-Up* programme. Topics included for example fractals and infinity, 2008–2010.

**As teaching assistant:**

- *Lie-Algebren und ihre Darstellungen in der Physik* [Lie Algebras and their representations in physics], Summer semester 2014
- *Ergänzungen zur klassischen Physik* [Advanced classical physics], Fall semester 2012
- *Symmetry Breaking*, Spring 2011
- *Inleiding Fourieranalyse* [Introduction to Fourier analysis], Spring 2010
- *Topologie* [Topology], Fall 2009
- *Introduction to partial differential equations*, Spring 2009
- *Analysis I*, Spring 2008

**Student supervision:**

- Leander Fiedler (PhD). Co-supervision with Prof. Reinhard Werner, referee for thesis. *Haag duality and Jones-Kosaki-Longo index in Kitaev's quantum double models for finite abelian groups*. Defended January 18, 2017
- Deniz Stiegemann (MSc). Co-supervision with Prof. Tobias Osborne. *Many-Body Localization and Spectral Theory*, October 2015
- Bachelor students:
  - Deniz Stiegemann (co-supervision with Prof. Tobias Osborne), *Lieb-Robinson bounds and coarse geometry*, December 2013
  - Lars Dammeier (co-supervision with Prof. Reinhard Werner), *Fehlertoleranzen von Basisprotokollen in der Quanteninformationsverarbeitung* [Fault tolerance of basic protocols in quantum information], December 2012

RESEARCH VISITS

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International research visits and programmes (of one week or longer):

- University of Tokyo, November 22–December 8, 2017
- Station Q/UC Santa Barbara, May 1–5, 2017
- AMS Mathematical Research Communities on fusion categories and topological quantum computation, Snowbird (UT), USA, June 23–30, 2014
- Workshop ESI programme on “Operator algebras and conformal field theory”, Vienna, Austria, September 8–19, 2008

INVITED TALKS

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- Workshop “Quantum Information and Operator Algebras”, Rome, 15–16 February 2018
- Condensed Matter Theory seminar, University of Cologne, 18 December 2017

- Workshop “Algebraic Structures and Quantum Physics”, Cardiff, 14–15 December 2017
- Operator Algebra Seminar, University of Tokyo, 4 December 2017
- Quantum Algebra and Topology Seminar, UC Santa Barbara, 3 May 2017
- Subfactor seminar, Vanderbilt, Nashville TN, 14 April 2017
- QMath13 (New topics session), Atlanta, GA, 9 October 2016
- Entanglement in Quantum Spin Systems, Simons Center, Stony Brook NY, 3 October 2016
- 34th Western States Meeting, Caltech, 16 February 2016
- Mathematical Physics and Probability seminar, UC Davis, October 21, 2015
- Quantum Spin Systems workshop, Cergy-Pontoise, France, June 24, 2015
- Born-Hilbert seminar, Göttingen, Germany, January 26, 2015
- Mathematical Physics and Probability seminar, UC Davis, January 14, 2015
- AMS Joint Mathematics Meeting, MRC session, San Antonio, TX, January 11, 2015
- Group seminar RWTH Aachen, Germany, September 4, 2014
- NSF/CBMS Conference on Quantum Spin Systems, Birmingham, AL, June 19, 2014
- Bonn-Köln-Algebra Seminar, Cologne, Germany, October 29, 2013
- Group Seminar Free University Berlin, Germany, August 27, 2013
- NTH Colloquium, Braunschweig, Germany, May 24, 2012
- Ph.D. Colloquium, Utrecht University, The Netherlands, June 23, 2010
- Oberseminar  $C^*$ -Algebren, Münster, Germany, February 2, 2010
- EIDMA Seminar, Eindhoven, The Netherlands, May 20, 2009

#### CONTRIBUTED TALKS

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- QMAP Seminar, UC Davis, January 27, 2017
- DPG Frühjahrstagung, Berlin, Germany, March 18, 2015
- DPG Frühjahrstagung, Berlin, Germany, March 20, 2014
- Poster. QIP 2014, Barcelona, Spain, February 3, 2014
- DPG Frühjahrstagung, Jena, Germany, February 28, 2013
- Poster. Benasque symposium on topological quantum information, Spain, February 14, 2013
- Young Researcher Symposium, International Congress on Mathematical Physics, Aalborg, Denmark, August 4, 2012
- 28th workshop on foundations and constructive aspects of QFT, Göttingen, Germany, July 2, 2011
- 27th workshop on foundations and constructive aspects of QFT, Leipzig, Germany, November 20, 2010
- 25th workshop on foundations and constructive aspects of QFT, Göttingen, Germany, January 15, 2010
- Mathematics staff colloquium, Nijmegen, May 27, 2009
- Philips mathematics award session, Dutch Mathematical Congress, Groningen, The Netherlands, April 15, 2009
- Seminar on quantization, non-commutative geometry and symmetry, Nijmegen, The Netherlands, February 2, 2008
- Seminar on quantization, non-commutative geometry and symmetry, Nijmegen, The Netherlands, January 22, 2008

#### SELECTED CONFERENCES, WORKSHOPS AND SUMMER SCHOOLS ATTENDED

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- Workshop “Operator algebras and quantum information”, Institut Henri Poincaré, Paris, September 10–14, 2017
- Workshop “Entanglement in Quantum Spin Systems”, Simons Center, Stony Brook, NY, October 3–7, 2016
- Workshop “Quantum spins”, Cergy-Pontoise, France, June 22–24, 2015
- AMS Joint Mathematics Meetings, San Antonio, TX, January 10–13, 2015
- AMS Mathematical Research Communities “Mathematics of Quantum Phases of Matter and Quantum Information”, Snowbird, UT, June 23–30, 2014

- NSF/CBMS conference on Quantum Spin Systems, Birmingham, AL, June 16–20, 2014
- Quantum Information Processing 2014, Barcelona, Spain, February 3–7, 2014
- QMath 12, Berlin, Germany, September 10–13, 2013
- Benasque symposium on topological quantum information, Benasque, Spain, February 12–16, 2013
- International Congress on Mathematical Physics, Aalborg, Denmark, August 3–11, 2012
- Mathematical Aspects of QFT and Quantum Statistical Mechanics, Hamburg, Germany, July 30–August 1, 2012
- Workshop “Topological Quantum Computing”, Simons Center, Stony Brook, NY, September 12–16, 2011
- Conference on Quantum Groups, Clermont-Ferrand, France, August 30–September 3, 2010
- International Congress on Mathematical Physics, Prague, Czech Republic, August 3–8, 2009
- AQFT: The first 50 years, Göttingen, Germany, July 29–31, 2009
- Summer school “Operator algebras and their applications”, Lisbon, Portugal, June 15–19, 2009
- DIAMANT meets GQT workshop, Leiden, The Netherlands, October 27–31, 2008
- Workshop ESI programme on “Operator algebras and conformal field theory”, Vienna, Austria, September 8–19, 2008
- 5th European Congress of Mathematics, Amsterdam, The Netherlands, July 14–19, 2008
- Stieltjes educational week on non-commutative integration, Leiden, The Netherlands, June 9–13, 2008

#### SERVICE TO THE COMMUNITY

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- Organised and co-organised the following seminar series:
  - *Mathematical Physics and Probability seminar*, Winter 2017, UC Davis
  - *Anyons!* research group seminar, Spring 2016, and with Bruno Nachtergaele for Fall 2016, Winter 2017 and Spring 2017, UC Davis
  - *Mathematics Ph.D. Colloquium*, September 2008–May 2011, Radboud University Nijmegen
  - Ph.D. seminars on operator algebras and harmonic analysis (as co-organiser), 2009–2010, Radboud University Nijmegen
- Outreach activities:
  - supervised group of three highschool students in *Siemens Competition in Science & Technology* (2016)
  - taught to high school students in Radboud University’s *Sprint-Up* programme (2007–2010)
  - active on *Academia StackExchange* (since 2012)
- Referee for *Communications in Mathematical Physics*, *Journal of Mathematical Physics*, *Reviews in Mathematical Physics*, *International Journal on Quantum Information*, and *QIP 2014*
- Reviewer for *AMS Mathematical Reviews*

#### MISCELLANEOUS

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- Member of *International Association of Mathematical Physics*, *American Mathematical Society*, *Koninklijk Wiskundig Genootschap* (Dutch Royal Mathematical Society), and *Deutsche Physikalische Gesellschaft* (German Physics Society).
- Languages: Dutch (native), English (full proficiency), German (upper intermediate), French (elementary)