

# Michael Groechenig

Date of Birth: July 2, 1988  
Citizenship: Austria (and permanent resident of Canada)  
Languages: English, French, German (native)  
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## Professional addresses:

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## Career

Associate professor, University of Toronto, since July 2023

(on parental leave July - December 2023)

Assistant professor, University of Toronto, since July 2018

(on parental leave January - April 2020)

Marie Skłodowska-Curie fellow in Esnault's group at Freie Universität Berlin, 2016-2018

Chapman fellow at Imperial College London, 2013-2016

## Research endeavours

Moduli spaces of Higgs bundles & the Hitchin fibration

proof of Hausel–Thaddeus Conjecture (with Wyss & Ziegler)

new proof of the Fundamental Lemma (with Wyss & Ziegler)

$K$ -theoretic analogue of Hausel–Thaddeus Conjecture (with Shen)

Rigid local systems

proof of Simpson's Integrality Conjecture in the coh. rigid case (with Esnault)

construction of Frobenius structures (with Esnault)

appendix to Pila–Shankar–Tsimmerman's proof of the André–Oort Conjecture

$K$ -theory

Construction of non-torsion classes in Zakharevich  $K$ -theory (with Braunling)

Motivic realization maps for Zakharevich  $K$ -theory (with Braunling & Nanavaty)

## Grants/fellowships/honours

2024 Coxeter-James Prize

2024 New Horizons Breakthrough Prize

2022 Alfred P. Sloan fellowship (75000 USD) 2022-2024

NSERC Discovery Grant “*Arithmetic and topology of moduli spaces*” (120,000 CAD), 2019-2024

Marie Skłodowska-Curie individual fellowship “*Higher Epsilon-factors for Higher Local Fields*”, 2016-2018 (EU grant amounting to a total of 159,460 Euro)

EPSRC studentship for the project “Topology of the Hitchin map and arithmetics of the character variety” (covering university fees and living expenses), 2009 - 2013

## Education

DPhil, University of Oxford, supervised by Tamás Hausel (2009 - 2013), doctoral exchange student at EPF Lausanne (2012 - 2013)

BSc Mathematics, ETH Zürich (2006 - 2009), *passed with distinction*

## Written Work

*Short descriptions of my articles can be found on this site:*

*<http://individual.utoronto.ca/groechenig/research.html>*

*Preprints and articles in preparation are listed below.*

### Publications

- (1) The de Rham stack and the variety of very good splittings of a curve, joint with Mark Andrea de Cataldo and Siqing Zhang  
accepted in *Math. Res. Notices*
- (2) Rigid non-cohomologically rigid local systems, joint with H el ene Esnault and Johan de Jong  
accepted in *Algebraic Geometry and Physics* (2023)
- (3) A Generalized Contou-Carr ere Symbol and its Reciprocity Laws in Higher Dimensions, with Oliver Braunling and Jesse Wolfson  
*Trans. of the AMS Series B* **8** (2021), 679–753
- (4) Hypertoric Hitchin systems and Kirchhoff polynomials, with Michael McBreen  
*IMRN* (2021) <https://doi.org/10.1093/imrn/rnab109>.
- (5) Rigid connections and  $F$ -isocrystals, with H el ene Esnault  
*Acta Math.* 225 (2020), 103-158
- (6) Geometric stabilisation via  $p$ -adic integration, with Dimitri Wyss and Paul Ziegler

- JAMS* 33 (2020), 807-873
- (7) Mirror symmetry for moduli spaces of Higgs bundles via p-adic integration, with Dimitri Wyss and Paul Ziegler  
*Inventiones* 221 (2020), 505-596
- (8) Cohomologically rigid local systems and integrality, with H el ene Esnault  
*Selecta Mathematica* 24 (2018), 4279-4292
- (9) The  $A_\infty$ -structure of the index map, with Oliver Braunling and Jesse Wolfson  
*Annals of K-theory* 3 (2018), no. 4 (2018), 581-614.
- (10) On the normally ordered tensor product for Tate objects, duality, and applications, with Oliver Braunling, Aron Heleodoro, and Jesse Wolfson  
*Theory and Applications of Categories* 33 (2018), no. 1, 296-349
- (11) Adelic Descent Theory  
*Compositio Mathematica* (2017), 153(8), 1706-1746
- (12) Relative Tate objects and boundary maps in the K-theory of coherent sheaves, with Oliver Braunling and Jesse Wolfson  
*Homology Homotopy Appl.* 19 (2017), no. 1, 341-369
- (13) Geometric and analytic structures on the higher ad eles, with Oliver Braunling and Jesse Wolfson  
*Res. Math. Sci.* 3 (2016), no. 22 (special volume in honour of F. Bogomolov)
- (14) Operator ideals in Tate objects, with Oliver Braunling and Jesse Wolfson  
*Math. Res. Lett.* 23 (2016), no. 6, 1565-1631
- (15) The Index Map in Algebraic K-theory, with Oliver Braunling and Jesse Wolfson  
*Selecta Mathematica* 24 (2018), no. 2, 1039-1091
- (16) Tate Objects in Exact Categories, with Oliver Braunling and Jesse Wolfson and an appendix by Jan  stov icek and Jan Trlifaj  
*Mosc. Math. J.* 16 (2016), no. 3, 433-504
- (17) Moduli Problems in Abelian Categories and the Reconstruction Theorem, with John Calabrese  
*Algebr. Geom.* 2 (2015), no. 1, 1-18.
- (18) Appendix to *Cluster algebras of infinite rank* by Grabowski–Gratz  
*J. Lond. Math. Soc.* (2) 89 (2014), no. 2, 337-363
- (19) Hilbert schemes as moduli of Higgs bundles and local systems  
*Int. Math. Res. Not.* IMRN 2014, no. 23, 6523-6575
- (20) Moduli stacks of maps for supermanifolds, joint with Tim Adamo  
*Adv. Theor. Math. Phys.* 17 (2013), no. 6, 1303-1342
- (21) Moduli of flat connections in positive characteristic  
*Math. Res. Lett.* 23 (2016), no. 4, 989-1047

**Preprints**

- (22) The standard realizations for the K-theory of varieties, joint with Oliver Braunling and Anubhav Nanavaty  
arXiv:2107.01168
- (23) Classes in Zakharevich  $K$ -theory constructed from Quillen  $K$ -theory, joint with Oliver Braunling  
arXiv:2109.01136
- (24) Appendix to *Canonical Heights on Shimura Varieties and the André-Oort Conjecture* by Pila–Shankar–Tsimmerman, joint with H el ene Esnault  
arXiv:2109.08788
- (25) Complex  $K$ -theory of dual Hitchin systems, joint with Shiyu Shen  
arXiv:2212.10695
- (26) Cristallinity of rigid flat connections revisited, joint with H el ene Esnault  
arXiv:2309.15949

**In preparation**

- (27)  $p$ -adic integration for Artin stacks and BPS invariants, joint with Dimitri Wyss and Paul Ziegler

**Not intended for publication in present form**

De Rham  $\varepsilon$ -factors, lecture notes for a mini-course held at FU Berlin in Spring 2018

Ad elic methods in geometry, lecture notes for a mini-course held at the University of Chicago in Spring 2016, with Oliver Braunling

Complex manifolds, lecture notes for a course held at Imperial College in spring 2016

Algebraic stacks, lecture notes for a course held at Imperial College in autumn 2014 (including contributions by students)

- (28) De Rham epsilon factors for flat connections on higher local fields

arXiv:1807.07888

- (29) Higher de Rham epsilon factors

arXiv:1807.03190

*I intend to include the two preprints above (in modified form) in a lecture-notes-style account of the theory of de Rham  $\varepsilon$ -factors.*

## Talks

### Invited conference talks and mini-courses

$p$ -adic integration, buildings and BPS invariants, CMS meeting *Montréal* (December 2023)

$p$ -adic integration, buildings and BPS invariants, *Madrid* conference on the Hitchin system, Langlands duality and mirror symmetry (April 2023)

Complex  $K$ -theory of dual Hitchin systems, *CaWAGS: Simon Fraser workshop on algebraic geometry* (March 2023)

Rigid local systems, *Madison (Wisconsin) workshop on arithmetics and topology over global fields* (June 2022)

Mini-course on  $p$ -adic integration, School on Mirror Symmetry and Moduli Spaces, *Lisbon summer school* (June 2022)

Mini-course on Simpson's integrality conjecture, Non abelian Hodge Theory, *Saint Jacut de la Mar summer school* (June 2022)

Complex  $K$ -theory for dual Hitchin systems, *Canberra workshop: Character Varieties, E-polynomials and Representation Zeta Functions* (February 2022), *online*

Complex  $K$ -theory for dual Hitchin systems, *IHÉS summer school: Enumerative Geometry, Physics and Representation Theory* (July 2021), *online*

Flat connections and symmetric differentials, *Mini workshop: Hodge Theory, Period Mapping and Local Systems* (December 2020), *online*

Non abelian Hodge Theory, *Grenoble summer school* (December 2020), **cancelled** (COVID-19)

$p$ -adic integration for Hitchin systems and the fundamental lemma, *Arithmetic and Algebraic Geometry in Ann Arbor*, (August 2019):

I **cancelled** my speaking commitment (birth of my son)

$p$ -adic integration for Hitchin systems and the fundamental lemma, *Texas Algebraic Geometry Symposium*, Austin (February 2019)

$p$ -adic integration for Hitchin systems and the fundamental lemma, *CMS Winter meeting*, Vancouver (November 2019)

A higher-dimensional generalisation of the epsilon connection,  *$p$ -adic cohomology and arithmetic geometry 2018*, Sendai (November 2018)

$p$ -adic integration for the Hitchin system, *Mathematical Congress of the Americas*, Montréal (July 2017)

$p$ -adic integration for the Hitchin system, mini-course (4 talks) at Northwestern University, Chicago (April 2017)

Adèles and the geometry of schemes, mini-course (3 talks), Nottingham (October/November 2016)

Contou-Carrère symbol, workshop *Homotopical approaches to categories and geometry*, Freiburg (June 2016)

Adèlic methods in geometry, mini-course at the University of Chicago, April 2016, with Oliver Braunling

Adèles and the geometry of schemes, Workshop *arithmetic aspects of moduli spaces*, Lausanne (February 2016)

Higgs bundles and crepant resolutions, *COW/Categorically Cardiff*, Cardiff (October 2013)

Moduli of local systems and Geometric Langlands in positive characteristic, Workshop on *vector bundles in positive characteristic*, Nice (June 2013)

### Invited seminar talks

Topological properties of the Frobenius-pullback, Montréal (January 2024)

An introduction to rigid local systems, Colloquium, Tsinghua (April 2023)

$p$ -adic points of stacks and applications, Columbia number theory seminar, New York (April 2023)

An introduction to rigid local systems, CRM Colloquium, Montréal (February 2023)

An introduction to rigid local systems Colloquium, Minneapolis (February 2023) - **cancelled due to inclement weather**

Complex  $K$ -theory and dual Hitchin systems, Princeton (February 2022)

Complex  $K$ -theory and dual Hitchin systems, Saskatoon (November 2022)

Higgs bundles and Langlands duality, Edinburgh (July 2022)

Au sujet de la  $K$ -théorie topologique des systèmes de Hitchin duaux, Jussieu (Paris VI) (June 2022)

A new perspective on the fundamental lemma, University of Ottawa (February 2022), *online*

Langlands Duality for the Hitchin system, Johns Hopkins (December 2022), *online*

Complex  $K$ -theory for dual Hitchin systems, Yale (November 2021), *online*

Complex  $K$ -theory for dual Hitchin systems, IST Vienna (October 2021), *online*

$p$ -adic integration and Kirchoff polynomials, Frankfurt (June 2021), *online*

Rigid local systems, Wisconsin (March 2021), *online*

Une nouvelle perspective sur le lemme fondamental, Sherbrooke (February 2021), *online*

$p$ -adic integration for Hitchin systems and the fundamental lemma, Michigan (October 2020), *online*

The  $\varepsilon$ -connection and algebraic  $K$ -theory, eAKT (August 2020), *online*

$p$ -adic integration for Hitchin systems and the fundamental lemma, University of Chicago (May 2020), *online*

$p$ -adic integration and hypertoric Hitchin systems, MIT (November 2019)

- p-adic integration for Hitchin systems and the fundamental lemma, MIT (November 2019)
- p-adic integration for Hitchin systems and the fundamental lemma, UMass Amherst (November 2019)
- p-adic integration for Hitchin systems and the fundamental lemma, Colloquium, Rutgers-Newark (April 2019)
- p-adic integration for Hitchin systems and the fundamental lemma, Colloquium, Western University (March 2019)
- A higher-dimensional generalisation of the epsilon connection, UIUC (November 2018)
- A higher-dimensional generalisation of the epsilon connection, Purdue University (November 2018)
- Higgs bundles and p-adic integration, Columbia University (September 2018)
- Higgs bundles and p-adic integration, University of Edinburgh (May 2018)
- Rigid local systems, Universität zu Regensburg (November 2017)
- Rigid local systems, Universität Zürich (October 2017)
- Tate objects and algebraic K-theory, UIC (April 2017)
- Refined motivic integration, University of Northwestern (April 2017)
- Mirror symmetry for Higgs bundles via arithmetic geometry, CIRGET seminar at UQAM, Montréal April 2017
- Adèles and the geometry of schemes, MPI Bonn (November 2016)
- Adèles and the geometry of schemes, Geometry Seminar, Université de Strasbourg (March 2016)
- Adèles and the geometry of schemes, Geometry Seminar, EPF Lausanne (September 2015)
- Infinite-dimensional vector bundles and reciprocity, Université Toulouse III Paul Sabatier (June 2015)
- Infinite-dimensional vector bundles and reciprocity, University of Edinburgh (March 2015)
- The algebraic K-theory of Tate objects, Algebraic Topology Seminar, Bonn (January 2015)
- Reciprocity laws for higher-dimensional varieties, Algebraic Geometry and Number Theory Seminar, Rice University, Houston (October 2014)
- Delooping and Reciprocity, Algebraic and Symplectic Geometry Seminar, University of Oxford (November 2013)
- Determinantal line bundles and reciprocity laws, Imperial College London (April 2013)
- Higgs bundles and crepant resolutions, Freie Universität Berlin (January 2013)
- Moduli of local systems and Geometric Langlands in positive characteristic, Universität Duisburg-Essen (June 2012)
- Flat connections in positive characteristic: Moduli and Langlands correspondence, Leibniz Universität Hannover (December 2011)

## Talks given in student seminars

An introduction to stacks, University of Toronto (February 2019)

Mini-course for graduate students on  $\infty$ -categories in algebraic geometry (4 hours), FU Berlin (June 2017)

$p$ -adic integration, Paris (March 2015)

$p$ -adic integration, London (January 2015)

Loop groups, Imperial College London (February 2014)

The character theory, Eugene (OR), August 2012

Perspectives on spectra, November 2011

Fundamental groups and positive characteristic, Oxford, June 2011

Geometrization of trace formulas, Oxford, 2010

Homotopy theory of  $C^*$ -algebras, Oxford, October 2010

Introduction to descent theory, Oxford, March 2010

## Organization of conferences and workshops

$K$ -theory and related topics, online workshop, May 2021

CMS session: Algebraic geometry of integrable systems, online workshop, December 2020 (including a mini-course by M. Mayrand)

Higgs bundles and related topics, online workshop, May 2020

## Research visits

One month at Jussieu, Paris, Summer 2022

Two week visit of the Simons Centre, Stony Brook, Spring 2019

Two week visit of Northwestern University, Spring 2017

Two week visit of the MFI Oberwolfach (Research in Pairs), Winter 2016

Month-long visit of the University of Chicago, Spring 2016

Ten day visit of the University of Chicago, Autumn 2014



## Conferences and Summer Schools attended

*Conference talks are listed above*

VBAC, Warwick, July 2022

Texas Algebraic Geometry Symposium, Austin, February 2019

CMS Winter meeting, November 2018

$p$ -adic cohomology and arithmetic geometry 2018, Sendai, November 2019

Homotopy theory summer, Berlin, June 2018

Motives for periods, Berlin, Autumn 2017

Mathematical Congress of the Americas, Montréal, Summer 2017

Representation theory and beyond, Oxford, Autumn 2016

AMS Summer Institute in Algebraic Geometry, Salt Lake City, Summer 2015

Geometry of moduli spaces and representation theory, Park City, PCMI Summer Session 2015

Symmetries and Correspondences, Nottingham and Oxford, Summer 2014

Towards a proof of the Geometric Langlands Conjectures, Jerusalem, Spring 2014

Workshop on vector bundles in positive characteristic, Nice, Summer 2013

Categorical Representation Theory, Eugene (OR), Summer 2012

Representation Theory and Symplectic Algebraic Geometry, Luminy, Summer 2012

Higher Categorical Structures and their Interactions with Algebraic Geometry, Algebraic Topology and Algebra, Luminy, Summer 2012

Characteristic  $p$  and  $p$ -adic geometry, Mainz, Spring 2012

Principal  $G$ -bundles, Madrid, Summer 2011

Moduli Spaces and Moduli Stacks, New York, Spring 2011

Flag Varieties, Luminy, Spring 2011

Geometric Langlands and Gauge Theory, Barcelona, Spring 2010

Sheaves in Representation Theory, Isle of Skye, Spring 2010

The Decomposition Theorem and the Topology of Algebraic Maps, Freiburg, Winter 2010

Geometric Methods in Representation Theory, Köln, Summer 2009

## Teaching

### *Supervision of student projects*

I'm currently supervising five PhD students at the University of Toronto (one of them in co-supervision)

supervision of four MSc project students (Vojin Jovanovic, Siddharth Mahendraker, Christopher Main, Yujia Yin Yin), Toronto 2020-2021

co-supervision (with A. Shankar and J. Kamnitzer) of Siddharth Mahendraker's NSERC summer project (USRA), Toronto 2019

co-supervision (with H. Esnault) of a PhD thesis by Yun Hao, Berlin 2017 - thesis completed and defended in May 2019

Bachelor thesis by Joaquim Ribeiro on *p-adic integration*, Berlin 2018

Bachelor thesis by Karl Volkenandt on *Barr-Beck*, Berlin 2018

Master thesis by Sangmin Lee on *geometric representation theory*, London 2015

Master thesis by Adam Schienle on  *$\infty$ -categories*, London 2014

Second year project on *a cohomological proof of Sperner's Lemma*, London 2014 & 2016

MSc semester project by Coralie Spahn on *sheaf cohomology*, Lausanne 2013

### *University of Toronto*

Elementary Lie Theory, Spring 2023, University of Toronto-Mississauga

Homological algebra, Fall 2022, University of Toronto (St. George)

Elementary Lie Theory, Spring 2022, University of Toronto-Mississauga

Classical geometries, Fall 2021, University of Toronto-Mississauga

Introduction to Real Analysis, Spring 2021, University of Toronto (Mississauga)

Algebraic Topology, Spring 2021, University of Toronto (St. George)

Topics in mathematics: Lie theory, Fall 2020, University of Toronto (Mississauga)

Classical geometries, Fall 2019, Spring 2019 and Fall 2021, University of Toronto (Mississauga)

Algebraic geometry: arithmetic techniques, Fall 2018, University of Toronto (St. George)

### *FU Berlin*

Co-organiser of a reading group (*Forschungsseminar*) on the Langlands programme over function fields at FU-Berlin, Spring 2017

I wrote the programme for the seminar and assisted speakers in preparing their talks

*Courses taught at Imperial College London*

Complex manifolds, Spring Term 2016

Algebraic Stacks, Taught Course Centre, Autumn Term 2014

Manifolds, Autumn Term 2013

*Teaching Assistance at EPF Lausanne*

Linear Algebra for engineers, Autumn 2013

*Teaching Assistance at University of Oxford**Class Teaching Seminar attended*

Differentiable Manifolds, Hilary 2012

Lie Algebras, Michaelmas 2010

Analysis at St Hilda's College, Michaelmas 2010

Galois Theory, Michaelmas 2009

*Teaching Assistance at ETH Zürich*

Topology, Spring 2009

Analysis I, Fall 2008

Numerical Methods, Spring 2008

Linear Algebra for civil engineers, Fall 2007

**Departmental service**

awards committee, 2021-22 (University of Toronto-Mississauga)

graduate committee, 2019 - ongoing

research council, 2019 - 2021 (University of Toronto-Mississauga)

the colloquium committee, 2018-2019

**Miscellaneous**

member of the editorial board of *Journal de l'École Polytechnique*, since February 2024

member of the editorial board of *Moduli*, since October 2022

co-organiser of the *Geometric representation theory seminar* at the University of Toronto/Fields Institute 2018-2021

co-supervised a workshop (2.5 hours) at FU Berlin's Girls' Day (letting 12-year olds discover the joy of mathematics), with Victoria Hoskins, April 2017 & 2018

Postdoc representative, Imperial College, 2015-2016

Peer review for *Compositio*, *Forum of Mathematics*, *Journal of Differential Geometry*, *Duke*,  
*Inventiones*, *JEMS*, *Math. Res. Lett.*, *Transactions*.

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