Eleni Tzirita Zacharatou Curriculum Vitae

Assistant Professor, IT University of Copenhagen Rued Langgaards Vej 7, 2300 Copenhagen, Denmark elza@itu.dk | ORCID <u>0000-0001-8873-5455</u> | heltzi.github.io

Education

Ph.D. in Computer Science

2013 - 2019

École Polytechnique Fédérale de Lausanne (EPFL), Switzerland

Thesis: Efficient Query Processing for Spatial and Temporal Data Exploration

Advisor: Prof. Anastasia Ailamaki

Diploma (M. Eng.) in Electrical & Computer Engineering National Technical University of Athens (NTUA), Greece 2007 - 2013

Thesis: Automatic Music Transcription

Advisor: Prof. Petros Maragos

Academic Experience

Hasso Plattner Institute (HPI), University of Potsdam Incoming Assistant Professor

Potsdam, Germany

March 2025 -

• Lead of Research Group Spatial Analytics and Large-Scale Data Processing

Berlin Institute for the Foundations of Learning and Data (BIFOLD) Fellow

Berlin, Germany July 2021 – now

IT University of Copenhagen (ITU) Assistant Professor

Copenhagen, Denmark May 2022 — February 2025

• Member of the Data-Intensive Systems and Applications (DASYA) group

• Research Focus: Spatial Big Data Analytics

Technical University of Berlin (TUB)

Berlin, Germany

Postdoctoral Researcher, Computer Science Department

Oct 2019 - Apr 2022

- Member of the Database Systems and Information Management (DIMA) group
- Supervisor: Prof. Volker Markl

New York University (NYU)

New York, USA

Visiting Researcher, Tandon School of Engineering

Jul 2016 - Oct 2016

- Member of the Visualization, Imaging and Data Analysis (VIDA) group
- Supervisors: Prof. Juliana Freire and Dr. Harish Doraiswamy

École Polytechnique Fédérale de Lausanne (EPFL)

Lausanne, Switzerland

Doctoral Assistant, Computer Science Department

Sep 2013 – Aug 2019

- Member of the Data-Intensive Applications and Systems (DIAS) group
- Research Focus: Spatial and temporal data management for exploratory applications
- Advisor: Prof. Anastasia Ailamaki

École Polytechnique Fédérale de Lausanne (EPFL) Research Intern, Computer Science Department

Lausanne, Switzerland Jan 2013 – Aug 2013

- Member of the Data-Intensive Applications and Systems (DIAS) group
- Supervisors: Prof. Anastasia Ailamaki and Prof. Thomas Heinis

Honors and Awards

• Distinguished Reviewer Award, VLDB Conference	2022
• Junior Fellowship, Berlin Institute for the Foundation of Learning and Data (BIFOLD)	2021
• Best Demonstration Award, ACM SIGMOD Conference	2018
• Travel Award, ExploreDB Workshop (in conjunction with ACM SIGMOD), USD 1K	2016
• Distinction in the Panhellenic Math Competition "Euclid", Hellenic Mathematical Society	2006

Publications Summary

Full papers at top-tier conferences (CORE A*/A ranking) and journals: 12

Other peer-reviewed conference papers: 4

Peer-reviewed workshop and demonstration papers: 9

Number of citations: 380 and h-index: 11 (as per Google Scholar in February 2025)

Full list of publications: see https://heltzi.github.io/publications.html

<u>Invited Talks and Conference Presentations</u>

- 10/2024: Unifying Spatial Data Analytics, D3A Conference, Nyborg, Denmark
- 07/2024: Spatial Data Management Systems, VLDB Summer School, Cluj-Napoca, Romania
- 07/2024: Surviving in Academia: Personal Story and Advice, BIFOLD Career Seminar, Berlin, Germany
- 07/2024: Transforming Heterogeneous Spatial Data into Insights, BIFOLD Lunch Talk, Berlin, Germany
- 06/2024: Analysis of Geospatial Data Loading, DBTest Workshop@SIGMOD, Santiago, Chile
- 11/2023: Efficient Data Management for Modern Spatial Applications, HPI-TU Darmstadt Joint Database Systems Seminar, Online
- 09/2023: Efficient Data Management for Modern Spatial Applications, NERDS (ITU) Seminar, Denmark
- 09/2022: Efficient Data Management for Modern Spatial Applications and the Internet of Moving Things, DIREC Seminar, Aarhus, Denmark
- 09/2021: Agora-EO: A Unified Ecosystem for Earth Observation, Monthly Research Meeting, Department of Geo-information Processing, University of Twente, Online
- 01/2021: The Case for Distance-Bounded Spatial Approximations, CIDR Conference, Online
- 11/2019: Efficient Bundled Spatial Range Queries, SIGSPATIAL Conference, Chicago, USA
- 08/2019: Efficient Query Processing for Spatial and Temporal Data Exploration, Public Defense, EPFL, Lausanne, Switzerland
- 07/2019: GPU Rasterization for Real-Time Spatial Aggregation over Arbitrary Polygons, Hellenic Data Management Symposium (HDMS), Athens, Greece
- 02/2019: Interactive and Exploratory Spatio-Temporal Data Analytics, DIMA Research Seminar, TU Berlin, Germany
- 08/2018: GPU Rasterization for Real-Time Spatial Aggregation over Arbitrary Polygons, VLDB Conference, Rio de Janeiro, Brazil
- 06/2018: Interactive Exploration of Urban Data with GPUs, Short Presentation, IC Research Day, EPFL, Lausanne, Switzerland
- 04/2018: Improving Spatial Data Processing by Clipping Minimum Bounding Boxes, ICDE Conference, Paris, France
- 06/2017: Real-Time Spatial Aggregation using GPU Rasterization, EcoCloud Annual Event, Lausanne, Switzerland
- 09/2016: Indexing the brain, Data Science Lunch Talk, NYU Center for Data Science, New York, USA

 \bullet 06/2015: RUBIK: Efficient Threshold Queries on Massive Time Series, SSDBM Conference, San Diego, USA

Panels

- Ph.D. Mentoring Panel, VLDB, August 2024
- A Discussion on Success in a Ph.D. Journey, VLDB Ph.D. Workshop, August 2024
- Spatial and Temporal Data Management Panel, ICDE, May 2022
- Spatio-Temporal Data System Panel, VLDB, August 2021

Advising (Current)

• Xenofon Chatziliadis, PhD, TUB, Primary advisor: Prof. Volker Markl	$Fall\ 2019 - now$
• Gereon Dusella, PhD, TUB, Primary advisor: Prof. Volker Markl	$Fall\ 2023-now$
• Mentor in the AI Grid network	2023 - now

Advising (Alumni)

• Martin Kiefer, PhD, TUB, Primary advisor: Prof. Volker Markl	Fall 2021 — Fall 2022
• Aske Wachs, MSc Research Project & Thesis, ITU	Fall 2023 — Spring 2024
• Johan Kjersgård Flensmark, Benjamin Hammer Thygesen, Alexander Theodo	r Bilde Pedersen,
MSc Research Project & Thesis, ITU	Fall 2023 — Spring 2024
• Barbara Puljak, MSc Research Project & Thesis, ITU	Fall 2023 — Spring 2024
• Dagmara Kamila Przygocka, Kamila Garczynska, MSc Research Project, ITU	Fall 2023
• Hanno Skowronek, MSc Thesis, TUB, Primary advisor: Prof. Begüm Demir	Spring 2023
• Carl Bruun & Rasmus Garbarsch, BSc Thesis, ITU	Spring 2023
• Gergo Gyori, BSc Thesis, ITU	Spring 2023
• Gereon Dusella, MSc Thesis, TUB, Co-supervisor: H. Gavriilidis	Spring 2023
• Peter Løffmann, Thomas Haugaard Mogensen, Zachery Kuntz, MSc Research	Project, ITU Fall 2022
• Laert Nuhu, MSc Thesis, TUB, Co-supervisor: H. Gavriilidis	Spring 2022
• Pablo Alberto Osinaga Arze, MSc Thesis, TUB	Fall 2021
• Iva Mihajlovska, MSc Thesis, TUB	Spring 2021
• Marcellus Prama Saputra, BSc Thesis, TUB	Spring 2021
• Robin Papke, MSc Thesis, TUB	Fall 2020
• Elena Beatriz Ouro Paz, MSc Thesis, TUB	Spring 2020
• Carlos E. Muniz Cuza, MSc Thesis, TUB & Aalborg University,	Spring 2020
Co-supervisors: Professors Nguyen Thi Thao Ho, Torben Bach Pedersen, Bin	Yang
• Vlad Mihaescu, MSc Research Project, EPFL	Fall 2018
• Maria Ilina, Summer Intern, EPFL	Summer 2018
• Parand Alizadeh, Summer Intern, EPFL	Summer 2018
• Chenxi Sun, Summer Intern, EPFL	Summer 2015

Guided Research

• Thanasis Georgiadis, Approximating Polygons as Raster Interval Lists	Spring 2023
• David Burell, Workload Prediction for IoT Data Management Systems	Fall 2022
• Felix Henze, Efficient Specialized Spreadsheet Parsing	Spring 2022
• Ahmet Kerem Aksoy, Satellite Image Search in AgoraEO	Spring 2022
• Christian Winter, A Query-Cache Accelerated Data Structure	Fall 2021
for Spatial Aggregation over Polygons	

PhD Thesis Committees

- Keven Richly, PhD, HPI (Advisor: Hasso Plattner)
- Martin Kiefer, PhD, TU Berlin (Advisor: Volker Markl)
- Morten Tychsen Clausen, PhD Midway, ITU (Advisor: Philippe Bonnet)

Transfer of the state of the st

2024

2023

2023

Teaching

Term	Institute	Course Name	Role
Fall 2023 -	ITU	Introduction to Database	Course Manager &
Fall 2024 &		Systems	Responsible Lecturer
Fall 2022			
Fall 2021,	TUB	DBPRA: Datenbankprak-	Responsible Lecturer
Spring 2021		tikum (Practical course on	
		databases)	
Fall 2020	TUB	AIM-3: Scalable Data Analy-	Lecturer
		sis and Data Mining	
Fall 2020,	TUB	BDASEM: Big Data Analyt-	Lecturer
Spring 2020,		ics Seminar	
Fall 2019			
Spring 2020	TUB	BDAPRO: Big Data Analyt-	Project Mentor
		ics Project	
Fall 2019	TUB	DBSEM: Foundations of	Lecturer
		Database Systems Seminar	
Fall	EPFL	Information, Computation,	Teaching Assistant
2018/2019,		Communication	
Spring 2014	DDDI	Dilli	TD 1: A :
Spring 2018,	EPFL	Database Systems	Teaching Assistant
Spring 2017	EDEL	D (;	TD 1: A :
Fall	EPFL	Programming I (in C)	Teaching Assistant
2017/2018		D 1 1 1111	
Spring 2016	EPFL	Probability and Statistics	Teaching Assistant
Fall	EPFL	Computer Architecture	Teaching Assistant
2015/2016			
Spring 2015	EPFL	Introduction to Database	Teaching Assistant
		Systems	
Fall	EPFL	Introduction to Object Ori-	Teaching Assistant
2014/2015		ented Programming (in Java)	

Service

Organization:

- Program Co-Chair, Hellenic Data Management Symposium (HDMS) 2025
- Proceedings Co-chair, SIGMOD 2025
- Diversity and Inclusion Co-chair, EDBT 2026, EDBT 2025
- Co-organizer, Data Management Aspects of Analytics Workshop (in conjunction with the D3A Conference), 2024
- Proceedings Chair, DEBS 2022
- Co-chair, BOSS Workshop 2020 (in conjunction with VLDB)

Program Committee:

- ACM SIGMOD: 2025, 2024, 2023, 2022, 2021 (Industrial track)
- VLDB: 2026, 2025, 2023, 2022
- IEEE ICDE: 2024 (Demo track)
- EDBT: 2022
- VLDB PhD Workshop: 2023
- BTW: 2023 (Demo track)
- ACM SIGSPATIAL Workshop on Location-based Recommendations, Geosocial Networks and Geoadvertising (LocalRec): 2023
- PLDI Workshop on Distributions, Relational Algebra, Graphs, Semi-Rings, Tensors, and All That (DRAGSTERS): 2023
- IEEE Intl. Workshop on Testing Distributed Internet of Things Systems (TDIS): 2025, 2022
- AI-ML Systems: 2021
- CIKM: 2018 (Short research papers track)

Journal Reviewer:

- VLDB Journal, 2021 2022
- Knowledge and Information Systems (KAIS) Journal, 2021 2022
- Big Data Research Journal, 2022

External Reviewer:

CIDR 2022, SIGMOD 2021, CIDR 2021, ICDE 2017

Session Chair:

EDBT 2023, VLDB 2021, VLDB 2020

Assessment and Admission Committees:

- Hiring Committee Member at University of Hamburg: Professorship of "W3 Data Engineering", 2024
- Program Admission Committee Member at ITU: Data Science Bachelor (Spring 2024), Software Design Master (Spring 2023)
- PhD Assessment Committee Member at ITU: Spring 2024, Spring 2023, Fall 2022
- Hiring Committee Member at TUB: Professorship of "W3 Big Data Engineering", 2021

Department Level:

- Co-organizer: CS Lectures Series, ITU, 2022 2024
- Co-organizer: CS Department Annual Retreat, ITU, 2023

Media, Blogs, and Interviews

- 2023: An Interview with Eleni Tzirita Zacharatou, DIMA TUB webpage
- 2021: Advancing Big Data Analytics: Post-Doctoral Research, DataTalksClub podcast
- 2021: BIFOLD welcomes the first six junior fellows, BIFOLD webpage
- 2021: The Case for Distance-Bounded Spatial Approximations, The Agora Technology Blog, Medium
- 2018: Student-teacher Duo from EPFL Wins Best Demonstration Award at SIGMOD, Ecocloud News
- 2018: Tandon Team Takes Home Top Honors at Association for Computing Machinery Conference, Tandon School of Engineering News

References

Provided upon request.

Languages

Greek (Native), English (Fluent), French (Fluent), German (Intermediate)

$\underline{Extracurricular}$

I have formally studied the piano, the violin, and music theory. I enjoy playing music alone or in groups.

- 2010: Piano Teaching Diploma (Ptychio), Grade Excellent, Athenaeum Conservatory
- 2005: Classical Harmony Diploma (Ptychio), Heraklion Conservatory

Eleni Tzirita Zacharatou Publications

Assistant Professor, IT University of Copenhagen elza@itu.dk | ORCID 0000-0001-8873-5455 | heltzi.github.io

Metric	Value
Peer-reviewed publications	25
Citations	380
h-index	11
i10-index	11

Table 1: Summary of bibliometrics as per Google Scholar in February 2025.

It's important to note that the database research community is relatively small, leading to smaller indices for database researchers, as evidenced by conference indices.¹ The venue ranking according to the CORE Conference Portal² is included when available. My name is highlighted in **boldface** and the names of students under my (co-)mentorship are marked with an asterisk (*).

Peer-Reviewed Journal Publications

- [1] T. Georgiadis, E. **Tzirita Zacharatou**, and N. Mamoulis. "Raster Interval Object Approximations for Spatial Intersection Joins". In: *The VLDB Journal* 34(8) (2025). DOI: https://doi.org/10.1007/s00778-024-00887-4. [Core A*].
- [2] X. Chatziliadis*, E. **Tzirita Zacharatou**, A. Eracar, S. Zeuch, and V. Markl. "Efficient Placement of Decomposable Aggregation Functions for Stream Processing over Large Geo-Distributed Topologies". In: *Proceedings of the Very Large Databases Endowment (PVLDB)* 17(6) (2024), pp. 1501–1514. [Core A*].
- [3] H. Gavriilidis, F. Henze*, E. **Tzirita Zacharatou**, and V. Markl. "SheetReader: Efficient Specialized Spreadsheet Parsing". In: *Information Systems* 115 (2023), p. 102183. [Core A*].
- [4] M. Kiefer*, I. Poulakis, E. **Tzirita Zacharatou**, and V. Markl. "Optimistic Data Parallelism for FPGA-Accelerated Sketching". In: *Proceedings of the Very Large Databases Endowment (PVLDB)* 16(5) (2023), pp. 1113–1125. [Core A*].
- [5] E. **Tzirita Zacharatou**, H. Doraiswamy, A. Ailamaki, C. T. Silva, and J. Freire. "GPU Rasterization for Real-Time Spatial Aggregation over Arbitrary Polygons". In: *Proceedings of the Very Large Databases Endowment (PVLDB)* 11(3) (2017), pp. 352–365. [Core A*].

Peer-Reviewed Conference Publications

- [6] V. Pandey, A. van Renen, E. **Tzirita Zacharatou**, A. Kipf, I. Sabek, J. Ding, V. Markl, and A. Kemper. "Enhancing In-Memory Spatial Indexing with Learned Search". In: *Datenbanksysteme für Business*, *Technologie und Web (BTW)*. Gesellschaft für Informatik e.V., 2025. To Appear.
- [7] C. E. Muñiz-Cuza*, N. Ho, E. **Tzirita Zacharatou**, T. B. Pedersen, and B. Yang. "Spatio-temporal graph convolutional network for stochastic traffic speed imputation". In: *International Conference on Advances in Geographic Information Systems (SIGSPATIAL)*. ACM, 2022, 14:1–14:12. [Core A].

 $^{^{1} \}texttt{https://scholar.google.de/citations?view_op=top_venues\&hl=en\&vq=eng_databasesinformationsystems}$

²www.core.edu.au/conference-portal

- [8] M. P. Saputra*, E. **Tzirita Zacharatou**, S. Papadias, and V. Markl. "In-Place Updates in Tree-Encoded Bitmaps". In: *International Conference on Scientific and Statistical Database Management (SSDBM)*. ACM, 2022, 18:1–18:4. [Core2021 B].
- [9] E. Ouro Paz*, E. **Tzirita Zacharatou**, and V. Markl. "Towards Resilient Data Management for the Internet of Moving Things". In: *Datenbanksysteme für Business, Technologie und Web (BTW)*. Gesellschaft für Informatik e.V., 2021, pp. 279–301.
- [10] E. **Tzirita Zacharatou**, A. Kipf, I. Sabek, V. Pandey, H. Doraiswamy, and V. Markl. "The Case for Distance-Bounded Spatial Approximations". In: *Conference on Innovative Data Systems Research* (CIDR). www.cidrdb.org, 2021. [Core A].
- [11] A. de Wall, B. Deiseroth, E. **Tzirita Zacharatou**, J.-A. Quiané-Ruiz, B. Demir, and V. Markl. "Agora-EO: A Unified Ecosystem for Earth Observation A Vision for Boosting EO Data Literacy". In: *Conference on Big Data from Space*. 2021, pp. 101–104.
- [12] C. Winter*, A. Kipf, C. Anneser, E. **Tzirita Zacharatou**, T. Neumann, and A. Kemper. "GeoBlocks: A Query-Cache Accelerated Data Structure for Spatial Aggregation over Polygons". In: *International Conference on Extending Database Technology (EDBT)*. OpenProceedings.org, 2021, pp. 169–180. [Core A].
- [13] A. Kipf, H. Lang, V. Pandey, R. A. Persa, C. Anneser, E. **Tzirita Zacharatou**, H. Doraiswamy, P. A. Boncz, T. Neumann, and A. Kemper. "Adaptive Main-Memory Indexing for High-Performance Point-Polygon Joins". In: *International Conference on Extending Database Technology (EDBT)*. OpenProceedings.org, 2020, pp. 347–358. [Core A].
- [14] E. **Tzirita Zacharatou**, D. Sidlauskas, F. Tauheed, T. Heinis, and A. Ailamaki. "Efficient Bundled Spatial Range Queries". In: *International Conference on Advances in Geographic Information Systems (SIGSPATIAL)*. ACM, 2019, pp. 139–148. [Core A].
- [15] D. Sidlauskas, S. Chester, E. **Tzirita Zacharatou**, and A. Ailamaki. "Improving Spatial Data Processing by Clipping Minimum Bounding Boxes". In: *International Conference on Data Engineering*, (*ICDE*). IEEE, 2018, pp. 425–436. [Core A*].
- [16] E. **Tzirita Zacharatou**, F. Tauheed, T. Heinis, and A. Ailamaki. "RUBIK: efficient threshold queries on massive time series". In: *International Conference on Scientific and Statistical Database Management (SSDBM)*. ACM, 2015, 18:1–18:12. [Core2014 A].

Peer-Reviewed Workshop and Demonstration Publications

- [17] G. Dusella*, H. Gavriilidis, L. Nuhu, V. Markl, and E. **Tzirita Zacharatou**. "Multi-Backend Zonal Statistics Execution with Raven". In: *International Conference on Management of Data (SIGMOD)*. ACM, 2024. Demo paper. [Core A*].
- [18] A. Wachs* and E. **Tzirita Zacharatou**. "Analysis of Geospatial Data Loading". In: *DBTest@SIGMOD*'24: Proceedings of the International Workshop of Testing Database Systems. To appear. 2024.
- [19] D. Burrell*, X. Chatziliadis*, E. **Tzirita Zacharatou**, S. Zeuch, and V. Markl. "Workload Prediction for IoT Data Management Systems". In: *Datenbanksysteme für Business, Technologie und Web (BTW)*. Gesellschaft für Informatik e.V., 2023, pp. 943–950. BTW 2023 DE4DS Workshop.
- [20] A. K. Aksoy*, P. Dushev, E. **Tzirita Zacharatou**, H. Hemsen, M. Charfuelan, J. A. Quiané-Ruiz, B. Demir, and V. Markl. "Satellite Image Search in AgoraEO". In: *Proceedings of the Very Large Databases Endowment (PVLDB)* 15(12) (2022), pp. 3646–3649. Demo paper. [Core A*].

- [21] F. Henze*, H. Gavriilidis, E. **Tzirita Zacharatou**, and V. Markl. "Efficient Specialized Spreadsheet Parsing for Data Science". In: *International Workshop on Design, Optimization, Languages and Analytical Processing of Big Data (DOLAP (co-located with EDBT))*. CEUR-WS.org, 2022, pp. 41–50. [Core B].
- [22] X. Chatziliadis*, E. **Tzirita Zacharatou**, S. Zeuch, and V. Markl. "Monitoring of Stream Processing Engines Beyond the Cloud: An Overview". In: *Open Journal of Internet Of Things (OJIOT)* 7(1) (2021), pp. 71–82. VLDB 2021 VLIoT Workshop.
- [23] S. Zeuch, E. **Tzirita Zacharatou**, S. Zhang, X. Chatziliadis, A. Chaudhary, B. D. Monte, D. Giouroukis, P. M. Grulich, A. Ziehn, and V. Markl. "NebulaStream: Complex Analytics Beyond the Cloud". In: *Open Journal of Internet Of Things (OJIOT)* 6(1) (2020), pp. 66–81. VLDB 2020 VLIoT Workshop.
- [24] H. Doraiswamy, E. **Tzirita Zacharatou**, F. Miranda, M. Lage, A. Ailamaki, C. T. Silva, and J. Freire. "Interactive Visual Exploration of Spatio-Temporal Urban Data Sets using Urbane". In: *International Conference on Management of Data (SIGMOD)*. ACM, 2018, pp. 1693–1696. Demo paper. [Core A*]
 - Best Demonstration Award.
- [25] M. Pavlovic, E. **Tzirita Zacharatou**, D. Sidlauskas, T. Heinis, and A. Ailamaki. "Space odyssey: efficient exploration of scientific data". In: *International Workshop on Exploratory Search in Databases and the Web (ExploreDB (co-located with SIGMOD))*. ACM, 2016, pp. 12–18.

Articles and Technical Reports (Non-Peer-Reviewed)

[26] Z. Bao, P. Bouros, R. Cheng, B. Choi, A. Dignös, W. Ding, Y. Fang, B. Han, J. Hu, A. Khan, W. Lin, X. Lin, C. Long, N. Mamoulis, J. Pei, M. Renz, S. Shekhar, J. Shi, E. **Tzirita Zacharatou**, S. Wang, X. Wang, X. Wang, R. C.-W. Wong, D. Yan, X. Yan, B. Yang, D. Yao, C. Zhang, P. Zhao, and R. Zhu. "A Summary of ICDE 2022 Research Session Panels". In: *Data Engineering Bulletin* 47 (2023). URL: http://sites.computer.org/debull/A23dec/p4.pdf.

Conference Proceedings

[27] Y. Zhou, P. K. Chrysanthis, V. Gulisano, and E. **Tzirita Zacharatou**, eds. 16th ACM International Conference on Distributed and Event-based Systems, DEBS 2022, Copenhagen, Denmark, June 27 - 30, 2022. ACM, 2022. ISBN: 978-1-4503-9308-9. DOI: 10.1145/3524860. URL: https://doi.org/10.1145/3524860. Proceedings chair.

PhD Thesis

[28] E. Tzirita Zacharatou. "Efficient Query Processing for Spatial and Temporal Data Exploration". PhD thesis. EPFL, 2019, p. 183.