

Curriculum Vitae — Peter Spacek

Personal information

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Current research

My current research considers mirror symmetry mostly on the level of the (*small*) quantum cohomology of a variety. This is a modification of the cohomology ring by replacing the cup product with the so-called quantum product whose structure constants are given by *Gromov-Witten invariants*. These invariants can be considered to count the number of rational curves between three given subvarieties.

Homogeneous spaces are varieties that can be realized as the quotient of a (complex) Lie or linear algebraic group. For these spaces, the quantum cohomology can be constructed by mirror symmetry as the coordinate ring of a so-called *mirror variety* modulo relations obtained from the derivatives of a function called the *superpotential*. This mirror construction was first achieved by Rietsch (2008) utilizing Lie-theoretic methods. To obtain a more geometric understanding of this mirror symmetry statement, alternative mirror models were investigated. Using ad-hoc local expressions of the Lie-theoretic models, *generalized Plücker coordinate* models were constructed by Marsh, Pech, Rietsch and Williams (2013, 2016, 2020) for Grassmannians, quadrics and Lagrangian Grassmannians, which were the most accessible cases of homogeneous spaces; namely, they are *cominuscule*, simplifying the relevant representation theory.

In [1], I described type-independently the local expressions for Rietsch's mirror models in the cominuscule case, and used these in [2] to find in collaboration with Dr. C. Wang similar Plücker coordinate models for the *Cayley plane* and the *Freudenthal variety*. These turned out to be closely related to the *cluster structures* of these varieties. Inspired by the generalizability of the methods in [2], we have recently released a preprint [4] where we have constructed a type-independent Plücker coordinate mirror model for cominuscule homogeneous spaces; some preliminary results had already been presented in the short conference proceedings [3]. These models also inspired us to propose a new type of polytopes in [5] forming Newton-Okounkov bodies for these spaces and thereby governing their toric degenerations and exhibiting better behavior than the string polytopes considered so far. Moreover, with the completion of [4], we have opened the way to geometric mirror models for more general homogeneous spaces; some preparatory groundwork has already been laid in collaboration with Prof. N. Perrin for the quasi-cominuscule cases.

Recently, Prof. C. Sevenheck, Dr. Y. Qin and I have started a collaboration considering the implications of the newly-found results on mirror symmetry on the level of \mathcal{D} -modules for homogeneous spaces. Among other directions of research, we will investigate how the *quantum differential equations* of homogeneous spaces are related to dimensional reductions of *tautological systems*, and have recently released an investigation into the Hodge-theoretic properties of the mirror isomorphisms [6].

Career

- 2021 – now Post-doctoral Researcher (Wissenschaftlicher Mitarbeiter), TU Chemnitz (Germany)
Funded by the DFG (German Research Council) during 2023 – 2025 (research only)
Funded by TU Chemnitz during 2021 – 2023 (research & teaching)
Supervised by Prof. Christian Sevenheck
- 2021 Early Career Fellow of the London Mathematical Society, hosted by Prof. N. Perrin at the Laboratoire de Mathématique de Versailles (France), UK-based due to COVID

Education

- 2017 – 2021 University of Kent (UK), PhD in Mathematics
Thesis: *Laurent polynomial Landau-Ginzburg models for cominuscule homogeneous spaces and mirror symmetry for the exceptional family*
Supervised by Dr. C.M.A. Pech & Prof. A.N.W. Hone
- 2014 – 2017 University of Amsterdam (NL)
– Master in Mathematics (track Algebra & Geometry), cum laude
– Master in Physics (track Theoretical Physics), cum laude
Thesis: *Supersymmetric string theory, derived categories, lattices and a generalized Mukai-Kondo theorem on K3-surfaces.*
Supervised by Dr. M.C.N. Cheng & Dr. H.B. Posthuma
- 2011 – 2014 University of Amsterdam (NL):
– BSc Mathematics, cum laude, cum honore
– BSc Physics & Astronomy, cum laude, cum honore
Thesis: *Symmetries of the Kepler problem.*
Supervised by Dr. R.R.J. Bocklandt
- 2005 – 2011 Barlaeus Gymnasium, Amsterdam (NL), cum laude

Publications

Pre-print:

6. *Irregular Hodge numbers of Frenkel–Gross connections*, joint with Y. Qin and C. Sevenheck, arxiv/abs/2412.05849
5. *Chevalley Polytopes and Newton–Okounkov Bodies*, joint with C. Wang, arXiv/abs/2411.10276
4. *Canonical Landau–Ginzburg models for cominuscule homogeneous spaces*, joint with C. Wang, arXiv/abs/2410.05070

Peer-reviewed:

3. *Canonical mirror models for maximal orthogonal Grassmannians*, joint with C. Wang, in “Lie Theory and Its Applications in Physics: Varna, Bulgaria, June 2023”, Springer Proc. Math. & Stat. **473** (2025), pages tba (arXiv/abs/2312.17656)
2. *Towards Landau–Ginzburg models for cominuscule spaces via the exceptional cominuscule family*, joint with C. Wang, J. of Algebra **630** (2023) p. 334–393, DOI:10.1016/j.j.algebra.2023.03.039 (arxiv/abs/2204.03548)
1. *Laurent polynomial Landau–Ginzburg models for cominuscule homogeneous spaces*, Transformation Groups **27** (2022), p. 1551–1584, DOI:10.1007/s00031-020-09636-7 (arxiv/abs/1912.09122)

Other:

- ii. *Combinatorics of plabic graphs*, extended abstract for the Oberwolfach Workshop Report 2023, **45**, p. 23–24
- i. *Laurent polynomial potentials for cominuscule homogeneous spaces*, summary of [1] for the Oberwolfach Workshop Report 2020, **10**, p. 16–18

Grants awarded

- 2023 DFG Research project funding (co-applicant under Prof. C. Sevenheck) for a two-year extension of a post-doctoral position at the TU Chemnitz
- 2021 LMS Early Career Fellowship, to visit Prof Perrin at the Lab. de Mathématiques de Versailles, on the project “Mirror symmetry for adjoint homogeneous spaces”
- 2019 LMS Postgraduate Research Conference Grant (scheme 8), for the conference “Young Researchers in Lie Theory” at the University of Kent
- 2019 Anglo-Frenco-German Network in Representation Theory and its Applications, support awarded for the conference “Young Researchers in Lie Theory”

Teaching experience and qualifications

- 2023 Postdoctoral lecturer for the BSc Mathematics, TU Chemnitz (Germany)
– Lie algebras and representation theory module
- 2021 – 2023 Teaching assistant for the BSc Mathematics, TU Chemnitz (Germany)
– algebraic geometry, algebra, and calculus modules
- 2019 Acquired qualification of Associate Fellow of the Higher Education Academy (UK)
- 2017 – 2020 Teaching assistant for the BSc Mathematics, University of Kent (UK)
– (linear) algebra, differential equations, quantum mechanics and calculus modules
- 2014 – 2017 Teaching assistant for the BSc Mathematics, University of Amsterdam (NL)
– linear algebra and differential equations modules

Organisational and administrative experience

- 2024 Reading group organiser “The Langlands program and conformal field theory”, TU Chemnitz
- 2023 Reading group co-organiser “Mirror symmetry & tropical geometry”, TU Chemnitz
- (COVID) Organiser of the conference “Young Researchers in Lie Theory”, University of Kent, with support of LMS and the Anglo-Franco-German Network in Representation Theory
- 2019 – 2020 Organiser of the quarterly Junior Cambridge–Oxford–Warwick regional algebraic geometer’s seminar (also known as the “Calf seminar”)
- 2018 – 2020 Representative for Graduate Teaching Assistants in the Mathematics Department in the education committee and the representative meetings, University of Kent (UK)
- 2018 – 2019 Organizer of the weekly PhD student seminars, University of Kent (UK)
- 2013 Liaison between Professional Services and the Math. Dep. of the U. of Amsterdam (NL)

Language proficiencies

Dutch	English	German	Chinese
native	fluent	intermediate	beginner

External talks given

- 02/12/2024 [invited] “Schubert Seminar”, Rutgers U. New Jersey (US, online)
Minuscule posets and superpotentials for cominuscule homogeneous spaces
- 06/08/2024 Conference “Mirrors in the Midlands”, U. of Birmingham (UK)
Type-independent canonical mirror models for cominuscule homogeneous spaces
- 09/02/2024 Combinatorics seminar, U. of Michigan (US)
The combinatorics of minuscule posets in mirror symmetry for homogeneous spaces
- 21/06/2023 [invited] Conference “Lie Theory and its Applications in Physics”, Varna (Bulgaria)
Towards type-independent canonical mirror constructions for cominuscule homogeneous spaces
- 18/07/2022 “The Fourth W. Killing and K. Weierstrass Colloquium”, U. of Gdansk (Poland)
Introducing LG-models for $qH^(G/P)$ through examples*
- 13/07/2022 Conference “StringMath22”, U. of Warsaw (Poland)
Landau-Ginzburg models for cominuscule homogeneous spaces
- 07/07/2022 “Saxonian Algebraic Geometry” Seminar, MPI MIS Leipzig (Germany)
Cominuscule homogeneous spaces, quantum cohomology, and mirror symmetry
- 14/07/2021 Conference “IMPANGA 20”, Bedlewo (online, Poland)
Landau-Ginzburg models for the small quantum cohomology of cominuscule homogeneous spaces
- 18/06/2021 Junior Cambridge-Oxford-Warwick regional algebraic geometers’ seminar (online, UK)
Landau-Ginzburg models for the small quantum cohomology of cominuscule homogeneous spaces
- 16/12/2020 Conference “Quantum Groups and Cohomology Theory of Quiver and Flag Varieties”,
Centre International de Rencontres Mathématiques, Marseille (online, France)
Mirror symmetry for cominuscule homogeneous spaces
- 04/12/2020 Stockholm Mathematics Center, Algebra & Geometry seminar (online, Sweden)
Mirror symmetry for cominuscule homogeneous spaces
- 08/09/2020 COW/EmSG/GLEN joint summer school (online, UK)
Laurent polynomial Landau-Ginzburg models for cominuscule homogeneous spaces
- 25/02/2020 Mini-workshop “Superpotentials in Algebra and Geometry”,
Mathematisches Forschungsinstitut Oberwolfach (Germany)
Laurent polynomial potentials for cominuscule homogeneous spaces
- 21/06/2019 Conference “Géométrie Algébrique en Liberté”, U. of Bucharest (Romania)
Introducing Mirror Symmetry for Homogeneous Spaces
- 11/04/2019 Workshop “Tropical Geometry meets Representation Theory II”, U. of Leicester (UK)
Introducing Mirror Symmetry for Homogeneous Spaces
- 22/10/2018 Junior Algebraic Geometers’ Seminar, U. of Warwick (UK)
Mirror Symmetry for Homogeneous Spaces
- 13/07/2018 Workshop “Cluster Algebras and Algebraic Geometry”, U. of Nottingham (UK)
Constructing a Mirror for the Cayley Plane