

# FULVIO GESMUNDO

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## Personal Information

born in Florence (Italy), on January 20th, 1987  
Italian Citizenship

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## Education

- 2013 – 2017 **Ph.D. in Mathematics at Texas A&M University.**  
Advisor: Prof. J. M. Landsberg  
Graduation: May 2017  
Thesis: Geometry and Representation Theory in the Study of Matrix Rigidity
- 2010 – 2012 **M.S. in Mathematics at Università degli Studi di Firenze (University of Florence).**  
Advisor: Prof. Giorgio Ottaviani.  
Graduation: April 2012.  
Thesis : Rango di tensori e Varietà Secanti  
(Tensor Rank and Secant Varieties)
- 2006 – 2010 **B.S. in Mathematics at Università degli Studi di Firenze (University of Florence).**  
Advisor: Prof. Donato Pertici.  
Graduation: April 2010.  
Thesis: Spazi Completamente Regolari e Compattificazione di Stone-Čech  
(Completely Regular Spaces and Stone-Čech Compactification)

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## Grants and Awards

- May 2017 *L. F. Guseman Prize*  
May 1st, 2017 - College Station, TX
- May 2016 *Bush School Travel Grant*  
May 20th, 2016 - College Station, TX
- March 2013 *Premio di Laurea Luigi Campedelli (Luigi Campedelli Thesis Prize)*  
Master's Thesis Award, March 11th, 2013 - Florence, Italy

### FELLOWSHIPS

- Fall 2022 *Simons Junior Leader*  
Institute of Mathematics of the Polish Academy of Sciences, Warsaw, Poland  
Duration: Six weeks
- Fall 2018 *Visiting Scholar*  
at Institute for Computational and Experimental Research in Mathematics, Providence, RI  
Duration: Three months
- Summer 2018 *Visiting Researcher*  
in the Research in Pairs program at CIRM Trento, Italy  
Duration: Four weeks

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## Work experience

- 2023 – **Chaire Professeur Junior**, *Institut de Mathématiques de Toulouse*, Université Toulouse III - Paul Sabatier.
- 2022 – 2023 **PostDoc**, *University of Saarland, Saarbrücken*, Dept. of Mathematics and Computer Science.

- Fall 2022 **Simons Junior Leader**, *Institute of Mathematics of the Polish Academy of Sciences*, Warsaw.  
during the AGATES semester on *Algebraic Geometry with Applications to Tensors and Secants*
- 2020 – 2022 **PostDoc**, *Max Planck Institute for Mathematics in the Sciences*, Leipzig.
- Fall 2018 **Visiting Scholar**, *Institute for Computational and Experimental Research in Mathematics*, Providence, RI.  
during a semester-long program on *Nonlinear Algebra*
- 2017 – 2020 **PostDoc**, *University of Copenhagen*, QMATH – Dept. of Mathematical Sciences.
- Fall 2014 **Visiting Scholar**, *Simons Institute for the Theory of Computing*, U.C. Berkeley.  
during a semester-long program on *Algorithms and Complexity in Algebraic Geometry*
- 2013 – 2017 **Graduate Student**, *Texas A&M University*, Department of Mathematics.

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## Organization

- August 2023 **SIAM Minisymposium: Tensors in Algebraic Geometry**, SIAM Conference on Applied Algebraic Geometry.  
Co-organizers: Alessandro Oneto, Luca Sodomaco, Neriman Tokcan
- Sept 2022 - Nov. 2022 **Events within the Thematic Semester AGATES**, Institute of Mathematics of the Polish Academy of Sciences – Warsaw.  
**Summer School on the Geometry of Tensors** – Co-organizers: F. Galuppi, J. Jelisiejew  
**Kickoff Workshop** – Co-organizers: F. Galuppi, J. Jelisiejew  
**Workshop in Algebraic Geometry and Complexity Theory** – Co-organizers: W. Buczyńska, N. Vannieuwenhoven
- August 2021 **SIAM Minisymposium: Tensor Networks and Geometry**, SIAM Conference on Applied Algebraic Geometry.  
Co-organizers: M. Christandl, D. Stilck-França, A. H. Werner
- June 2018 **QMATH Masterclass - Tensors: Geometry and Quantum Information**, University of Copenhagen and Niels Bohr International Academy.  
Co-organizers: S. Andersen, M. Christandl, A. H. Werner
- June 2021 - Dec. 2021 **Nonlinear Algebra Seminar**, Max Planck Institute for Mathematics in the Sciences.  
Co-organizers: B. Sturmfels, S. Telen

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## Teaching experience

- 2023 **PostDoc**, *Saarland University*, Department of Computer Science.  
Teaching assistant for Quantum Computing, Spring 2023
- 2021 **PostDoc**, *Max Planck Institute for Mathematics in the Sciences*.  
Designing and lecturing for the course Introduction to Enumerative Geometry  
<https://sites.google.com/view/intro-enumerative-geometry/>
- 2019 **PostDoc**, *University of Copenhagen*, Department of Mathematics.  
Teaching assistant for Complex Analysis II, Spring 2019 and Fall 2019
- 2013 – 2017 **Teaching Assistant**, *Texas A&M University*, Department of Mathematics.  
Teaching assistant experience four several undergraduate courses in Mathematics:  
Help Sessions in Linear Algebra (Spring 2013)  
Recitations in Calculus 1 (Fall 2013)  
Help Sessions in Linear Algebra (Spring 2014)  
Recitations in Calculus 2 (Spring 2015)  
Grader for Cryptography (Spring 2016 - Fall 2016)

## MENTORSHIP

**Leonie Kayser**, 2023 – (*current*), MPI-MiS, Leipzig.  
I serve as a *mentor*. In this capacity, I am actively involved in guiding the student's research and providing assistance in their mathematical development alongside their advisor.

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## Outreach

- 2017 **Kulturnatten**, University of Copenhagen.  
Collaboration in the event organized by QMATH on *cake cutting with straight edge and compass*.
- 2015 **Pi Day of the Century**, Texas A&M University.  
Outreach event geared towards elementary, middle and high school students,  
in collaboration with Texas A&M Math Circle.
- 2008 – 2012 **Gara matematica (Mathematics Contest)**, Dipartimento di Matematica Ulisse Dini,  
Florence.  
Collaboration in proctoring and grading in an annual contest for high school students.

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## Publications

- 1 **Homogeneous Algebraic Complexity Theory and Algebraic Formulas**, (w/P. Dutta, C. Ikenmeyer, G. Jindal, V. Lysikov), to appear ITCS, 2024.
- 2 **Partial Degeneration of Tensors**, (w/M. Christandl, V. Lysikov, V. Steffan), to appear SIAM J. Mat. An. (SIMAX), 2023.
- 3 **A Gap in the Subrank of Tensors**, (w/M. Christandl, J. Zuiddam), SIAM J. Appl. Geom. Alg (SIAGA), vol. 7 (4), pp. 742–76, 2023, doi:10.1137/22M154327.
- 4 **Decompositions and Terracini loci of cubic forms of low rank**, (w/L. Chiantini), to appear in Deformation of Artinian Algebras and Jordan Types, CONM, 2023.
- 5 **Geometry of Tensors: Open problems and research directions**, A report on the AGATES Kickoff Workshop, 2023.
- 6 **Algebraic Compressed Sensing**, (w/P. Breiding, M. Michałek, N. Vannieuwenhoven), Appl. Comp. Harm. An., 65, 374–406, 2023, doi:10.1016/j.acha.2023.03.006.
- 7 **Dimension of Tensor Network Varieties**, (w/A. Bernardi, C. De Lazzari), Comm. Cont. Math., 25(10), 2250059, 2023, doi:10.1142/S0219199722500596.
- 8 **Degree-restricted strength decompositions and algebraic branching programs**, (w/P. Ghosal, C. Ikenmeyer, V. Lysikov), FSTTCS 2022 - Leibniz International Proceedings in Informatics (LIPIcs), 250, 20:1-20:15, 2022, doi:10.4230/LIPIcs.FSTTCS.2022.20.
- 9 **The Geometry of Discotopes**, (w/C. Meroni), Le Matematiche 77 (1), 2022, doi:10.4418/2022.77.1.8.
- 10 **Optimization at the boundary of the tensor network variety**, (w/M. Christandl, D. Stilck França, A. Werner), Phys. Rev. B 103 (19), 195139, 2021, doi:10.1103/PhysRevB.103.195139.
- 11 **The Degree of Stiefel Manifolds**, (w/T. Brysiewicz), Enumerative Combinatorics and Applications, vol. 1(3), n. S2R20, 2021.
- 12 **Border rank non-additivity for higher order tensors**, (w/M. Christandl, M. Michałek, J. Zuiddam), SIAM J. Matrix Anal. Appl., 42(2), 503–527, 2021, doi:10.1137/20M1357366.
- 13 **Geometric conditions for strict submultiplicativity of rank and border rank**, (w/E. Ballico, A. Bernardi, E. Ventura, A. Oneto), Ann. Mat. Pura ed Appl. vol. 200, 187–210, (2021), doi:10.1007/s10231-020-00991-6.
- 14 **Towards a Geometric Approach to Strassen’s Asymptotic Rank Conjecture**, (with A. Conner, J. M. Landsberg, E. Ventura, Y. Wang), Collectanea Math. vol. 72, 63–86, (2021), doi:10.1007/s13348-020-00280-8.
- 15 **SARS-CoV-2 transmission routes from genetic data: a Danish case study**, (w/A. Bluhm, M. Christandl, F. R. Klausen, L. Mancinska, V. Steffan, D. Stilck França, A. Werner), PLOS ONE 15 (10), e0241405, 2020, doi:10.1371/journal.pone.0241405.
- 16 **Kronecker powers of tensors and Strassen’s laser method**, (w/A. Conner, J. M. Landsberg, E. Ventura), ITCS 2020, Leibniz International Proceedings in Informatics (LIPIcs), 151, 10:1–10:28 (2020), doi:10.4230/LIPIcs.ITCS.2020.10.
- 17 **Partially symmetric versions of Comon’s problem via simultaneous rank**, (w/A. Oneto, E. Ventura), SIAM J. Matrix Anal. Appl., 40(4), 1453–1477, (2019), doi:10.1137/18M1225422.
- 18 **Explicit polynomial sequences with maximal spaces of partial derivatives and a question of K. Mulmuley**, (w/J. M. Landsberg), Theory of Computing 15(3), 1–24, (2019), doi:10.4086/toc.2019.v015a003.

- 19 **Border rank is not multiplicative under the tensor product**, (w/M. Christandl, A. K. Jensen), SIAM J. Appl. Alg. Geom (SIAGA), Vol. 3 (2), 231–255 (2019), doi:10.1137/18M1174829.
- 20 **On the partially symmetric rank of tensor product of  $W$ -states and other symmetric tensors**, (w/E. Ballico, A. Bernardi, M. Christandl), Rend. Lincei Mat. Appl. 30, 93–124 (2019), doi:10.4171/RLM/837.
- 21 **A note on the cactus rank for Segre-Veronese varieties**, (w/E. Ballico, A. Bernardi), J. Algebra Vol. 526, pp. 6–11 (2019), doi:10.1016/j.jalgebra.2019.01.027.
- 22 **Matrix Product States and the Quantum max-flow/min-cut conjectures**, (w/J. M. Landsberg, M. Walter), J. Math. Phys, Vol. 59 (10), 102205 (2018), doi:10.1063/1.5026985.
- 23 **Geometric Complexity Theory and matrix powering**, (w/C. Ikenmeyer, G. Panova), Diff. Geom. and Appl., Vol. 55, 106–127 (2017), doi:10.1016/j.difgeo.2017.07.001.
- 24 **Geometric Aspects of Iterated Matrix Multiplication**, J. Algebra Vol. 461, pp.42–64, (2016), doi:10.1016/j.jalgebra.2016.04.028.
- 25 **Complexity of linear circuits and geometry**, (w/J. Hauenstein, C. Ikenmeyer, J. M. Landsberg), FOCM, Vol. 16 (3), 599–635, (2016), doi:10.1007/s10208-015-9258-8.
- 26 **An asymptotic bound for secant varieties of Segre varieties**, Ann. Univ. Ferrara, Vol.59 (2), 285–302, (2013), doi:10.1007/s11565-013-0175-y.

## PREPRINTS

- 1 **Bernstein-Gelfand-Gelfand meets geometric complexity theory: resolving the  $2 \times 2$  permanents of a  $2 \times n$  matrix**, (w/A. Huang, H. Schenck, J. Weyman), preprint arXiv:2312.12247, 2023.
- 2 **Collineation varieties of tensors**, (w/H. Keneshlou), preprint arXiv:2312.07982, 2023.
- 3 **Quatroids and Rational Plane Cubics**, (w/T. Brysiewicz, A. Steiner), preprint arXiv:2309.07357, 2023.
- 4 **Characteristic polynomials and eigenvalues of tensors**, (w/F. Galuppi, E. Turatti, L. Venturello), preprint arXiv:2308.10957, 2023.
- 5 **The next gap in the subrank of 3-tensors**, (w/J. Zuiddam), preprint arXiv:2307.06115, 2023.
- 6 **Hilbert Functions of Chopped Ideals**, (w/L. Kayser, S. Telen), preprint arXiv:2307.02560, 2023.
- 7 **Quantum max-flow in the bridge graph**, (w/V. Lysikov, V. Steffan), preprint arXiv:2212.09794, 2022.
- 8 **De-bordering and Geometric Complexity Theory for Waring rank and related models**, (w/P. Dutta, C. Ikenmeyer, G. Jindal, V. Lysikov), preprint arXiv:2211.07055, 2022.
- 9 **Tensors with maximal symmetries**, (w/A. Conner, J. M. Landsberg, E. Ventura), preprint arXiv:1909.09518, 2019.

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## Selected Seminars

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| Dec. 2023  | <b>Geometric methods for lower bounds in complexity theory</b> , <i>IRIT Scientific Day</i> , Toulouse, FR.  |
| Oct. 2023  | <b>Characteristic polynomials of tensors</b> , <i>Nonlinear Algebra Seminar</i> , MPI Leipzig, DE.   |
| July 2023  | <b>A Gap in the Subrank of Tensors</b> , <i>SIAM Conf. Applied Algebraic Geometry (SIAM AG23)</i> , TU Eindhoven, NL.  |
| May 2023   | <b>Rank algorithms, Hilbert functions and non-saturated ideals</b> , <i>Workshop Cactus v. Secants</i> , Toulouse Mathematics Institute.   |
| April 2023 | <b>Tensor subrank and the geometry of small orbits</b> , <i>Seminario di Algebra, Geometria Algebrica e Applicazioni</i> , UniTo-PoliTO, Torino.   |
| March 2023 | <b>Border rank and homogeneous complexity classes</b> , <i>7th Workshop on Algebraic Complexity Theory (WACT 2023)</i> , U. Warwick.   |
| Nov. 2022  | <b>Optimization on Tensor Network Varieties</b> , <i>AGATES Workshop on Tensors in statistics, optimization and machine learning</i> , IMPAN – Warsaw.                                     |
| July 2022  | <b>Lower bounds for algebraic branching programs via intersection theory</b> , <i>Applied Algebraic Geometry Seminar</i> , Dipartimento di Matematica e Informatica Ulisse Dini - Firenze. |
| April 2022 | <b>Tensor subrank and homomorphism duality</b> , <i>Workshop on geometry and complexity theory</i> , Toulouse Mathematics Institute.   |

- Dec. 2021 **Optimization on Tensor Network Varieties**, *Workshop on Optimization Under Symmetry*, Simons Institute - Berkeley.
- Oct. 2021 **Geometry of Tensor Networks**, *Séminaire Calcul Formel*, Université de Limoges.
- Aug. 2021 **Geometry of Direct Sums and Kronecker Powers of Tensors**, *SIAM Conf. Applied Algebraic Geometry (SIAM AG21)*, Texas A&M University - College Station, TX.
- April 2021 **Geometry of Tensor Network Varieties**, *Algebra and Geometry Seminar*, Università degli Studi di Trieste.
- March 2021 **Border rank under direct sum: from Schönhage to tensor networks**, *Quantum Information, Algebra and Geometry Seminar*, Università degli Studi di Trento.
- Dec. 2020 **Varieties of sums of powers, Stiefel manifolds and their degrees**, *Algorithmic Mathematics and Complexity Theory Seminar*, TU Berlin.
- Nov. 2020 **Segre reembedding of secant varieties and multiplicativity of rank and border rank**, *Real Algebraic Geometry Seminar*, University of Konstanz.
- Oct. 2020 **Approaching the boundary of tensor network varieties**, *Geometry Seminar*, Texas A&M University - College Station, TX.
- March 2020 **Border rank and tensor product: geometry and complexity**, *Nonlinear Algebra Seminar Online*, Max Planck Institute for Math. in the Sciences - Leipzig.
- Sept. 2019 **Tensors, Symmetries and Matrix Multiplication**, *Congresso UMI 2019*, Università di Pavia - Italy.
- Jul. 2019 **Rank, border rank, multiplicativity and entanglement**, *SIAM Conf. Applied Algebraic Geometry (SIAM AG19)*, University of Bern - Switzerland.
- Jan. 2019 **Tensors with Symmetries and Matrix Multiplication**, *Workshop on Theoretical Computer Science and Algebraic Geometry*, Max Planck Institute for Informatics - Saarbrücken - Germany.
- Sept. 2018 **Barriers for Geometric Methods in Complexity Theory**, *UMI-SIMAI-PTM Joint Meeting*, Wrocław - Poland.
- July 2018 **SLOCC transformations, tensor restriction and Strassen's asymptotic rank conjecture**, *Quantum Information, Algebra and Geometry Seminar*, Università degli Studi di Trento.
- April 2018 **Cactus rank and multihomogeneous polynomials**, *Geometry Seminar*, Texas A&M University - College Station, TX.
- Feb. 2018 **Multiplicativity of rank and border rank**, *Seminario di Geometria*, Dipartimento di Matematica e Informatica Ulisse Dini - Firenze.
- Sept. 2017 **On multiplicativity of various notions of rank**, *Geometry seminar*, Texas A&M University - College Station, TX.
- Jan. 2017 **Rigidità di matrici e complessità del prodotto matrice-vettore**, *Seminario di Geometria*, Dipartimento di Matematica e Informatica Ulisse Dini - Firenze.
- Geometric Complexity Theory and matrix powering**, TU Berlin.
- July 2016 **Matrix Rigidity and the Complexity of Performing a Linear Map**, *DGA: Differential Geometry and Applications Conference*, Masaryk University - Brno.
- May 2016 **Geometry of Small Matrix Multiplication**, *Workshop on Software and Applications in Numerical A.G.*, University of Notre Dame.
- Nov. 2014 **The Geometry of Iterated Matrix Multiplication**, *Computational Algebraic Geometry Seminar*, UC Berkeley.