Marwan Benyoussef

PhD student at Freie Universität Berlin

Education

2018-2020 **Master of Science in Mathematics, with honours**, *Sorbonne University*, *Paris (with one semester exchange at University of Montreal)*

2018 **Bachelor of Science in Mathematics, with honors**, *Sorbonne University*, Paris, *France*

2007 **Embedded Systems Engineer**, *Ecole des Mines de Saint-Etienne*, Saint-Etienne, *France*

Languages

French Native.

Arabic Native.

English Fluent.

German Beginner, obtained an A_2-level certificate.

Computer skills

Operating Systems: Windows, Unix, Linux, HP, Aix, TPF-IBM, Vmware, virtualBox

Config Management: CVS, Mercurial, Git

Languages: SageMath, GAP, C/Embedded C, C++, Qt, SQL, Latex, PHP, Shell, Perl, Python, Ruby, AngularJS, UML

Tools: Scipy, mathplotlib, scikit-learn, Eclipse, Xemacs, LabView, Valgrind, Gdb

Design: Rational Rose, StarUML, Design Patterns, ISIS, Ares

Continuous Integration : GitLab, Jenkins, hudson, Maven, Ant

Master thesis

title *On the Hitchin morphism in positive characteristic*

supervisor João Pedro P. dos Santos

description My thesis work is an exposition of some results relating the Hitchin fibration in positive characteristic and the theory of connections on vector bundles. The nice functorial properties of the sheaf of principal parts and the relative Frobenius morphism on a smooth projective curve entail categorical and geometric properties of the moduli stack of vector bundles with integrable connections. In particular, the stack of vector bundles with integrable connections is relatively representable, algebraic and of finite type over the affine line. Moreover, one can construct an interpolating object between a Higgs field and a connection, and define a special analogue of p-curvature, for which the characteristic polynomial factors through an affine subspace, and such that the fiber over zero coincides with the Hitchin morphism.

Teaching Experience

My duties range from designing the class content, grading the assignments and exams, choosing the right problems to illustrate the mathematical concepts, to giving background and motivating lectures to the some central topics in algebraic geometry like scheme theory and moduli spaces. Moreover, I am very motivated to guide my students through the process of choosing their preferred future research area. For computer science teaching duties, I am also responsible for teaching my students how to use the software (C, C++, Maple, LaTeX) and how to conceive efficient algorithms and best design paradigms.

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Teaching assistant in Mathematics

Oct 2023 – Present **Algebra I (Graduate Level)**, *Complex Analysis Department*, FU Berlin
Conducting central exercise classes for the Algebra I module, covering concepts such as affine algebraic varieties, rings, ideals and modules, noetherian rings, local rings and localization, primary decomposition, finite and integral extensions, dimension theory, and regular rings.

Oct 2023 – Present **Algebra and Number theory(Undergraduate Level)**, *Mathematics and Computer Science Department*, FU Berlin
Lecturing on topics including divisibility in rings (e.g., ring of integers and polynomial rings), residual classes and congruences, modules and ideals, Euclidean, principal ideal and factorial rings, the square reciprocity law, prime number testing and cryptography, structure of abelian groups, theorem on symmetric functions, field extensions, Galois correspondence, constructions with compass and ruler, non-abelian groups (Lagrange's theorem, normal subgroup, solvability, Sylow groups).

Oct 2022 – Mar 2023 **Algebra and Number Theory Teaching Assistant (Undergraduate Level)**, *Complex Analysis Department*, FU Berlin
Conducted exercise classes covering topics such as divisibility in rings, residual classes, congruences, modules, ideals, Euclidean, principal ideal and factorial rings, square reciprocity law, prime number testing, cryptography, structure of abelian groups, theorem on symmetric functions, field extensions, Galois correspondence, constructions with compass and ruler, non-abelian groups (Lagrange's theorem, normal subgroup, solvability, Sylow groups).

Apr 2022 – Sep 2022 **Geometry Exercise Class (Undergraduate Level)**, *Complex Analysis Department*, FU Berlin
Conducted exercise sessions covering conic sections, transformations in Euclidean and affine geometry, projective geometry, and hyperbolic geometry.

Oct 2021 – Mar 2022 **Algebra III Exercise Class (Graduate Level)**, *Complex Analysis Department*, FU Berlin
Conducted exercise sessions covering Čech cohomology, schemes, cohomology of affine schemes, projective spaces, line bundles on projective spaces, their cohomology, group schemes, and algebraic groups.

Apr 2021 – Sep 2021 **Algebra II Exercise Class (Graduate Level)**, *Complex Analysis Department*, FU Berlin
Conducted exercise sessions covering categories and functors, additive and abelian categories, cohomology, ringed spaces, and sheaf theory.

Oct 2020 – Mar 2021 **Algebra I Exercise Class (Graduate Level)**, *Complex Analysis Department*, FU Berlin
Conducted central exercise class covering affine algebraic varieties, rings, ideals and modules, noetherian rings, local rings and localization, primary decomposition, finite and integral extensions, dimension theory, and regular rings.

Jun 2018 – Jun 2020 **Math Tutor**, *Paris, France*
Provided tutoring for high school students preparing for "Classes préparatoires pour les grandes écoles ", focusing on undergraduate linear algebra and calculus for highly competitive examination entrance to engineering schools.

Teaching assistant in Computer Science, Cybersecurity

Mar 2023 – Sep 2023 **Cybersecurity Exercise Class (Graduate Level)**, *Computer Science Department*, FU Berlin
Conducted exercise class for Cybersecurity module, including the following concepts: authentication mechanisms, security models (Access Control Matrix Model, the Take-Grant Protection Model, the Bell-LaPadula and related models, the Chinese Wall Model, the Lattice Model of Information Flow), capability based systems and hardware protection mechanism concepts (protection rings). The course included also implementation vulnerabilities such as race conditions, stack and heap overflows, integer overflows, and return oriented programming. Problems that arise when humans interface with security e.g., password habits and password entry mechanisms, human responses to security prompts, incentives and distractors for better security, or reverse Turing tests.

Sep 2017 – Mar 2018 **Part-time Lecturer (Undergraduate Level)**, *Mathematics and Computer Science Department*, Paris-Sud University
Taught C++ and Object-Oriented Development and conducted lectures on algorithms and optimization.

(Co-)organized seminars

Undergraduate Seminars

Oct 2022 – Mar 2023 **Proseminar on "Proofs from THE BOOK"**, *Complex Analysis Department*, FU Berlin

Conducted a proseminar on efficient, concise, and beautiful proofs in linear algebra, analysis, number theory, and discrete mathematics, inspired by Paul Erdos "The Proofs from THE BOOK". The goal of the seminar is to bring undergraduate students to the level where can choose among different mathematical subjects a topic to present. I have accompagnied them through the process of choosing the important parts to present and to customize a ninety minutes talk, taking into account time management for the content and answering questions from the audience. During this seminar, I had highly motivated students who gave very diverse and successful talks, including

- Approximation of integrals with tiling recltangles,
- The classical Cantor's diagonal argument about the uncountability of the reals using binary trees for counting the ratioals,
- Subexponentially growing sequence of integers providing infinitely many proofs for the existence of infinitely many prime numbers,
- Buffons needle problem and probability theory to approximate π, proving its irrationality,
- Using non-archimedean valuations to prove Monsky's theorem, stating the impossibility to dissect a square into an odd number of triangles of equal area.

Graduate Seminars

Winter Semester 2022 **Seminar on "Derived categories and the Mukai transform"**, *Complex Analysis Department*, FU Berlin

Homological algebra deals with complexes in abelian categories and their cohomology. This leads, among other things, to the concept of quasi-isomorphism between complexes. It is also observed that homotopic homomorphisms between complexes induce the same homomorphism on the cohomology. The derived abelian category is obtained by forming the homotopy category of complexes in which the morphisms consist of homotopy equivalence classes of homomorphisms of a complex K, and demanding that quasi-isomorphisms become isomorphisms. The last step in particular is technically complex. The derived category of an abelian category is no longer an abelian category. Short exact sequences are replaced by distinguished triangles. This concept is formalized by the concept of a triangulated categories. The known functors from homological algebra can now be elegantly introduced as functors between derived categories. The derived categories are very interesting objects. This is especially true for the derived categories of algebraic varieties, which arise from the abelian categories of coherent sheaves varieties. The seminar covered the basic notions of the theory of triangulated categories and the construction of derived categories. Special attention was paid to the derived categories of algebraic varieties. During this seminar, we covered chapters 1 to 3 from the book by Huybrechts [1]. Highly motivated students gave interesting talks delivering the following content:

- Triangulated categories, exact functors and Serre functors,
- Equivalences of derived categories, exceptional collections, (semi-)orthogonal decompositions,
- Localisation of categories, the derived category of an abelian category,
- Bounded derived categories of an abelian category via injective and projective resolutions,
- Derived functors,
- Spectral sequences,
- The Grothendieck spectral sequence,
- Derived categories in algebraic geometry,
- Derived functors in algebraic geometry.

Research Seminars

Summer Semester 2023 **Seminar on "Groebner bases"**, *Complex Analysis Department*, FU Berlin

- Talk 1: Groebner bases, commutative and non-commutative cases.(notes)
- Talk 2: Hochschield cohomology.(notes)
- Talk 3: Exactness.(notes)

Winter Semester 2023 **Seminar on "On the Hitchin morphism for higher dimensional varieties"**, *Complex Analysis Department*, FU Berlin

The talks delivered the following topics.

- Seminar program,
- Talk 1: Hitchin fibration for algebraic curves(notes).
- Talk 2: Spectral covers (notes)
- Talk 3: Cameral covers(notes).
- Talk 4: Representability Lemma (notes)
- Talk 5: Spectral data morphism and Hitchin map via Weyl polarization (notes),
- Talk 6: Cohen-Macaulay spectral surfaces (notes),
- Talk 7: Some examples and consequences (notes).

Summer Semester 2022 **Seminar on "Bridgeland Stability Conditions"**, *Complex Analysis Department*, FU Berlin

A semiar co-organized with my colleagues Juan Martin Perez Bernal, Cesare Goretti, Jan Marten Sevenster. The talks delivered the following topics.

- Seminar program.
- Talk 1: The motivating example of Num_X.(notes)
- Talk 3: Bridgeland stability conditions.(notes)
- Talk 4: Moduli Spaces.(notes)
- Talk 5: Walls and chambers.(notes)

Winter Semester 2022 **Seminar on "Infinite dimensional GIT"**, *Complex Analysis Department*, FU Berlin

A semiar co-organized with my colleague Juan Martin Perez Bernal, the talks delivered the following topics.

- Seminar program,
- Talk 1: Ind-schemes and affine grassmanians for GL_n(notes).
- Talk 2: Corepresentability ofthe moduli functor of semistable bundles (notes)
- Talk 3: Theta instability theory (notes).
- Talk 5: Classical vs Infinite dimensional GIT (notes)
- Talk 6: Rational filling for torsion-free sheaves (notes),
- Talk 7: Theta stratifications (notes),
- Talk 8: The geometric template (notes).

References

[1] Daniel Huybrechts. *Fourier-Mukai transforms in algebraic geometry*. Clarendon Press, 2006.