

SCGP Workshop

MODERN MUSINGS ON MONOPOLES

October 20–24, 2025

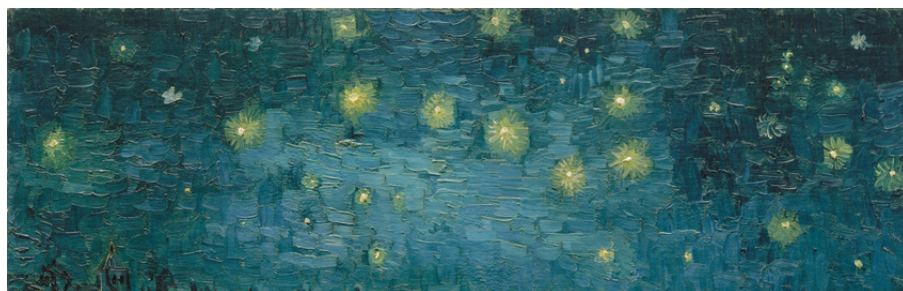


Titles and Abstracts

Special features in our schedule:

- On Monday 20, 1:00 pm, Jacques Hurtubise will deliver a **workshop colloquium** as part of our celebration of the 50th anniversary of magnetic monopoles.
- On Thursday 23, we shall be hosting a special **thematic day** dedicated to Holomorphic Floer Theory (HTF) and its relation to symmetric monopoles, with a sequence of four talks by Szilárd Szábo, Yan Soibelman (two talks) and Andrea Ferrari.
- Our **workshop banquet** will take place on Thursday 23, starting at 6:00 pm, at the SCGP cafeteria.

NB: As unexpected, last-minute circumstances have prevented both Jacques Hurtubise and Yan Soibelman to attend our workshop in person, their contributions will be delivered via Zoom.



HARRY BRADEN (University of Edinburgh, UK)

Monopoles and Curves: a Reverie?

Monday 20, 11:00

It is now over 40 years ago that Hitchin in a seminal paper established the fundamental trichotomy between Euclidean $SU(2)$ BPS monopoles up to gauge equivalence, Nahm data for the interval $[0, 2]$ up to gauge equivalence and spectral curves. I shall survey a number of aspects of this trichotomy relevant to obtaining analytic solutions for the gauge data. Here integrable systems techniques are relevant. I will end with some newer results, open problems and more general musings.

BENOIT CHARBONNEAU (University of Waterloo, Canada)

Constructing Monopoles with Arbitrary Symmetry Breaking

Monday 20, 9:30

For structure group $SU(n)$, with $n > 2$, monopoles offer a rich landscape. I will focus on the part of this landscape where the limit of the Higgs field at infinity has repeated eigenvalues. I will review the work done with Nagy on the Nahm transform, and provide a survey of results for symmetric monopoles we have explored with Dayaprema, Lang, Nagy, and Yu.

SERGEY CHERKIS (University of Arizona, USA)

Dynamics of Far-Separated Monopole Clusters

Monday 20, 14:30

Considering r clusters of $SU(2)$ monopoles we find a spectral description (with one spectral curve for each cluster) that leads to a metric on their moduli space that is “algebraically exact”, meaning it is accurate up to exponentially small terms in cluster separation distance. Moreover, this metric admits a $U(1)^r$ triholomorphic isometry, fulfilling the geometric hypothesis used in Segal and Selby’s work on the Sen conjecture. We also provide the corresponding Nahm-type data and propose an exploded twistor space formulation that patches such metrics for different cluster decompositions.

This is collaboration with Roger Bielawski and Jacques Hurtubise.

PANAGIOTIS DIMAKIS (University of Maryland, College Park, USA)

Asymptotic Geometry at Infinity of Quiver Varieties

Wednesday 22, 11:00

Using an approach developed by Melrose to study the geometry at infinity of the Nakajima metric on the reduced Hilbert scheme of points on $\mathbb{C}^2$, we show that the Nakajima metric on a quiver variety is quasi-asymptotically conical (QAC) whenever its defining parameters satisfy an appropriate genericity assumption. As such, it is of bounded geometry and of maximal volume growth. Combining this with the work of Kottke and Rochon, we compute its reduced L^2 -cohomology and prove the Vafa–Witten conjecture.

This is joint work with Frédéric Rochon.

LINDEN DISNEY-HOGG (University of Leeds, UK)

Symmetry, Integrability and Computation of Hyperbolic Monopole Curves

Tuesday 21, 9:30

The spectral curves of hyperbolic monopoles are a powerful tool to leverage the techniques of algebraic geometry to gain insight. By reviewing the connections to instantons, Euclidean monopoles, and other integrable systems I will describe what is known so far, as well as muse on what is still to come.

This is based on joint work with Harry Braden and Derek Harland.

DANIEL FADEL (University of São Paulo, Brazil)

Energy Concentration and Min-Max Solutions in $SU(2)$ Yang–Mills–Higgs Theory with Arbitrary Positive Coupling Constant

Tuesday 21, 14:30

I will present recent joint work with Da Rong Cheng (Miami) and Luiz Lara (Unicamp) on the $SU(2)$ Yang–Mills–Higgs functional with arbitrary positive coupling constant over oriented Riemannian 3-manifolds. Motivated by Pigati–Stern’s work on the abelian case, we introduce a scaling parameter and study sequences of critical points under natural energy bounds, proving that as the parameter tends to zero, energy concentrates at finitely many points with the remaining energy captured by an L^2 harmonic 1-form. Around each concentration point, finitely many non-trivial “bubbles” arise on $\mathbb{R}^3$, and an energy gap plus a no-neck result guarantee that the total concentrated energy equals the sum of the bubble energies. On closed 3-manifolds, we adapt Pigati–Stern’s min–max construction to the $SU(2)$ setting to produce non-trivial critical points for sufficiently small parameter values, ensuring bubbling on rational homology 3-spheres and thus the existence of non-trivial critical points on $\mathbb{R}^3$. I will conclude with open questions, higher-dimensional extensions, and connections with problems such as the large-mass limit of G_2 -monopoles.

ANDREA FERRARI (DESY, Hamburg, Germany)

Spectral Data for Periodic Monopoles, Berry Connections, and (Generalized) Cohomology Theories

Thursday 23, 16:00 HFT day (4)

One very special instance of HFT is an equivalence between two different kinds of spectral data for (periodic) Cherkis–Kapustin monopoles in three dimensions. These are difference modules, as described in detail by Mochizuki, and vector bundles with filtrations. I will mention how similar monopoles can emerge in physics as Berry connections for 2d $(2, 2)$ theories, and relate elementary aspects of the two kinds of spectral data to novel physical constructions. In the case that a theory flows to a sigma model into some Kähler target X , the data will be closely related to (generalized) cohomology theories for X . More precisely, the difference modules will be related to the quantum equivariant cohomology of X , whereas the vector bundles with filtrations to its equivariant K-theory. This setup will hopefully provide a playground where shadows of Riemann–Hilbert correspondences for generalized periodic monopoles imply interesting geometric results.

LORENZO FOSCOLO (University of Rome I “La Sapienza”, Italy)

Hypertoric Varieties, W -Hilbert Schemes and QALF Hyperkähler Metrics of Dihedral Type

Wednesday 22, 16:00

Motivated by physics, in the late 1990s Sen discussed a construction of complete hyperkähler metrics in (real) dimension 4 and so-called ALF (asymptotically locally flat) asymptotics as a “superposition” of simpler explicit building blocks, namely $\mathbb{Z}_2$ -invariant multi-Taub-NUT metrics and the Atiyah–Hitchin metric. These metrics were then produced by Cherkis–Kapustin and Cherkis–Hitchin, amongst others, via twistor theory and Nahm’s equations. In this talk I will discuss joint work with R. Bielawski about a higher-dimensional version of this story. We study transverse equivariant Hilbert schemes of hypertoric varieties invariant under the action of a Weyl group W . We investigate the conjectural hyperkähler metric on these spaces in terms of twistor theory and Nahm’s equations and discuss the relation of (symplectic quotients of) such Hilbert schemes with the Coulomb branches of 3-dimensional $\mathcal{N} = 4$ supersymmetric gauge theories in theoretical physics.

GUILLERMO GALLEGO (Free University of Berlin, Germany)

Multiplicative Higgs Bundles

Friday 24, 13:00

A result of Charbonneau and Hurtubise states that monopoles on the product of a Riemann surface X and a circle are in natural correspondence with (stable) multiplicative Higgs bundles on X . These are pairs formed by a principal bundle E on X and a meromorphic section of the adjoint group bundle of E . The “pole data” of this section correspond with the “Dirac-type singularities” of the related monopole. The theory of multiplicative Higgs bundles is currently being developed, but there are some recent highlights. In this talk, I will give a review of the state of the art of this theory, including some recent original results on Langlands duality and mirror symmetry, the “real group version” of the theory (in joint work with O. García-Prada), and some currently ongoing work with O. García-Prada and J. Hurtubise.

SAMAN HABIBI ESFAHANI (CMSA, Harvard University, Cambridge, USA)

Fueter Sections and $\mathbb{Z}_2$ -Harmonic 1-Forms

Tuesday 21, 16:00

I will discuss Fueter sections of monopole bundles over 3-manifolds and related compactness problems, which arise in the study of monopoles and calibrated geometry on Calabi–Yau 3-folds and G_2 -manifolds. Taubes suggested that counting Fueter sections of monopole bundles on 3-manifolds could lead to new 3-manifold invariants, while Donaldson and Segal proposed counting them over special Lagrangians to define invariants of Calabi–Yau 3-folds. Similar problems also appear in the study of the space of coassociatives in G_2 geometry. The central question in all of these proposals is whether the space of Fueter sections is compact. We address this question in certain cases, proving and disproving several conjectures in the field and, in particular, answering a question raised by Taubes in 1999. A key observation is that $\mathbb{Z}_2$ -harmonic forms play a crucial role in the problem.

This talk is based on joint work with Yang Li.

AMIHAY HANANY (Imperial College, London, UK)

Symplectic Singularities and Moduli Spaces of Monopoles

Wednesday 22, 14:30

Symplectic singularities appear naturally in supersymmetric gauge theories with 8 supercharges as either Higgs branches or Coulomb branches. Some singularities can be embedded in string theory using brane systems. When this is possible, there is also an interpretation of these symplectic singularities as moduli spaces of monopoles. We will go over several examples, including hyperkähler quotients using simple monopole moduli spaces.

DEREK HARLAND (University of Leeds, UK)

L^2 and Twistor Metrics for Hyperbolic Monopoles

Tuesday 21, 11:00

It is well-known that the L^2 metric on the moduli space of hyperbolic monopoles, defined using a Coulomb gauge fixing condition, diverges. Recently we found a solution to this problem using a supersymmetry-inspired gauge-fixing condition. This talk will review this construction, and compare it with structures introduced by Nash and Bielawski–Schwachhöfer using twistor theory. It will present results of ongoing calculations of these metrics.

This is joint work with Linden Disney-Hogg, Guido Franchetti and Thomas Galvin.

JACQUES HURTUBISE (McGill University, Montreal, Canada)

Workshop Colloquium:	Monopoles... throughout the Ages
----------------------	---

Monday 20, 13:00

I will be giving a review of the work on monopoles since the nineteen eighties, their construction, and their moduli, focussing mostly on monopoles over $\mathbb{R}^3$, but trying to see the various areas of mathematics into which these elusive objects have intruded.

RICHARD MELROSE (MIT, Cambridge, USA)

Configuration Spaces, Generalized Products and Magnetic Monopoles

Monday 20, 16:00

Resolved configuration spaces provide a link between multiparticle systems and their quantized analogues. I will discuss the manner in which this provides effective local models for the moduli spaces of higher charge $SU(2)$ magnetic monopoles on $\mathbb{R}^3$.

This is joint work with Chris Kottke and Michael Singer.

FRÉDÉRIC ROCHON (UQAM, Montreal, Canada)

Geometry at Infinity of Hypertoric Varieties

Wednesday 22, 9:30

After reviewing the notion of hypertoric manifolds, we will explain how those hypertoric manifolds that are simply connected of finite topological type with maximal volume growth are generically quasi-asymptotically conical. In the asymptotically conical case, we will also explain how to describe the geometry at infinity of their Taub–NUT deformations of order 1, yielding in particular many examples with tangent cone at infinity of dimension smaller than the rate of the volume growth at infinity.

YAN SOIBELMAN (Kansas State University, Manhattan, USA)

Holomorphic Floer Theory and Generalized Riemann–Hilbert Correspondence

Thursday 23, 11:00 HFT day (2)

In 2014, together with Maxim Kontsevich, we started the program “Holomorphic Floer Theory” devoted to various questions of Floer theory in the framework of complex symplectic manifolds. As part of that program, we formulated the generalized Riemann–Hilbert correspondence. It connects deformation quantization of a complex symplectic manifold with its Fukaya category. Among other things, our generalized RH-correspondence unifies Riemann–Hilbert correspondences for differential, difference, q -difference and elliptic difference equations. In this talk I am going to review some mathematical aspects of the generalized RH-correspondence.

Holomorphic Floer Theory and Periodic Monopoles

Thursday 23, 14:30 HFT day (3)

Motivated by the generalized Riemann–Hilbert correspondence of Kontsevich and myself, as well as by Simpson’s non-abelian Hodge theory, we developed the generalized non-abelian Hodge theory in terms of the twistor families of categories. In the case of q -difference and elliptic difference equations, the role of harmonic bundles is played by 2-periodic and 3-periodic monopoles. Aim of my talk is to review some ideas ideas behind generalized non-abelian Hodge theory.

SZILÁRD SZABÓ (Eötvös Loránd University, Budapest, Hungary)

Nonabelian Hodge Theory, Riemann–Hilbert Correspondence and Exponential Integrals

Thursday 23, 9:30 HFT day (1)

We start by introducing nonabelian Hodge theory and the Riemann–Hilbert correspondence for smooth compact complex curves. We will explain the modifications that are necessary to generalize these correspondences to noncompact curves (tame case, due to Carlos Simpson). We go on to discuss the topology of the moduli spaces near infinity, and the (partly conjectural) use of exponential integrals in describing the asymptotic behaviour of the correspondences. In rank 2, this description relies on the ‘fiducial solutions’ of Rafe Mazzeo et al. In the same direction in higher rank, we will mention our joint result with Takuro Mochizuki.

GRAEME WILKIN (University of York, UK)

Loop Groups, Brieskorn's Theorem and ALE Spaces

Friday 24, 11:00

Gravitational instantons are classified by the asymptotic behaviour of their metric near the boundary. The asymptotically locally Euclidean (ALE) instantons have a beautiful classification (due to Kronheimer) in terms of affine ADE Dynkin diagrams. In the first part of the talk I will describe partial compactifications of ALE spaces that have the same underlying complex manifold as some of the ALG spaces constructed by Hein for which Chen and Chen have recently given a complete classification. These can also be interpreted as wild nonabelian Hodge spaces constructed by Biquard and Boalch. In the last part of the talk I will describe work in progress to put this in a more general framework and give a gauge-theoretic construction of these spaces in type A using loop groups and Brieskorn's theorem.

This is joint work with Rafe Mazzeo.

XUWEN ZHU (Northeastern University, Boston, USA)

L^2 Cohomology of ALH^* Gravitational Instantons

Friday 24, 9:30

Gravitational instantons are 4-dimensional noncompact Calabi–Yau manifolds with L^2 curvature decay at infinity. ALH^* is one of such types with a warped end structure characterized by the Calabi ansatz. We study the Laplacian and Dirac operators of such metrics using the $\mathfrak{a}$ -pseudodifferential calculus of Grieser and Hunsicker, and use this to determine the space of L^2 harmonic forms explicitly.

This is joint work with Rafe Mazzeo.