Union College Math Conference: Differential Geometry and Geometric Analysis

SEPTEMBER 18–20, 2026

Friday program

4:30–5:30pm: Reception and registration (Olin Rotunda)

5:30–6:30pm: Plenary talk I: Carina Curto: *Network Dominoes: Composable Building Blocks for Recurrent Networks* (Olin 115)

Saturday program

8:00–9:00am: Registration, coffee & light breakfast (Bailey 204)

8:30–10:30am: Session I (ISEC 222)

- 8:30–8:55 Jesse Madnick: *Hyperbolicity and Schwarz Lemmas in Calibrated Geometry*
- 9:00–9:25 Kuan-Hui Lee: *Pluriclosed 3-folds with vanishing Bismut Ricci form*
- 9:30–9:55 Xiangjin Xu: *Heat kernel and Green's function on manifolds with nonnegative Ricci curvature*
- 10:00–10:25 Dawit Mengesha: *Sharp L^2-Michael-Simon-Sobolev inequality via conformal geometry*

10:30–11:00am: Coffee break (Olin Rotunda)

11:00am–12:00pm: Plenary talk II: Kristine Bauer: *The Categorical Derivative in Functor Calculus* (Olin 115)

12:00–1:30pm: Lunch break

1:30–3:30pm: Session II (ISEC 222)

- 1:30–1:55 Tedi Draghici: *On pluricanonical locally conformally almost Kähler metrics*
- 2:00–2:25 Jonathan Delgado: *The Mapping Cone Yang-Mills Functional: A Form-Sensitive Gauge Theory*
- 2:30–2:55 Aghil Alaee Khangha: *A Comparison Theorem For the Mass of ALE and ALF Toric 4-Manifolds*
- 3:00–3:25 Ivo Terek: *Finiteness of Totally Magnetic Hypersurfaces*

3:30–4:00pm: Coffee break (Olin Rotunda)

4:00–5:00pm: Plenary talk III: Julie Blackwood: *Nonlinear Leslie matrix models across scales: from the evolution of bird song to cicada emergence* (Olin 115)

5:00–6:00 pm: Reception (Olin Rotunda)

Sunday program

8:00–8:30am: Coffee & light breakfast (Bailey 204)

8:30–10:30am: Session III (ISEC 222)

- 8:30–8:55 Ralph Gomez: *Berglund-Hübsch Transpose, Rational Homology 7-Spheres and Sasaki-Einstein Geometry*
- 9:00–9:25 Megan Kerr: *Einstein metrics on compact Homogeneous manifolds: Existence and nonexistence*
- 9:30–9:55 Xuanyu Li *Uniqueness and nonuniqueness results of harmonic map flows*
- 10:00–10:25 Ali Maalaoui: *Singular Spinorial Yamabe Problem*

10:30–11:00am: Coffee break (Olin Rotunda)

11:00am–12:00pm: Plenary talk: Lan-Hsuan Huang: *Bartnik's Quasi-Local Mass in General Relativity* (Olin 115)

Abstracts

Lan-Hsuan Huang (University of Connecticut)
Plenary talk: *Bartnik's Quasi-Local Mass in General Relativity*
Einstein's theory of general relativity describes gravity through the geometry of space and time and is one of the greatest achievements of modern science. Yet some fundamental questions remain. How can we measure the gravitational energy contained within a region of space? Can we determine how gravity behaves inside a region by observing its boundary? In this talk, we will discuss Bartnik's proposal of quasi-local mass, which is inspired by the concept of capacity in electrostatics, and explore its properties and its connections with the positive mass theorem.

Aghil Alaee Khangha (Clark University)
A Comparison Theorem For the Mass of ALE and ALF Toric 4-Manifolds
One of the fundamental conjectures in mathematical relativity is the positivity of total mass for complete non-compact Riemannian manifolds assuming appropriate lower bounds on scalar curvature. This conjecture has been proved for AE manifolds using several techniques. There are counterexamples to this conjecture in the ALF and ALE cases. In this talk, we establish sharp lower bounds for the ALE and ALF toric 4-manifolds, in terms of equilibrium geometries consisting of gravitational instantons.

Jonathan Delgado (University of California, Irvine)
The Mapping Cone Yang-Mills Functional: A Form-Sensitive Gauge Theory
We introduce a mapping cone Yang-Mills functional: a functional on the space of mapping

cone connection forms which couple the usual connection forms from gauge theory with any distinguished closed 2-form on a closed manifold (e.g. a Kähler or symplectic form). This functional can be seen as a dimensional reduction of an S^1-invariant Yang-Mills functional in special cases, generalizing the zero potential Yang-Mills-Higgs functional. We study properties of these cone connection forms and cone curvature.

Tedi Draghici (Florida International University)
On pluricanonical locally conformally almost Kähler metrics
This talk is based on joint work with E. Addison and M. Lejmi. We introduce and study pluricanonical locally conformally almost Kähler (LCAK) metrics, extending to the non-integrable case a definition given by Kokarev in the complex case. We give various equivalent characterizations of this notion and obtain several results showing that a pluricanonical LCAK metric satisfying additional conditions must have a parallel Lee form. These generalize known results for pluricanonical LCK metrics.

Ralph Gomez (Swarthmore College)
Berglund-Hübsch Transpose, Rational Homology 7-Spheres and Sasaki-Einstein Geometry
In 2001 Boyer, Galicki and Nakamaye showed the existence of many rational homology 7-spheres admitting Sasaki-Einstein structures via links of isolated hypersurface singularities defined by weighted homogeneous polynomials. Among these examples are so-called "twins" which are pairs of Sasaki-Einstein rational homology 7-spheres with the same order of H_3, degree of the weighted homogeneous polynomial defining the link, and Milnor number. In this talk, we discuss how these twins can arise from the Berglund-Hübsch transpose, which is a tool coming from Berglund-Hübsch-Krawitz mirror symmetry.

Megan Kerr (Wellesley College)
Einstein metrics on compact Homogeneous manifolds: Existence and nonexistence
Given a compact homogeneous space $M \cong G/H$, we ask, when does M admit a G-invariant Einstein metric? Einstein metrics have a variational characterization: they are exactly the critical points of the scalar curvature functional $s(g)$ on unit volume metrics. Using this, we can detect when G-invariant Einstein metrics must exist for global reasons. On a compact homogeneous space G/H, if a simplicial complex $\Delta_{G/H}$ is non-contractible, then G/H admits a G-invariant Einstein metric (Böhm, 2004). However, there are many compact homogeneous spaces with a *contractible* $\Delta_{G/H}$, which nevertheless admit one or more G-invariant Einstein metrics.

We consider the class $\mathcal{N}^c_{0,k}$ of compact homogeneous manifolds G/H such that G is a compact, connected, simple Lie group, (i) $\text{rank}(G) - \text{rank}(H) = 0$, (ii) the simplicial complex $\Delta_{G/H}$ is contractible (so that Einstein metrics are not guaranteed), and (iii) the isotropy representation of G/H has exactly k irreducible summands. One goal is classification of the spaces in examples in $\mathcal{N}^c_{0,k}$, known for $k = 1$ and $k = 2$. We extend this to $k = 3$ and $k = 4$. A further goal is finding more algebraic tools for detecting Einstein metrics for $k > 2$, as we have for $k = 2$.

Kuan-Hui Lee (McGill University)
Pluriclosed 3-folds with vanishing Bismut Ricci form
In this talk, we discuss compact complex 3-dimensional non-Kähler Bismut Ricci flat pluriclosed Hermitian manifolds (BHE) via their dimensional reduction to a special Kähler geometry in complex dimension 2. The reduced geometry satisfies a 6th order non-linear PDE

which has infinite dimensional momentum map interpretation, similar to the much studied Kähler metrics of constant scalar curvature (cscK). We use this to associate to the reduced manifold or orbifold Mabuchi and Calabi functionals, as well as to obtain obstructions for the existence of solutions in terms of the automorphism group, paralleling results by Futaki and Calabi–Lichnerowicz–Matsushima in the cscK case. Through the obstruction theorem, we show that the quotients of $SU(2) \times SU(2)$ or $SU(2) \times \mathbb{R}^3$ as the only non-Kähler BHE 3-folds with 2-dimensional Bott–Chern $(1,1)$-cohomology group, for which the reduced space is a smooth Kähler surface. Lastly, we discuss explicit solutions of the PDE on orthotoric Kähler orbifold surfaces which yield infinitely many non-Kähler BHE structures on $S^3 \times S^3$ and $S^1 \times S^2 \times S^3$.
Joint work with Vestislav Apostolov and Abdellah Lahdili.

Xuanyu Li (Cornell University)
Uniqueness and nonuniqueness results of harmonic map flows
Harmonic map flow is the negative gradient flow of the energy functional on the space of Sobolev maps. As a nonlinear parabolic equation, it may fail to admit a unique solution when the initial data are singular. In this talk, I will survey several results concerning uniqueness and nonuniqueness for harmonic map flow. In particular, I will present my recent result establishing nonuniqueness for a broad class of initial maps.

Ali Maalaoui (Clark University)
Singular Spinorial Yamabe Problem
In this talk I will discuss the existence of singular solutions to the Spinorial Yamabe Problem on the standard n-sphere, $n \geq 3$. The problem is equivalent to solving a critical Dirac equation

$$D_{g_0}\psi = |\psi|^{\frac{2}{n-1}}\psi,$$

on $S^n \setminus \Sigma$, where Σ corresponds to the singular set. I will present the construction of non-standard singular solutions when the singularity is just two antipodal points and when $\Sigma = S^k$ is a great sphere of dimension k. Along the way, I will discuss some properties of these solutions along the singularity. This is a joint work with V. Martino.

Jesse Madnick (Seton Hall University)
Hyperbolicity and Schwarz Lemmas in Calibrated Geometry
In complex geometry, "hyperbolicity" refers to the interplay of three a priori unrelated ideas: (1) strongly negative curvature, (2) the scarcity of holomorphic lines (Brody hyperbolicity), and (3) the non-degeneracy of certain invariant pseudo-distances (Kobayashi hyperbolicity).

In this talk, we generalize all three of these ideas, as well as the theorems that connect them, to arbitrary calibrated manifolds (such as quaternionic-Kahler, G_2, and Spin(7)-manifolds). The key tool is a Schwarz lemma for conformal curves in calibrated manifolds, a generalization of the Ahlfors Schwarz lemma for holomorphic curves.

This is joint work with Kyle Broder (Queensland), Da Rong Cheng (Miami), Anton Iliashenko (BIMSA), and Spiro Karigiannis (Waterloo).

Dawit Mengesha (Pennsylvania State University)
Sharp L^2-Michael-Simon-Sobolev inequality via conformal geometry

We use methods from conformal geometry to show that the best constant in the L^2-Michael-Simon-Sobolev inequality for an n-dimensional minimal submanifold of Euclidean $(m+n)$-space is equal to the sharp constant in the usual L^2-Sobolev inequality on $\mathbb{R}^n$ as computed by Aubin and Talenti. This removes the codimension restriction $m \leq 2$ from a result of Brendle. This is joint work with Jeffrey Case.

Ivo Terek (University of California, Riverside)
Finiteness of Totally Magnetic Hypersurfaces
In a recent work of Filip–Fisher–Lowe it is shown that, in the real-analytic category, a negatively-curved closed Riemannian manifold has only finitely many closed totally geodesic hypersurfaces, unless it is arithmetic hyperbolic. In joint work with James Marshall Reber, we generalize this result to the setting of magnetic systems: a negatively-curved magnetic system on a closed manifold admits only finitely many closed totally magnetic hypersurfaces, unless the magnetic 2-form vanishes and the underlying manifold is arithmetic hyperbolic. Many ingredients used in our proof, such as dynamical versions of the second fundamental form, exponential mapping, and Cartan's axiom of the k-planes, are of independent interest.

Xiangjin Xu (Binghamton University)
Heat kernel and Green's function on manifolds with nonnegative Ricci curvature
In this talk, we discuss sharp Gaussian bound estimates for the heat kernel and large-scale bounds for the Green's function on a complete manifold with nonnegative Ricci curvature.

First part, based on the sharp Li-Yau's Harnack inequality on manifolds with nonnegative Ricci curvature, global two-sided Gaussian bounds for the heat kernel are established, sharpening the well-known Li-Yau two-sided bounds by eliminating the ϵ-loss in the Gaussian term, and optimal gradient and Laplacian estimates for the logarithmic heat kernel are obtained.

Second part, on manifolds with nonnegative Ricci curvature and Euclidean volume growth (EVG), new two-sided pointwise bounds for the heat kernel are obtained in terms of the decay rate of geodesic ball volumes. As applications, the asymptotic behavior of the heat kernel along a path are obtained, improving previous results by Li and Li-Tam-Wang. And, for $n \geq 3$, to confirm a claim by Colding-Minicozzi, explicit two-sided bound estimates on the Green's function on manifolds with nonnegative Ricci curvature and EVG are obtained, formulating by precise functions based on the decay rate of geodesic ball volumes.