Henry Adams, Colorado State University

**Title 1:** An introduction to applied and computational topology

**Abstract 1:** This talk is an introduction to computational topology, as applied to data analysis and to sensor networks. The shape of a dataset often reflects important patterns within. Two such datasets with interesting shapes are a space of 3x3 pixel patches from optical images, which can be well-modeled by a Klein bottle, and the conformation space of the cyclo-octane molecule, which is a Klein bottle glued to a 2-sphere along two circles of singularities. I will introduce topological tools (persistent homology and mapper) for visualizing and understanding high-dimensional datasets. As a second application, I will describe how topology has been applied to coverage problems in sensor networks and mobile sensor networks.

**Title 2:** Metric reconstruction via Vietoris-Rips complexes and optimal transport

**Abstract 2:** Given a metric space $X$ and a distance threshold $r > 0$, the Vietoris-Rips simplicial complex has as its simplices the finite subsets of $X$ of diameter less than $r$. A theorem of Jean-Claude Hausmann states that if $X$ is a Riemannian manifold and $r$ is sufficiently small, then the Vietoris-Rips complex is homotopy equivalent to the original manifold. Janko Latschev proves an analogous theorem when $X$ is a sufficiently dense finite sampling. Little is known about the behavior of Vietoris-Rips complexes for larger values of $r$, even though these complexes arise naturally in applications using persistent homology. We describe how as $r$ increases, the Vietoris-Rips complex of the circle obtains the homotopy types of the circle, the 3-sphere, the 5-sphere, ..., until finally it is contractible (these homotopy types are connected to cyclic polytopes and centrally symmetric polytopes). Furthermore, we discuss how Vietoris-Rips complexes can be used not only to recover homotopy type but also in metric reconstruction.

Augustin Banyaga, Penn State University

**Title:** On $C^0$ rigidity theorems and uniqueness of generators

**Abstract:** We give a new proof of the following result of Seyfادini: If an isotopy $\rho_t$ is a $C^0$ limit of Hamiltonian isotopies, whose Hamiltonians are Cauchy in the Hofer $L^{(1,\infty)}$ metric, then $\rho_t$ is a Hamiltonian isotopy. Our proof is a consequence of a theorem of uniqueness of generators of strong sympleotopies.
David Blair, Michigan State University

Title: Almost Hermitian $g$-natural Metrics on Tangent Bundles
joint work with Handan Yildirim, Istanbul University

Abstract: In this talk I will begin by reviewing the notions of “geometric object” and of being “natural” and then review the geometry of the tangent bundle of a Riemannian manifold. Previous studies of $g$-natural metrics have not considered the role played by the standard almost complex structure on the tangent bundle. The first result with Dr. Yildirim is that if a $g$-natural metric becomes an almost Hermitian metric then it is conformally equivalent to the more familiar Sasaki metric on the tangent bundle with a particular form to the conformal factor. I will then turn to the question of the Bochner flatness of such a $g$-natural metric and we showed that this is equivalent to the metric being conformally equivalent to the Sasaki metric of a flat Riemannian manifold. It is important to note that the Bochner tensor of a general almost Hermitian metric is much more complicated than that of a Kähler manifold and as time permits I will discuss this tensor in detail.

Charles Boyer, University of New Mexico

Title: Obstructions for Extremal Sasaki Metrics

Abstract: Using relative $K$-semistability on the affine cone over a Sasakian manifold, we show how the Lichnerowicz obstruction as used by Gauntlett, Martelli, Sparks, and Yau to obstruct Sasakian-Einstein metrics gives obstructions to extremal Sasakian metrics in the entire Sasakian cone of links of weighted homogeneous hypersurfaces. This is joint work with Craig van Coevering.

Tristan Collins, Harvard University

Title: The $J$-equation on Toric Kähler Manifolds

Abstract: I will discuss the solvability of the $J$-equation, which defines the critical point of Chen-Donaldson's $J$-functional. It is known that there do not exist solutions to the $J$-equation in general. A notion of algebro-geometric stability has been proposed by Lejmi-Székelyhidi which is conjectured to be equivalent to the existence of solutions. I will discuss a proof of this conjecture on toric varieties, and some connections to the deformed Hermitian-Yang-Mills equation, and mirror symmetry. This work is based on joint with G. Székelyhidi, and A. Jacob and S.-T. Yau.

Alix Deruelle, Université Paris-Sud

Title: Expanding Ricci solitons coming out of metric cones

Abstract: We study the regularizing properties of the Ricci flow in a Kähler context. We provide necessary and sufficient conditions for a resolution of a Kähler
cone to admit an asymptotically conical expanding gradient Kähler-Ricci soliton. This is joint work with Ronan Conlon.

**Paul Feehan,** Rutgers University

**Title:** The Lojasiewicz-Simon gradient inequality and applications to energy discreteness and gradient flows in gauge theory

**Abstract:** The Lojasiewicz-Simon gradient inequality is a generalization, due to Leon Simon (1983), to analytic or Morse-Bott functionals on Banach manifolds of the finite-dimensional gradient inequality, due to Stanislaw Lojasiewicz (1963), for analytic functions on Euclidean space. We shall discuss several recent generalizations of the Lojasiewicz-Simon gradient inequality and a selection of their applications, such as global existence and convergence of Yang-Mills gradient flow over four-dimensional manifolds and discreteness of the energy spectrum for harmonic maps from Riemann surfaces into analytic Riemannian manifolds.

**Anna Fino,** University of Torino

**Title:** Algebraic dimension of complex nilmanifolds

**Abstract:** Let \( a(M) \) be the algebraic dimension of a complex manifold \( M \) and \( h(M) \) be the dimension of its space of holomorphic differentials. We show that, If \( M \) is a compact complex nilmanifold, then \( a(M) \leq h(M) \). We use it to determine \( a(M) \) when \( M \) has complex dimension 3 and also mention a relation with the Kähler rank of \( M \). The talk is based on a joint paper with G. Grantcharov and M. Verbitsky.

**David Hurtubise,** Penn State University

**Title:** Twisted Morse homology and Lichnerowicz cohomology

**Abstract:** Let \( \eta \) be a closed 1-form on a finite dimensional smooth manifold \( M \). The Lichnerowicz cohomology of \( M \) is defined by perturbing the differential \( d \) in the deRham cochain complex by \( \eta \), \( d_\eta \xi = d\xi + \eta \wedge \xi \). This perturbation can be viewed as a generalization of the Witten deformation to closed 1-forms. Given a Morse-Smale function \( f \) on a finite dimensional closed smooth Riemannian manifold \( M \), a closed 1-form \( \eta \) can also be used to twist the Morse-Smale-Witten coboundary operator by integrating the form \( \eta \) along the gradient flow lines of \( f \). In this talk I will define \( \eta \)-twisted Morse cohomology and show that it is isomorphic to the Lichnerowicz cohomology. The \( \eta \)-twisted Morse cohomology can be viewed as a special case of a more general theory of Morse homology/cohomology with local coefficients. If time permits, I will give an introduction to the general theory of Morse homology with local coefficients and describe how to prove that it is isomorphic to the singular homology with local coefficients. This is joint work with Augustin Banyaga and Peter Spaeth.
Mehdi Lejmi, CUNY, Bronx College

Title: The Chern-Yamabe problem

Abstract: On an almost-Hermitian manifold, the Chern connection is the unique Hermitian connection with vanishing $J$-invariant part of the torsion and actually coincides in the integrable case with the usual Chern connection. In this talk, we compare the Chern scalar curvature with the Riemannian one. We also study an analog of Yamabe problem by looking for an almost-Hermitian metric with constant Chern scalar curvature in a conformal class extending some results of Angella-Calamai and Spotti to the non-integrable case. This is joint work with Markus Upmeier.

Chi Li, Purdue University

Title: Sasaki-Einstein metrics and normalized volumes

Abstract: I will show that the real valuation associated to the Reeb vector field of a Sasaki-Einstein metric minimizes the normalized volume among all centered valuations. This is a generalization of a result of Martelli-Sparks-Yau. If time permits I will also discuss the application of normalized volumes to the study of metric tangent cones on singular Kahler-Einstein metrics.

Tian-Jun Li, University of Minnesota

Title: The symplectomorphism groups of rational surfaces

Abstract: This talk is on the recent advances about the topology of $\text{Symp}(M,\omega)$, where $\text{Symp}(M,\omega)$ is the symplectomorphism group of a symplectic rational surface $(M,\omega)$. We will illustrate our approach with the 5 point blowup of the projective plane. For an arbitrary symplectic form on this rational surface, we are able to determine the symplectic mapping class group and describe the answer in terms of the Dykin diagram of Lagrangian sphere classes. In this case, we are also able to compute the fundamental group of $\text{Symp}(M,\omega)$ for an open region of the symplectic cone. This is a joint work with Jun Li and Weiwei Wu.

Gideon Maschler, Clark University

Title: Equivariant index, equivariant eta invariant and distinguished metrics

Abstract: For manifold with boundary with an action of a compact Lie group, Donnelly and Goette gave two versions of the equivariant index theorem for $G$-equivariant Dirac operators which are product near the boundary. We extend Goette’s version to a setting where the associated metric and related structures are not product near the boundary. The non-equivariant non-product case was initiated by Gilkey following analytic work of Grubb, and our method could be described as a version of his, bypassing the use of invariance theory. The characteristic and
transgression forms appearing in the formula are computed in the case of the signature complex for the class of SKR metrics on a four-manifold with boundary, which includes many Kahler conformally Einstein metrics. For reducible metrics of this type we obtain a vanishing result for the transgression. This enables one to obtain a formula for the infinitesimal equivariant eta invariant for this complex. This is joint work in progress with Maxim Braverman.

Jose Perea, Michigan State University

Title 1: Topology and learning

Abstract 1: It has been observed recently that in several data science questions and classification tasks, topology-inspired features are highly effective. I will show in this talk how tools from topological data analysis are being translated to the machine learning arena. Application areas include computer vision, computational biology, neuroscience, time series analysis, etc.

Title 2: Projective coordinates for the analysis of data

Abstract 2: Barcodes — the persistent homology of data — have been shown to be effective quantifiers of multi-scale structure. Moreover, the universal coefficient theorem implies that (for a fixed field of coefficients) the barcodes obtained with persistent homology are identical to those obtained with persistent cohomology. Cohomology, on the other hand, is better computationally and allows one to use powerful interpretations such as the Brown representability theorem. We will show in this talk how one can use persistent cohomology to produce maps from data to (real and complex) projective space, and conversely, how to use these projective coordinates to interpret persistent cohomology computations.

Daniel Ruberman, Brandeis University

Title: Gauge-theoretic invariants of non-simply connected 4-manifolds

Abstract: I will survey recent work on using techniques of gauge theory to define invariants of the simplest sorts of non-simply connected manifolds. Older work with Mrowka and Saveliev defined a Seiberg-Witten invariant of a manifold $X$ with the homology of a product of circle and the 3-sphere. I will present a new formula for this invariant from work with Lin and Saveliev when the 3-dimensional homology of $X$ is carried by a rational homology sphere, and some sample applications. I will also describe some recent work with Levine on how to relax this restriction using twisted Heegaard Floer theory.

Song Sun, SUNY, Stony Brook

Title: Geometric flows and algebraic stability
Abstract: We study the asymptotic behavior of certain canonical geometric flows on projective manifolds, and relate it to algebraic stability and optimal degenerations. This leads to a new proof of the Kähler-Einstein result on Fano manifolds via Kähler-Ricci flow. We will also explain potential applications in the existence problem of extremal Kähler metrics on general polarized manifolds via the Calabi flow. Joint work with X. Chen and B. Wang.

Gabor Szekelyhidi, University of Notre Dame

Title: Sasaki-Einstein metrics and K-stability

Abstract: We show that a polarized affine variety admits a Ricci flat Kähler cone metric, if it is K-stable. This generalizes Chen-Donaldson-Sun’s solution of the Yau-Tian-Donaldson conjecture to Kähler cones, or equivalently, Sasakian manifolds. As an application we show that the five-sphere admits infinitely many families of Sasaki-Einstein metrics.

Misha Verbitsky, Moscow Independent University

Title: Teichmuller space of symplectic structures

Abstract: The Teichmuller space of geometric structures of certain type is the quotient of the set of all geometric structures of this type by the group of isotopies (that is, the connected component of the diffeomorphism group). The natural examples are Teichmuller spaces of complex, symplectic, holomorphically symplectic, hyperkahler or holonomy G2 structures; they are all finite-dimensional and often smooth manifolds. I will focus on the Teichmuller space of symplectic structures, which is a smooth, finite-dimensional manifold, and describe it explicitly for hyperkahler manifolds, such as K3 surface and a torus.

Jeff Viaclovsky, University of Wisconsin

Title: Deformation theory of scalar-flat Kahler ALE surfaces

Abstract: I will discuss a Kuranishi-type theorem for deformations of complex structure on ALE Kahler surfaces, which will be used to prove that for any scalar-flat Kahler ALE surface, all small deformations of complex structure also admit scalar-flat Kahler ALE metrics. A local moduli space of scalar-flat Kahler ALE metrics can then be constructed, which is universal up to small diffeomorphisms. I will also discuss a formula for the dimension of the local moduli space in the case of a scalar-flat Kahler ALE surface which deforms to a minimal resolution of an isolated quotient singularity. This is joint work with Jiyuan Han.