The 54th Spring Topology and Dynamics Conference

hosted online by Murray State University
Murray, KY, USA

May 12–15, 2021

Welcome to the 54th Spring Topology and Dynamics Conference, 2nd iteration!

This conference was originally scheduled for March of 2020, but was canceled due to the COVID-19 pandemic, and then rescheduled for May 2021 as a virtual conference. With participants from over 20 countries, we are pleased to see that attendance is just as strong is typical for an in-person conference.

Sadly, a long-time participant in the conference, Włodzimierz J. Charatonik, has recently passed away. The Continuum Theory Special Session will be dedicated to his memory.

The organizers are grateful for support from the following institutions:

- Murray State University
- Jesse Jones College of Science, Engineering and Technology
- Department of Mathematics and Statistics
- National Science Foundation

Murray State University organizers:
Susanne D'Angelo, Dubravko Ivanšić, Ted Porter, Tim Schroeder

Special session organizers:
Continuum Theory: Javier Camargo, Sergio Macías, Patrick Vernon
Dynamical Systems: Lori Alvin
Geometric Group Theory: Kasia Jankiewicz, Rachel Skipper, Daniel Studenmund
Geometric Topology: Molly Moran, Boris Okun
Set-Theoretic Topology: Natasha Dobrinen, Lynne Yengulalp

MURRAY STATE UNIVERSITY

Abstracts

Plenary talk/Semi-Plenary talk/ Topology in Data Science Workshop

Hussam Abobaker
Virginia Polytechnic Institute and State University
Coauthors: W. J. Charatonik

A Survey of the Set Function T

We give a survey of the set function T and present solutions to some open problems.

Henry Adams
Colorado State University

Topology in Data Science

Part one of this workshop will be an introduction to applied topology. I will introduce Čech (nerve) simplicial complexes, Vietoris-Rips (clique) simplicial complexes, persistent homology, the stability theorem, and how these techniques can be used to approximate the shape of a dataset when given only a finite sample. A motivating example is the conformation space of the cyclo-octane molecule, which is a Klein bottle glued to a 2-sphere along two circles of singularity.

In part two of the workshop, I will advertise open questions in applied topology for which tools from geometric group theory, shape theory, quantitative topology, geometric topology, and equivariant topology are relevant. If a point cloud is sampled from a manifold, then as more samples are drawn, the persistent homology of the Vietoris-Rips complex of the point cloud converges to the persistent homology of the Vietoris-Rips complex of the manifold. But what are the homotopy types of Vietoris-Rips complexes of manifolds? Essentially nothing is known, except that as the scale parameter increases, the Vietoris-Rips complex of the circle obtains the homotopy types of the circle, the 3-sphere, the 5-sphere, the 7-sphere, ..., until finally it is contractible. I will survey emerging connections between Vietoris-Rips complexes of manifolds and the filling radius (which Gromov used to prove the systolic inequality in 1983), Borsuk-Ulam theorems, Bestvina-Brady Morse theory, and thick-thin decompositions.

Ana Anušić
University of Sao Paulo

On the Nadler-Quinn problem

We say that a point x of a planar continuum X is accessible (from the complement) if there exists an arc A in the plane which intersects X only in x. It is well-known that every chainable continuum can be embedded in the plane, but it is still unclear to what extent we can manipulate the set of accessible points. This question dates back to 1972, when Nadler and Quinn asked whether for every chainable continuum X and $x \in X$ there exists an embedding of X in the plane so that x is accessible. In 2001, Piotr Minc suggested an example of a chainable continuum which was believed to be a strong candidate for a counterexample to the Nadler-Quinn question. We will show that for every point x of Minc's continuum X_M there is a planar embedding of X_M which makes x is accessible. Furthermore, we will show that the result generalizes to a (large) class of chainable continua of the form $\varprojlim(I, f)$, where $f\colon I \to I$ is piecewise monotone, post-critically finite, and locally eventually onto.

Lei Chen
Caltech
Coauthors: Kathryn Mann

Actions of diffeomorphism groups on 1-manifolds

In this talk, I will explain a proof of a conjecture of Matsumoto that any nontrivial actions of the diffeomorphism group of a manifold M on 1-manifold is always natural. This means that M is 1-dimensional and the action is induced by embeddings. I will explain the basic idea of the proof.

Steven Clontz
University of South Alabama

Limited information strategies for infinite-length games

Several ideas from topology and set theory may be characterized by considering two-player infinite-length games. During each round $n \in \omega = \{0, 1, 2, \dots\}$, suppose Player 1 makes a move a_n (perhaps choosing an open cover of a given regular space), followed by Player 2 making a move b_n (perhaps choosing a finite subcollection from 1's chosen cover); the winner of such a game is determined by the sequence of moves $a_0, b_0, a_1, b_1, \dots$ (perhaps Player 2 wins if their choices form a cover).

The topological game specified above is known as Menger's game, and Player 2 has an unbeatable strategy that only uses information limited to the round number and the most recent move of Player 1 in this game if and only if the given regular space is σ-compact. In this talk, we will explore various results of this flavor found in the literature, including an interesting game-theoretic proof appropriate for undergraduates that the real numbers are uncountable.

Carina Curto
Pennsylvania State University

Graphs, network motifs, and threshold-linear algebra in the brain

Threshold-linear networks (TLNs) are commonly-used rate models for modeling neural networks in the brain. Although the nonlinearity is quite simple, it leads to rich dynamics that can capture a variety of phenomena observed in neural activity: persistent activity, multistability, sequences, oscillations, etc. Here we study competitive threshold-linear networks, which exhibit both static and dynamic attractors. These networks have corresponding hyperplane arrangements whose oriented matroids encode important features of the dynamics. We will show how the graph associated to such a network yields constraints on the set of (stable and unstable) fixed points, and how these constraints affect the dynamics. In the special case of combinatorial threshold-linear networks (CTLNs), we find an even stronger set of "graph rules" that allow us to predict emergent sequences and to engineer networks with prescribed dynamic attractors.

Spencer Dowdall
Vanderbilt University
Coauthors: Matthew Durham, Christopher Leininger, and Alessandro Sisto

Geometric finiteness and Veech group extensions of surfaces groups

The notion of convex cocompactness and its generalization geometric finiteness play an important role the classical theory of Kleinian groups, that is, discrete subgroups of isometries of hyperbolic space. By means of analogy, in 2002 Farb and Mosher defined a subgroup of the mapping class group of a closed surface to be convex cocompact if it acts cocompactly on a quasi-convex subset of Teichmuller space. These subgroups have received much attention and it is known that they are precisely the subgroups whose corresponding surface group extensions are Gromov hyperbolic. However, it remains unclear precisely how geometric finiteness should manifest in mapping class groups nor how it should relate to the geometry of surface group extensions. This talk will look at perhaps the most compelling candidates for geometric finiteness in mapping class groups, namely

Veech subgroups. I will explain the structure of Veech groups and show that their corresponding surface group extensions exhibit strong aspects of negative curvature and in fact are hierarchically hyperbolic.

Andrew Dykstra
Hamilton College
Coauthors: Nic Ormes and Ronnie Pavlov

Complexity in symbolic dynamical systems

Given a symbolic dynamical system X, the word-complexity function, $c_X(n)$, counts the number of words of length n that occur in X. Keeping track of how quickly the word-complexity function grows as $n \to \infty$ is useful for distinguishing between systems. For example, the topological entropy of X is the exponential growth rate of $c_X(n)$. In this talk, we will focus on systems with zero topological entropy, where $c_X(n)$ is at most linear. We will see how the linear growth rate of $c_X(n)$ restricts the number and types of subsystems that can occur within X. In addition to looking at examples, we will discuss recent results in this area.

Vera Fischer
University of Vienna, Kurt Gödel Research Center

Spectra and definability

In this talk, we will consider two aspects in the study of extremal sets of reals, sets like maximal families of eventually different functions, maximal cofinitary groups, or maximal independent families. On one side, we will discuss their spectrum, defined as the set of cardinalities of such families and on the other, the existence of witnesses of optimal projective complexity. We will emphasize recent developments in the area and indicate interesting remaining open questions.

Craig Guilbault
University of Wisconsin-Milwaukee
Coauthors: Burns Healy and Brian Pietsch

$(E)\,\mathcal{Z}$-structures for groups of the form $G \rtimes \mathbb{Z}$

Bestvina introduced the notion of a *$\mathcal{Z}$-structure* on a group G to provide an axiomatic treatment of group boundaries that simultaneously generalizes visual boundaries of CAT(0) groups and Gromov boundaries of hyperbolic groups. The definition requires G to act geometrically (properly, cocompactly, by isometries) on a "nice" space X and for that space to admit a nice compactification $\overline{X}$ (a *$\mathcal{Z}$-compactification*). In addition, one requires that translates of compact subsets of X get small in $\overline{X}$. An equivariant version of this definition—an *$E\mathcal{Z}$-structure*—was introduced by Farrell and Lafont and used to prove the Novikov conjecture for various groups. Many non-CAT(0) and non-hyperbolic groups have been shown to admit $(E)\,\mathcal{Z}$-structures, but the general question of which groups admit these structures remains open.

In his 2018 dissertation, Brian Pietsch showed that, if a torsion-free group G admits a $\mathcal{Z}$-structure, then so does every semidirect product $G \rtimes \mathbb{Z}$. Since then, Burns Healy and I have been working on (among other things) extending those $\mathcal{Z}$-structures to $E\mathcal{Z}$-structures whenever possible. In this talk, I will discuss our progress on that project, along with some interesting examples and applications.

James Hyde
Cornell

Finitely generated simple groups of orientation preserving homeomorphisms of the real line

We will give examples of finitely generated simple groups of orientation preserving homeomorphisms of the real line. We will discuss the other interesting properties some of these examples have. For example, several examples are uniformly simple, some act by homeomorphisms on the circle and some have the property that every element has fixed points.

Olga Kharlampovich
CUNY Graduate Center and Hunter College

Countable elementary free groups

We call a group elementary free if it has the same first-order theory as a finitely generated non-abelian free group. Finitely generated elementary free groups groups were described by Kharlampovich-Myasnikov and Sela. In this talk we discuss countable elementary free groups.

Christopher Leininger
Rice University
Coauthors: Moon Duchin, Viveka Erlandsson, and Chandrika Sadanand

Billiards, symbolic coding, and cone metrics

Given a polygon in the Euclidean plane, a billiard trajectory in the polygon is the geodesic path of a particle in the polygon bouncing off the sides so that the angle of reflection is equal to the angle incidence. A billiard trajectory determines a symbolic coding via the sides of the polygon encountered. A natural question asks the extent to which the set of all coding sequences, the "bounce spectrum", determines the shape of a Euclidean polygon. In joint work with Duchin, Erlandsson, and Sadanand, we have shown that one can completely characterize those polygons which are billiard rigid (the generic case), meaning that they are determined up to isometry by their bounce spectrum. When rigidity fails for a polygon P, we also describe the space of polygons having the same bounce spectrum at P. These results for billiards are a consequence of a rigidity/flexibility theorem for certain types of cone metrics on surfaces. In the talk I will explain the relationship with cone metrics, state our rigidity/flexibility theorem for such metrics, and as time allows describe some of the ideas involved in the proofs.

Ronnie Pavlov
University of Denver
Coauthors: Kevin McGoff

Entropies of intermediate factors

I will present recent work (joint with Kevin McGoff) on entropies of intermediate factors of dynamical systems on countable amenable groups; given a factor ϕ from $\mathbf{X}$ to $\mathbf{Y}$, we say $\mathbf{Z}$ is an **intermediate factor** if ϕ can be decomposed into factors from $\mathbf{X}$ to $\mathbf{Z}$ and $\mathbf{Z}$ to $\mathbf{Y}$.

We proved that for every countable amenable group G and every factor between G-subshifts $\mathbf{X}$ and $\mathbf{X}$, there exists a set of intermediate G-subshift factors with entropies dense in the interval $[h(\mathbf{Y}), h(\mathbf{X})]$. We use the same techniques to show that if $\mathbf{X}$ and $\mathbf{Y}$ are instead assumed to be zero-dimensional G-systems, then there exists a set of intermediate zero-dimensional factors achieving every entropy in the interval $[h(Y), h(X)]$.

We will give definitions of all relevant concepts, and also describe relations of our results to work by Shub-Weiss, Lindenstrauss, and others on the so-called 'lowerability of entropy' question.

Columba Pérez
Instituto de Matemáticas, UNAM, Mexico
Coauthors: Chris Good

On Countable Dynamical Systems

(X, f) is called a *countable dynamical system* if X is a countable compact Hausdorff space and $f : X \to X$ a continuous function. Countable dynamical systems appear naturally in different situations, e.g. as subsystems of onto interval maps. Interestingly, most of the dynamical properties of this type of systems rely on the scattered nature of their phase space. In this talk we will look at concepts such as expansivity, transitivity and shadowing in the context of countable dynamical systems, mentioning both old and new results on them.

Michel Smith
Auburn University

On the Prevalence of Hereditarily Indecomposable Continua

We engage in an excursion into hereditarily indecomposable continua. Some of their fascinating properties are reviewed and some highlights are considered in detail. We will discuss some of the major tools used to analyze their behaviours. Beginning with metric continua we will continue into the exploration of non-metric hereditarily indecomposable continua and end with our own personal journey on the boundary between metric and non-metric spaces.

Iian Smythe
University of Michigan

Equivalence of generic reals

We will discuss how the method of forcing, originally developed to prove independence results in set theory, can be used to construct a family of countable Borel equivalence relations on "generic" sets of reals, each corresponding to a different notion of forcing. In the case of Cohen forcing, which involves a topological notion of genericity, we will show that the resulting equivalence relation is of relatively low complexity within the hierarchy of countable Borel equivalence relations. In the case of random forcing, where the notion of genericity is measure-theoretic, the resulting equivalence relation is comparatively complex. These results and the methods used to prove them are closely related to well-known open questions concerning the complexity of unions of hyperfinite equivalence relations and of Turing equivalence.

Jing Tao
University of Oklahoma
Coauthors: Camille Horbez

Classification of surface homeomorphisms

In the 1970s, Thurston generalized the classical classification of self-maps of the torus to surfaces of higher genus. This is known as the Thurston classification of surface homeomorphisms. Since Thurston's work, many alternative proofs have been given. Perhaps the most famous is due to Bers, who rephrased the classification in terms of an extremal problem on complex structures on surfaces. In joint work with Camille Horbez, we revisit Bers' approach but from the point of view of hyperbolic geometry. This gives a new proof of the Thurston classification as well as new structural results on pseudo-Anosov homeomorphisms.

Continuum Theory

Dedicated to the memory of Włodzimierz J. Charatonik (1957–2021)

Maria Elena Aguilera, Alejandro Illanes, Paweł Krupski, Verónica Martínez de la Vega Robert Roe, Sahika Sahan

Remembering Włodek

A warm remembrance of the life and work of Włodzimierz J. Charatonik (1957–2021).

Gerardo Acosta
Instituto de Matemáticas, UNAM, Mexico
Coauthors: David Fernández-Bretón

Equicontinuous Mappings on Finites Trees

If X is a finite tree and $f\colon X \to X$ is a map, we present eight conditions each of which is equivalent to the fact that f is equicontinuous. To name some of such conditions, the equiconuity of f is equivalent to the fact that for some nonprincipal ultrafilter u, the function $f^u\colon X \to X$ is continuous (in other words, failure of equicontinuity of f if equivalent to the failure of of continuity of every element of the Ellis remainder of f.). One of the tools used in the proofs is the Ramsey-theoretic result known as Hindman's theorem.

Jan Boronski
AGH University of Science and Technology
Coauthors: Sonja Štimac

Densely branching trees as models for Hénon-like and Lozi-like attractors

Inspired by a recent work of Crovisier and Pujals on strongly dissipative diffeomorphisms of the plane, we show that Hénon-like and Lozi-like maps on their strange attractors are conjugate to natural extensions (a.k.a. shift homeomorphisms on inverse limits) of maps on metric trees with dense set of branch points. In consequence, these trees very well approximate the topology of the attractors, whereas the maps on them give good models of the dynamics. To the best of our knowledge, these are the first examples of canonical two-parameter families of attractors in the plane for which one is guaranteed such a 1-dimensional locally connected model tying together topology and dynamics of these attractors. For Hénon maps this applies to Benedicks-Carleson positive Lebesgue measure parameter set, and sheds more light onto the result of Barge from 1987, who showed that there exist parameter values for which Hénon maps on their attractors are not natural extensions of any maps on branched 1-manifolds. For Lozi maps the result applies to an open set of parameters given by Misiurewicz in 1980. Our results can be seen as a generalization to the non-uniformly hyperbolic world of a classical result of Williams from 1967.

Félix Capulín
Universidad Autónoma del Estado de México
Coauthors: David Maya, Leonardo Juárez and Enrique Castañeda

Pseudo-contractibility on G-growth hyperspaces

We introduce a new class of hyperspaces of a continuum, namely the g-growth hyperspaces, which are a generalization of growth hyperspaces. We give some basic properties of them. On the other hand, we know that pseudo-contractibility is a generalization of contractibility. A general problem is to determine classes of topological spaces where both concepts are equivalent. In particular, we prove that every pseudo-contractible g-growth hyperspace is contractible.

Jernej Činč
University of Vienna and IT4Innovations Ostrava
Coauthors: Piotr Oprocha

Pseudo-arc in measurable Dynamical Systems

There are results indicating that pseudo-arc appears as a generic continuum in very general settings. For instance, Bing has proven that in any manifold M of dimension at least 2, the set of subcontinua homeomorphic to the pseudo-arc is a dense residual subset of the set of all subcontinua of M (equipped with the Vietoris topology). In this talk I will present a result which reveals that pseudo-arc appears as a generic object also in a measure theoretical setting; namely, I will show that the inverse limit of the generic Lebesgue measure preserving interval map is the pseudo-arc. If time permits, I will mention consequences and several applications of this result.

Tavish Dunn
Baylor University
Coauthors: David Ryden

Generalized Inverse Limits and the Intermediate Value Property

We examine two versions of the Intermediate Value Property applicable to upper semicontinuous set-valued functions $f : [0, 1] \to 2^{[0,1]}$. We use the weaker version to provide sufficient conditions such that the corresponding inverse limit spaces are connected. We use the stronger version of the Intermediate Value Property to examine the relationship between the existence of indecomposable subcontinua of these inverse limits with a single bonding map and the existence of periodic cycles of the bonding map with period not a power of 2, by way of ensuring the Full Projection Property holds.

Sina Greenwood
University of Auckland
Coauthors: Gareth Davies, Michael Lockyer, Yuki Maehara

Inverse limits of upper semicontinuous functions and indecomposable continua

We consider how inverse limits and Mahavier-products of upper semicontinuous functions relate to their bonding functions with respect to indecomposability and connectedness. We show that if such an inverse limit is decomposable then for some n, the Mahavier product of its first n bonding functions is decomposable. It is known that if the graphs of bonding functions of a Mahavier-product or inverse limit are pseudoarcs then it is disconnected. A natural question arising is: is the Mahavier-product whose bonding functions are indecomposable connected? We present and example of a connected Mahavier-product whose bonding functions have indecomposable graphs. We also show that the full projection property is not a necessary condition for an indecomposable inverse limit.

Rodrigo Hernández-Gutiérrez
Universidad Autónoma Metropolitana, Iztapalapa
Coauthors: Logan Hoehn

Almost rigid smooth fans

Recently, Logan Hoehn and Yaziel Pacheco-Juárez have given characterizations of some dendroids in terms of their homogeneity degree. We will restrict our attention to the class of smooth fans. On the opposite side of the homogeneity spectrum lie the so-called rigid spaces. While it can be easily proved that a smooth fan is never rigid, it might be interesting to investigate whether there are smooth fans with properties close to rigidity. We define a smooth fan X to be almost rigid if every homeomorphism $h\colon X \to X$ is the identity when restricted to the set of endpoints $E(X)$. In this talk we discuss some examples of almost rigid fans.

Logan C Hoehn
Nipissing University
Coauthors: Lex G. Oversteegen

Folding maps on graphs and hereditarily indecomposable continua

As part of our 2016 work on homogeneous plane continua, Lex Oversteegen and I gave a new characterization of hereditarily indecomposable continua in terms of mappings to graphs. The result is: A continuum X is hereditarily indecomposable if and only if for any graphs G and F, for any map $g : X \to G$, for any "folding map" $\varphi : F \to G$, and for any $\varepsilon > 0$, there exists a map $f : X \to F$ such that $d(g, \varphi \circ f) < \varepsilon$. In this talk, I will discuss this result and explain the notion of a folding map, and I will pose some questions towards possible generalizations.

Alejandro Illanes
Universidad Nacional Autonóma de México
Coauthors: Verónica Martínez de la Vega and Daria Michalik

Continua with unique cone

A continuum X is said to have unique cone provided that the following implication holds: if Y is a continuum and cone(X) is homeomorphic to cone(Y), then X is homeomorphic to Y. In this talk we present some characterizations of continua having unique cone. Particularly, we consider the following families of continua:

(a) locally connected curves,
(b) indecomposable continua such that their non-degenerate proper sub continua are areas, and
(c) fans.

Matt Insall
Missouri S&T
Coauthors: Peter Loeb

The Fixed Point Property for Some Planar Continua

We provide new arguments for some fixed point theorems related to the Plane Fixed Point Problem.

Wayne Lewis
Texas Tech University

100+ Years of Indecomposable Continua

Last year was the 100th anniversary of the introduction of the concept of indecomposable continua. A few examples were presented earlier. We give some background and history, while also discussing some open questions.

David Lipham
Auburn University at Montgomery

Endpoints of Julia sets

Julia sets of exponential functions such as $f(z) = \exp(z) - 1$ are Lelek fans, and their endpoint sets are homeomorphic to the irrational Hilbert space. In this talk we show that f generates a copy of the *rational* Hilbert space $\mathfrak{E} = \{x \in \ell^2 : x_n \in \mathbb{Q} \text{ for all } n < \omega\}$. Namely, the set of all endpoints whose orbits tend to infinity in the imaginary direction is homeomorphic to $\mathfrak{E}$. We use the escaping endpoint set to prove that $\mathfrak{E}$ is not stable under multiplication by all of its $F_{\sigma\delta}$-subspaces. This property distinguishes $\mathfrak{E}$ from its zero-dimensional counterpart $\mathbb{Q}^\omega$. We also determine the topological type of the set of non-escaping endpoints.

Michael Lockyer
Auckland University of Technology
Coauthors: Sina Greenwood

Path-connected inverse limits of set-valued functions on intervals

In this talk we investigate necessary and sufficient conditions for the inverse limit of set valued functions on intervals to be path connected. In particular, we present the notion of a path-component base and show that if $\mathbf{f}$ admits a path-component base then $\varprojlim \mathbf{f}$ is not path connected, and we also provide a characterisation of path connected Mahavier products.

Rosario A. López
Institute of Mathematics, National University of Mexico
Coauthors: Sergio Macías

On Weakly Continuum-Chainable Continua

A continuum is a compact connected metric space. In this talk, we present two new classes of continua, *semiweakly continuum-chainable continua* and *weakly continuum-chainable continua*, which are generalizations of continuum-chainable continua. We present properties of these new classes of continua.

Emanuel R Márquez
Facultad de Ciencias, UNAM

The pseudoarc does not admit nontrivial pseudomeans

Let X be a continuum. A *pseudomean* for X is a continuous retraction $r : X \times X \to \Delta X$ where ΔX is the diagonal. Note that we can defined two trivial pseudomeans the first assings to each ordered pair (x, y) the pair (x, x) and the second the pair (y, y). In a paper of 2007 Lysko [1] asked the following:

Assume that P is the pseudoarc and $r : P \times P \to \Delta P$ is a pseudomean for P. Must r be of the form $r(x, y) = (x, x)$ for all (x, y), or $r(x, y) = (y, y)$ for all (x, y)?

As part of my doctoral research we answered this question affirmatively. In this talk I will give a brief sketch of the proof.

[1] Question p.88 in *Maps of products of continua.* Continuum theory: in honor of Professor David P. Bellamy on the ocassion of his 60th birthday, 85–89, Aportaciones Mat. Investig., 19, Soc. Mat. Mexicana, México, 2007.

Verónica Martínez de la Vega
Instituto de Matemáticas, UNAM
Coauthors: A. Illanes, D. Darji, J. Martínez-Montejano

Topological Mixing and UPE

In this talk we study relationships between topological mixing and uniform positive entropy (UPE). For a compact metric space X with an open subset homeomorphic to the interval $(0, 1)$ and a mapping $f : X \to X$, we show that the property of f being weakly mixing is equivalent to f having the m-UPE property. We show the same when X is a dendrite and f is an open mapping.

David Maya
Universidad Autónoma del Estado de México

Noncut subsets of the hyperspace of subcontinua

Coauthors: Javier Camargo and Patricia Pellicer-Covarrubias

Let $C(X)$ be the hyperspace of all subcontinua of a continuum X topologized by the Hausdorff metric. For a nonempty closed subset A of a continuum X, consider the following properties: A is subset of colocal connectedness, strong noncut subset, weak nonblock subset, shore subset, not strong center and noncut subset of X. In this talk, we present the relation between a one-point subset $\{p\}$ of X having one of these properties in X and maximal order arcs α from $\{p\}$ having the same property in $C(X)$.

Daria Michalik
Jan Kochanowski University in Kielce, Poland

On representation spaces — some new results

Coauthors: W. J. Charatonik, M. Insall

In 2009, J. G. Anaya-Ortega, F. Capulín-Perez, E. Castañeda-Alvarado, W. J. Charatonik, and F. Orozco-Zitli introduced the idea of representation space, i.e. the space of continua with the topology generated by some natural closure operator. During my talk I will present some new results concerning this space.

Ulises Morales-Fuentes
(no affiliation)

Rectangles inscribed in plane continua

Coauthors: Cristina Villanueva-Segovia

A plane continuum X is said to admit an inscribed rectangle if for every embedding $\gamma : X \to \mathbb{R}^2$, all vertices of at least one Euclidean rectangle lie on $\gamma(X)$. In this talk we characterize locally connected plane continua that admit an inscribed rectangle whose aspect ratio has not been prescribed. More precisely, we prove that if a plane continuum X contains a copy of the capital letter H continuum, the simple 4-od, or S^1, then X admits an inscribed rectangle. We prove, as well, that the only locally connected plane continua that do not admit an inscribed rectangle are the arc and the simple 3-od.

Patricia Pellicer-Covarrubias
UNAM

Path connectedness of the hyperspace of nontrivial convergent sequences

Coauthors: J. Camargo, D. Maya

The hyperspace of nontrivial convergent sequences was defined in 2015 by S. Garcia-Ferreira and Y.F. Ortiz-Castillo. In this talk we discuss some aspects related to the path connectedness of such hyperspace.

Erick I. Rodríguez-Castro
Instituto de Matemáticas, UNAM, México

Differences and similarities between some hyperspaces

Coauthors: Alejandro Illanes

Given a positive integer n and X a metric continuum, let $C_n(X)$ denote the hyperspace of closed subsets of X with at most n components and let $F_n(C(X))$ the hyperspace of subsets of $C(X)$ with at most n elements. In this talk we discuss some differences and similarities between these hyperspaces.

David Ryden
Baylor University
Coauthors: Tavish Dunn

A Hereditarily Decomposable Generalized Inverse Limit from a Function on [0,1] with Cycles of All Periods

A result of Barge and Martin states that, for a continuous function $f : [0, 1] \to [0, 1]$, the presence of a periodic orbit whose period is not a power of two guarantees the existence of an indecomposable subcontinuum in the inverse limit of f. In this talk we consider the following question: Does this connection between periodicity and indecomposability hold for an upper semicontinuous function $f : [0, 1] \to 2^{[0,1]}$ with the intermediate value property? We show this is not true in general by constructing a function with periodic cycles of all periods for which the inverse limit is an hereditarily decomposable tree-like continuum.

Scott Varagona
University of Montevallo

Inverse Limits with Smith Functions

We call an upper semi-continuous function $f : [0, 1] \to 2^{[0,1]}$ a *Smith function* if f is surjective, the graph of f is connected, and the graph of f is the union of finitely many vertical and horizontal line segments. We will investigate inverse limits with a single bonding function f, where f is a Smith function. The connectedness, dimension, decomposability, etc., of such inverse limits will be considered. We will also show how to construct an indecomposable continuum using an inverse limit with a single idempotent Smith function.

Jorge E. Vega
Instituto de matemáticas, UNAM
Coauthors: Verónica Martínez de la Vega and Jorge M. Martínez-Montejano

The hyperspace of non-cut subcontinua, $NC^*(X)$

Given a continuum X, let $C(X)$ denote the hyperspace of all subcontinua of X. For $A \in C(X)$, we say that A is a non-cut set of X if $X \setminus A$ is connected. We define $NC^*(X) = \{A \in C(X) : A \text{ non-cut set of } X\}$. In this talk we present the relationships between $NC^*(X)$ and X when X is a finite graph or a dendrite. Also, we present under which conditions $NC^*(X)$ is compact, connected, locally connected, among others.

Dynamical Systems

Sourav Bhattacharya
University of Alabama at Birmingham
Coauthors: Alexander Blokh

Monotonicity of the Over-rotation Intervals for Bimodal maps

We show that the set of *parameters* for which the *over-rotation interval* of a bimodal interval map is constant is a *connected set*. In other words, the *over-rotation interval* is a *monotone function* of a bimodal interval map.

Alexander Blokh
UAB
Coauthors: Lex Oversteegen, Vladlen Timorin

A model of the cubic connectedness locus

We construct a model of the cubic connectedness locus.

Van Cyr
Bucknell University
Coauthors: Bryna Kra

Invariant measures for Language Stable Subshifts

Given a subshift, a natural question is whether there exists a Borel probability measure, supported on the shift, that is invariant under every element of its automorphism group. Such measures were recently named characteristic measures by Frisch and Tamuz. It is an open question whether all subshifts have characteristic measures. In this talk, I will discuss recent joint work with B. Kra in which we define a new class of shifts, the language stable subshifts, that can be shown to have characteristic measures and are generic in the set of all subshifts.

Jernej Činč
University of Vienna and IT4Innovations Ostrava
Coauthors: Ana Anušić

Towards the understanding of inhomogeneities in strange attractors

Brown-Barge-Martin embeddings of inverse limits provide a natural way to construct curious examples of strange attractors of homeomorphisms on manifolds of dimension at least two through the inverse limit technique. In the recent years we were building towards the better understanding of inhomogeneities of such strange attractors. In this talk I will review the part of the work that was done on inverse limits of one-dimensional manifolds. Namely, I will show that in such a setting we have complete understanding of basic types of inhomogeneities (i.e. folding points and endpoints) through the dynamics of bonding maps when these are piecewise monotone and locally eventually onto. If time permits I will also discuss work in progress that generalises and applies these results.

Michal Doucha
Institute of Mathematics, Czech Academy of Sciences
Coauthors: Jakub Gismatullin

On dual surjunctivity

The famous Gottschalk surjunctivity conjecture asks whether for every group G, every injective continuous G-equivariant map $T : A^G \to A^G$, where A is finite, is surjective. Very recently, Capobianco, Kari and Taati found a proper reverse of the conjecture and introduced the notion of 'dual surjunctivity'. I will present my recent work with Jakub Gismatullin where we explore this notion further, both from group theoretic and dynamical side. In particular, we study dual surjunctivity for more general expansive dynamical systems than for topological Bernoulli shifts.

Magdalena Foryś-Krawiec
AGH University of Science and Technology
Coauthors: Jan P. Boroński, Jernej Činč

On rigid minimal spaces

A Slovak space is a compact metric space whose group of homeomorphisms is cyclic and generated by some minimal homeomorphism. If the group of homeomorphisms $H(X)$ of a compact metric space X has the property that:

$$H(X) = H_+(X) \cup H_-(X), \text{ with } H_+(X) \cap H_-(X) = \{id_X\}$$

where $H_+(X)$ is cyclic and generated by a minimal homeomorphism, and for every $g \in H_-(X)$ we have $g^2 \in H_+(X)$, then X is referred to as an almost Slovak space.

We present the construction of almost Slovak spaces that are not Slovak and show they do not admit minimal noninvertible maps. As a result we get the whole class of minimal spaces without minimal noninvertible maps that are neither Slovak space, nor the circle $\mathbb{S}^1$. We modify the obtained class of examples to show the existence of minimal spaces with degenerate homeomorphism groups. We also prove the existence of decomposable Slovak spaces.

Axell Gómez-Ramos
Instituto de Matemáticas, UNAM

NDS and a variation on the concept of weak-mixing

A discrete nonautonomous dynamical system (a NDS for short) is a pair (X, f_∞) where X is a topological space and f_∞ is a sequence of continuous functions $(f_1, f_2, \dots)$ from X to itself. Notice that NDS' notion generalizes the usual notion of a discrete dynamical system: it is enough to take f_∞ as a constant sequence.

The aim of this talk is to show at least one of the differences between NDS and discrete dynamical systems related with dynamical properties which are variations of weak mixing property.

James Kelly
Christopher Newport University
Coauthors: Kevin McGoff

Dynamics of Markov multi-maps on the interval

We consider a class of dynamical systems on an interval called Markov multi-maps. These are a generalization of single-valued, Markov interval maps, and their structure allows us to code orbits using sequences from a shift of finite type. We let (X, σ) be the shift space of forward orbits of the multi-map, and we let (Σ, σ) be the associated shift of finite type.

In a previous article (Kelly, McGoff; 2021), it was shown that under certain conditions on the Markov multi-map, there is an entropy conjugacy between the two shift spaces. In this talk, we use similar methods to explore Devaney chaos, topological mixing, and the specification property. We show that under certain conditions, the presence of one of these properties in (X, σ_X) or (Σ, σ) implies its presence in the other.

Judy Kennedy
Lamar University
Coauthors: Iztok Banič, Piotr Minc

Characterizations of P-like continua that do not have the fixed point property

We give characterizations of P-like continua without the fixed point property in terms of open covers of X that follow fixed point free patterns. We also establish a useful relationship between sequences of tree chain open covers and commutative simplicial diagrams, which we use later to construct a finite sequence (of any length) of tree chains that follow a fixed point free pattern.

Przemek Kucharski
AGH University of Technology

Orientation preserving Lozi maps

Lozi maps is a parametrized family of plane homeomorphisms, defined by the formuIa $f(x, y) = (1 + y - a|x|, bx)$. In 1980 Misiurewicz proved that for a certain set of parameters, for which Lozi maps are orientation reversing, there always exist strange attractors. I will discuss my work on a potential generalization of Misiurewicz's result to the orientation preserving case.

Tamara Kucherenko
The City College of New York
Coauthors: Anthony Quas

Flexibility of the Pressure Function

We discuss the flexibility of the pressure function of a continuous potential with respect to a parameter regarded as the inverse temperature. The points of non-differentiability of this function are of particular interest in statistical physics, since they correspond to phase transitions. It is well known that the pressure function is convex, Lipschitz, and has an asymptote at infinity. We show that in a setting of one-dimensional compact symbolic systems these are the only restrictions. We present a method to explicitly construct a continuous potential whose pressure function coincides with any prescribed convex Lipschitz asymptotically linear function starting at a given positive value of the parameter.

Krystyna Kuperberg
Auburn University

Periodic points near an adding machine

Let $h : \mathbb{R}^2 \to \mathbb{R}^2$ be a homeomorphism of the plane with an invariant Cantor set $\mathbf{C}$ such that h restricted to $\mathbf{C}$ is an adding machine. It is known that the closure of the set of periodic points of h intersects $\mathbf{C}$. We will investigate the existence of periodic orbits of h arbitrarily close to $\mathbf{C}$.

Olga Lukina
University of Vienna
Coauthors: Henk Bruin

Rotated odometers

We consider a class infinite interval exchange transformations (IETs) obtained as a composition of a finite IET and the von Neumann-Kakutani map, and study their dynamical and ergodic properties by means of the associated Bratteli-Vershik diagram. In particular, we study the question whether such a Bratteli-Vershik system or its minimal subsystem factor onto the dyadic odometer.

David McClendon
Ferris State University
Coauthors: Aimee S.A. Johnson

Speedups of $\mathbb{Z}^d$-odometers

Given a dynamical system (X, T), a speedup of (X, T) is another dynamical system (X, T^p) where $p : X \to \{1, 2, 3, \dots\}$. We are interested two big-picture questions involving speedups: (1) to what degree must (X, T^p) be "equivalent" to (X, T)? (2) given two dynamical systems, when does there exist a speedup of the first that is "equivalent" to the second? In this talk, we will briefly review results addressing both questions.

Then, we will discuss what is meant by a speedup of an action of $\mathbb{Z}^d$. In particular, we will focus on speedups of $\mathbb{Z}^d$-odometers. One notable result generalizes work of Alvin, Ash and Ormes: we will show is that a bounded speedup of a $\mathbb{Z}^d$-odometer must be an odometer (as in the $\mathbb{Z}$ case), but unlike the $\mathbb{Z}$ case, the speedup need not be topologically conjugate to the original odometer.

Jonathan Meddaugh
Baylor University

Shadowing of continuously generated pseudo-orbits

It is well-known that if (X, f) has the shadowing property (pseudo-orbit tracing property), then for every $\epsilon > 0$, there exists $\delta > 0$ such that if $g : X \to X$ is within δ of f, then every g-orbit is ϵ-shadowed by an f-orbit—in other words, *continuously generated* pseudo-orbits are shadowed.

In this talk, we demonstrate that there is a large class of compact metric spaces for which this weaker form of shadowing is sufficient to guarantee the full shadowing property. In particular, if X belongs to this class of spaces, a map $f : X \to X$ has the shadowing property precisely when its orbits sufficiently well approximate the orbits of nearby functions.

Piotr Oprocha
AGH University, Poland
Coauthors: Łukasz Cholewa

On completely invariant sets in Lorenz maps

Lorenz maps appear in a natural way as Poincaré maps in geometric models of well-known Lorenz attractor. In this talk we will discuss connections between completely invariant sets and renormalizations in Lorenz maps with constant slope.

Samuel Roth
Silesian University in Opava
Coauthors: Zuzana Roth, Lubomir Snoha

Flexibility and Rigidity of Polynomial Entropy

Polynomial entropy (sometimes called slow entropy) arose from the idea that not all systems with zero topological entropy are equally complex. This invariant measures the polynomial growth rate of distinguishable orbit segments. We show that the polynomial entropy is flexible, in the sense that every nonnegative real number is the polynomial entropy of some homeomorphism on a continuum. However, for maps of the interval, polynomial entropy is rigid, being limited to integer values. This follows from our main result, that the polynomial entropy of an interval map can be calculated as the supremum of the lengths of so-called "one-way horseshoes."

Skyler Simmons
Utah Valley University

A Newtonian n-body Collision-Based Periodic Orbit in Three Dimensions

I will present a collision-based periodic orbit of eight bodies in three dimensions in the Newtonian n-body problem. In this orbit, each body collides in turn with its nearest three neighbors. A construction of the orbit, its regularization, symmetries, and determination of the initial conditions will be given. Results relating to stability in multiple settings will also be discussed.

Sandeep Chowdary Vejandla
University of Alabama at Birmingham
Coauthors: Alexander Blokh, Lex Oversteegen, Nikita Selinger

Parameter space of cubic symmetric laminations

To gain a better understanding of the space of cubic polynomials $f(z) = z^3 + bz^2 + \lambda z$, our goal is to study a particular slice i.e, the space of all cubic symmetric polynomials of the form $f(z) = z^3 + \lambda^2 z$. A lamination is a family of chords in the unit disk which do not intersect inside the disk. Thurston has built a topological model for the space of quadratic polynomials $f(z) = z^2 + \lambda$ using the parametrization of space of quadratic invariant laminations. In the same spirit as Thurston's work, we will parametrize space of cubic symmetric laminations which will provide a model for the space of cubic symmetric polynomials. In my talk, i will present the details about the space of cubic symmetric laminations.

Jim Wiseman
Agnes Scott College

Persistence for finite-resolution dynamics

To study the dynamics of a continuous self-map on a metric space, we can use a finite-resolution approximation of the map. But the dynamics of the approximation depend on the choice of resolution. We study the persistence — a notion from topological data analysis — of the dynamics as the resolution changes, in particular of the Morse decomposition of the recurrent set.

Kitty Yang
University of Memphis
Coauthors: Scott Schmieding

Mapping class group of miminal subshifts

Let (X, σ) be a subshift. A flow equivalence of two spaces is an orientation-preserving homeomorphism of the suspension spaces. The mapping class group of a subshift is the group of self-flow equivalences up to isotopy. We compute the mapping class group for various classes of minimal zero-entropy subshifts.

Geometric Group Theory

Santana Afton
Georgia Institute of Technology

Representations of Fundamental Groups with a Profinite and p-Adic Flavor

Many of the groups commonly studied in geometric group theory are countable and discrete. However, there are a wealth of uncountable and locally compact groups which have interesting group theory. In particular, we will focus on groups that arise naturally in arithmetic geometry related to the fundamental group of an algebraic curve over a finite field. These groups and their representation theory have ties to finding random models for 3-manifolds fibered over a circle, the Weil conjectures, and the Langlands program — though no familiarity of these topics will be assumed.

Ulysses Alvarez
Binghamton University
Coauthors: Ross Geoghegan

The Up Topology on the Grassmann Poset

For a discrete poset $\mathcal{X}$, McCord proved that there exists a weak homotopy equivalence from the order complex $|\mathcal{X}|$ to where $\mathcal{X}$ has the Up topology. Much later, Živaljević defined the notion of the order complex of a topological poset. For a large class of such topological posets we prove the analog of McCord's theorem, namely that there exists a weak homotopy equivalence from the order complex to the topological poset with the Up topology. An interesting example of a topological poset of said class is the Grassmann poset, that is, the collection of nonzero proper linear subspaces of $\mathbb{R}^{n+1}$, whose order complex is understood to be homotopy equivalent to the m-sphere for some m. In particular, there is a weak homotopy equivalence from the m-sphere to the Grassmann poset with the Up topology.

Simon André
Vanderbilt University

Acylindrical hyperbolicity and elementary equivalence

Two groups are said to be elementarily equivalent if they satisfy the same first-order sentences. I will talk about the preservation of geometric properties of groups, such as hyperbolicity or acylindrical hyperbolicity, under elementary equivalence.

Chloe Avery
University of Chicago
Coauthors: Lvzhou Chen

Stable Torsion Length

The stable torsion length in a group is the stable word length with respect to the set of all torsion elements. We show that the stable torsion length vanishes in crystallographic groups. We then give a linear programming algorithm to compute a lower bound for stable torsion length in free products of groups. Moreover, we obtain an algorithm that exactly computes stable torsion length in free products of finite abelian groups. The nature of the algorithm shows that stable torsion length is rational in this case. As applications, we give the first exact computations of stable torsion length for nontrivial examples.

Michael Brandenbursky
Ben Gurion University
Coauthors: Jarek Kedra

Fragmentation norm and relative quasimorphisms

We prove that manifolds with complicated enough fundamental group admit measure-preserving homeomorphisms which have positive stable fragmentation norm with respect to balls of bounded measure.

Lvzhou Chen
University of Texas at Austin
Coauthors: Danny Calegari

Normal subgroups of big mapping class groups

Big mapping class groups are the mapping class groups of infinite-type surfaces. For a (possibly once-punctured) closed surface S minus a Cantor subset K, we show that any homomorphism from the mapping class group Maps(S-K) to a countable group factors through the forgetful map Maps(S-K)→Maps(S). This is done by studying the normal closure of certain elements. As a consequence, we show such a big mapping class group is generated by torsion and actually normally generated by a "generic" torsion element.

Matthew B. Day
University of Arkansas
Coauthors: Richard Wade and Andrew Sale

Calculating the virtual cohomological dimension of the automorphism group of a right-angled Artin group

We give an algorithm that takes in the defining graph of a RAAG and outputs the vcd of its automorphism group. The main tool for this is restriction maps (introduced by Charney–Crisp–Vogtmann), and a short exact sequence for relative outer automorphism groups of RAAGs from previous work of Day–Wade. Other ideas in this algorithm include the application of a theorem of Bieri on rational vcd, and a computation of the vcd of certain Fouxe-Rabinovitch groups using the Guirardel–Levitt outer space.

George Domat
University of Utah

Big pure mapping class groups are never perfect

We prove that pure mapping class groups of infinite type surfaces are never perfect, i.e., they have non-trivial abelianization. This is in contrast to the result of Powell that pure mapping class groups of finite type surfaces are perfect if the surfaces have genus at least 3. In fact, we show that the abelianization of a particular closed subgroup always contains uncountable direct sums of rationals. To accomplish this we make use of the projection complex machinery of Bestvina, Bromberg, and Fujiwara in order to build specific quasimorphisms on finite type mapping class groups.

Sami Douba
McGill University

Virtually unipotent curves in some non-NPC graph manifolds

A graph manifold is a compact aspherical 3-manifold all of whose JSJ pieces are Seifert. It follows from work of Leeb that if a graph manifold M cannot be endowed with a nonpositively curved (NPC) Riemannian metric, then $\pi_1(M)$ admits no discrete and faithful representation into $\mathrm{GL}(n,\mathbb{C})$ whose image consists entirely of diagonalizable matrices. For at least some of these manifolds M, it is even true that there is a non-trivial element of $\pi_1(M)$ whose image under any (possibly non-discrete) representation $\pi_1(M) \to \mathrm{GL}(n,\mathbb{C})$ has a unipotent power. In particular, and in contrast to the fundamental groups of their NPC cousins, the fundamental groups of such M admit no faithful finite-dimensional unitary representations. We discuss this phenomenon.

Elizabeth Field
University of Utah
End periodic homeomorphism and volumes of mapping tori
Coauthors: Heejoung Kim, Christopher Leininger, and Marissa Loving

In this talk, we will discuss mapping tori associated to irreducible, end periodic homeomorphisms of certain infinite-type surfaces. Inspired by a theorem of Brock in the finite-type setting, we will relate the minimal convex core volume of such a mapping torus to the translation distance of its monodromy on (a certain subgraph of) the pants graph.

Jianhua Gong
United Arab Emirates University
Projection in the moduli space of Kleinian groups
Coauthors: Hala Alaqad & Gaven Martin

The results in this talk are related to projections and principal characters of two-generator Kleinian groups, including the closedness of useful projections from three complex dimensional moduli space of the principal characters of two-generator Kleinian groups to the two complex dimensional spaces.

Zohar Grinbaum-Reizis
Ben-Gurion University of the Negev
Vanishing of cohomology via angles between subspaces
Coauthors: Izhar Oppenheim

We introduce a new geometric criterion for vanishing of cohomology for groups acting on simplicial complexes. In particular, we show a general decomposition theorem in Hilbert spaces, and how this decomposition yields a new criterion for vanishing of cohomology for groups acting on simplicial complexes. Moreover, our criterion gives a sharp vanishing result for BN-pair groups acting on affine buildings.

Meng-Che Ho
California State University Northridge
Rational growth and languages of geodesics of groups
Coauthors: Mark Pengitore, Seongjun Choi

For a group G with a finite generating set S, we define $b(n)$ to be the size of the n-ball in the Cayley graph of G. A group G is said to have rational growth if the power series associated to $b(n)$ is a rational function. The rationality of hyperbolic groups, virtually abelian groups, and certain nilpotent groups have been studied by various people. The rational growth of a few solvable groups are also established, and in many cases this is done by finding a nice language of geodesics. We will discuss some past and recent results, and how the languages of geodesics may be useful in other work.

Huang Jingyin
Ohio State University
Coauthors: Bruce Kleiner, Stephan Stadler

Introduction to Morse Quasiflats

We are motivated by looking for traces of hyperbolicity in a space or group which is not Gromov-hyperbolic. One previous approach in this direction is the notion of Morse quasigeodesics, which describes "negatively-curved" directions in the spaces; another previous approach is "higher rank hyperbolicity". One example which illustrates the idea of higher rank hyperbolicity is that though the "thin triangles property" fails in products of two hyperbolic planes, a version of "thin tetrahedron property" holds true. We introduce the notion of Morse quasiflats, which unifies these two seemingly different approaches and applies to a wider range of objects. In the talk, I will provide motivations and examples for Morse quasiflats, as well as a discussion of related works by other people. We will also show that Morse quasiflats are asymptotically conical, and comment on potential applications.

Justin Katz
Purdue University
Coauthors: D.B. Mcreynolds, D. Arapura, P. Solapurkar

Integral Gassman equivalence of hyperbolic manifolds

In this talk, I will describe a method for constructing arbitrarily large families of nonisometric closed hyperbolic n-manifolds which are pairwise indistinguishable relative to several spectral and geometric invariants.

Marissa Miller
University of Illinois at Urbana-Champaign

Stable subgroups of handlebody groups

In a paper examining convex cocompact subgroups of the mapping class group, Durham and Taylor introduce the notion of a stable subgroup. These subgroups, which can be defined for any finitely generated group, are defined as those which are undistorted in the ambient group and for which quasi-geodesics in the ambient group with endpoints in the subgroup uniformly fellow travel. In the setting of mapping class groups, by combining work of Durham-Taylor, Kent-Leininger, and Hamenstädt, one finds that stable subgroups of mapping class groups are precisely those whose orbit maps quasi-isometrically embed into the curve graph.

There are many groups closely related to the mapping class group that also come with a related hyperbolic graph, so one can ask if there is a similar characterization of stable subgroups in those settings as well. In this presentation, I will discuss the characterization of stable subgroups in the setting of handlebody groups, which are mapping class groups of three dimensional handlebodies. We find that for genus two, there is an analogous characterization using orbit maps to the disk graph, but for all higher genus, we can find counter examples to this characterization.

MurphyKate Montee
Carleton College

Cubulation and Property (T) in Random Groups

The study of random groups is one way to answer the question, "What does a 'typical' group look like?" In the Gromov model of random groups, we choose a group presentation by picking cyclically reduced relators of a given length uniformly at random, where the number of relators is controlled by a quantity called the density. For some properties there is a sharp threshold at which the probability of satisfying the property switches from 1 to 0. Currently, sharp thresholds for Property (T) and cubulation are unknown, but we have some bounds. In this talk I'll discuss recent work that suggests ways to sharpen the bounds for both properties, and show that with overwhelming probability for densities $d < 3/14$ random groups act non-trivially on a CAT(0) cube complex.

Jean Pierre Mutanguha
Max Planck Institute for Mathematics

Limit dendrites for free group automorphisms

The study of outer automorphisms of free groups borrows a lot of tools and ideas from the study of mapping classes of closed orientable surfaces. One tool that's still missing is the canonical decomposition of mapping classes: up to isotopy, an orientation preserving surface homeomorphism preserves a unique minimal multicurve and the restriction to (orbits of) components of the multicurve's complement is either a pseudo-Anosov or a finite-order homeomorphism. We will translate this canonical decomposition in terms of $\mathbb{R}$-trees and then describe an analogue for exponentially growing outer automorphisms of free groups.

Thomas Ng
Technion – Israel Institute of Technology
Coauthors: Robert Kropholler and Rylee Lyman

Efficient free subgroups in group extensions

Efficient subgroup generation is a central tool in demonstrating that groups have uniform exponential growth. Non-positive curvature can often be leveraged to construct such free subgroups. Jankiewicz uses these ideas to give an obstruction to groups acting on certain finite dimensional CAT(0) cube complexes. I will discuss joint work with Robert Kropholler and Rylee Lyman that describes when efficient generation of free subgroups is inherited by group extensions. One consequence is that Jankiewicz's approach does not exhibit fibered 3-manifold groups with arbitrarily high cubical dimension. Our methods can further be used to show uniform exponential growth for automorphism groups of one-ended (total relatively) hyperbolic groups.

Eduardo Oregón-Reyes
UC Berkeley

Cubulated relatively hyperbolic groups

I will talk about a generalization of Agol's theorem on cubulated hyperbolic groups. This new result (also obtained independently by Groves and Manning) states that properly and cocompactly cubulated relatively hyperbolic groups are virtually special, provided the peripheral subgroups are virtually special in a way that is compatible with the cubulation. In particular, we deduce virtual specialness for properly and cocompactly cubulated groups that are hyperbolic relative to virtually abelian groups, extending Wise's results for limit groups and fundamental groups of cusped hyperbolic 3-manifolds

Mark Pengitore
OSU
Coauthors: Rob Kropholler

Coarse embeddings and homological filling functions

In this talk, we will relate homological filling functions and the existence of coarse embeddings. In particular, we will demonstrate that a coarse embedding of a group into a group of geometric dimension 2 induces an inequality on homological Dehn functions in dimension 2. As an application of this, we are able to show that if a finitely presented group coarsely embeds into a hyperbolic group of geometric dimension 2, then it is hyperbolic. Another application is a characterization of subgroups of groups with quadratic Dehn function.

Jacob Russell
Rice University

Extending surface groups by curve stabilizers

For a closed surface S, a surface group extension is any group E that surjects onto a group G with kernel $\pi_i(S)$. Work of Farb and Mosher plus Hamenstadt characterized when such surface group extensions are Gromov hyperbolic using the convex cocompact subgroups of the mapping class group of S. In progress towards a geometric classification of the extension groups outside of the hyperbolic case, we investigate the geometry of the extension group when the quotient group is the subgroup of the mapping class group that stabilizes a multicurve on S. While these extension groups cannot be Gromov hyperbolic, we prove they are hierarchically hyperbolic, a strong notion of non-positive curvature in a group.

Chandrika Sadanand
University of Illinois Urbana Champaign

Heegaard splittings and square complexes

A construction of Stallings encodes the information of a Heegaard splitting as a continuous map between 2–complexes. We investigate this construction from a more geometric perspective and find that irreducible Heegaard splittings can be encoded as square complexes with certain properties.

Jordan Sahattchieve
(no affiliation)

A fibering theorem for compact 3-manifolds

I would like to communicate the proof of a fibering theorem for compact 3-manifolds. Without a doubt, most of us are familiar with *Stallings' Fibration Theorem*, which, in brief, tells us that a compact, irreducible 3-manifold M whose fundamental group G contains a finitely generated normal subgroup N not of order 2, with an infinite cyclic quotient G/N, necessarily fibers over $\mathbb{S}$. The fiber is a surface F whose fundamental group is isomorphic to N. Stallings' Fibration Theorem is the best possible converse to the observation that if M is a surface bundle over the circle, one has $1 \longrightarrow \pi_1(F) \longrightarrow \pi_1(M) \longrightarrow 1$. Interesting results have been proven when one relaxes the various assumptions on the structure of the group G. For example, we have the theorems of Hempel and Jaco from 1972, as well as results by Elkalla (1983), and Moon (2005). My interest in this vein of research has been restricted to the case when N is subnormal and not necessarily finitely generated but only contained in a finitely generated subgroup U. Unlike Stallings, we do not require that G/N be infinite cyclic, but we still have an infinite "quotient" assumption by requiring that U be of infinite index in G. My work is an extension of Moon's results from 2005 and finishes where he left off prior to the proof of the Geometrization Conjecture by Perelman.

Luis Jorge Sánchez Saldaña
National University of Mexico

The Eilenberg-Ganea problem for families

The Eilenberg-Ganea theorem states that the geometric dimension and the cohomological dimension of a group almost always coincide. The only posibility for these dimensions to be different is given by the existence of a group G with cohomological dimension 2 and geometric dimension 3. It is a famous open problem to prove or disprove the existence of such a group. Given a family $\mathcal{F}$ of subgroups of G, one can define the $\mathcal{F}$-cohomological and geometric dimension of G. There is an Eilenberg-Ganea type problem for these dimensions. Surprisingly there are examples of groups, due to Brady-Leary-Nucinkis and Fluch-Leary, with $\mathcal{F}$-cohomological dimension 2 and $\mathcal{F}$-geometric dimension 3 for the families of finite and virtually cyclic groups. In this talk I will present a way to construct more groups that exhibit this king of behavior for the families of virtually abelian subgroups and the family of virtually poly-Z subgroups. What we use as input are the Brady-Leary-Nucinkis examples to construct certain graph of groups with fundamental group having again $\mathcal{F}$-cohomological dimension 2 and $\mathcal{F}$-geometric dimension 3.

Takamichi Sato
Waseda University

Direct decompositions of groups of piecewise linear homeomorphisms of the unit interval

We consider subgroups of the group $\mathrm{PLo}(I)$ of piecewise linear orientation-preserving homeomorphisms of the unit interval $I = [0, 1]$ that are differentiable everywhere except at finitely many real numbers, under the operation of composition. We provide a criterion for any two subgroups of $\mathrm{PLo}(I)$ which are direct products of finitely many indecomposable non-commutative groups to be non-isomorphic. As its application we give a necessary and sufficient condition for any two subgroups of the R. Thompson group F that are stabilizers of finite sets of numbers in the interval $(0, 1)$ to be isomorphic.

Hung C. Tran
The University of Oklahoma
Coauthors: Noel Brady

Superexponential Dehn functions inside CAT(0) groups

We construct 4–dimensional CAT(0) groups containing finitely presented subgroups whose Dehn functions are $\exp^{(n)}(x^m)$ for integers $n, m \geq 1$ and 6–dimensional CAT(0) groups containing finitely presented subgroups whose Dehn functions are $\exp^{(n)}(x^\alpha)$ for integers $n \geq 1$ and α dense in $[1, \infty)$. This significantly expands the known geometric behavior of subgroups of CAT(0) groups.

Geometric Topology

Jerzy Dydak
University of Tennessee and XATU
Coauthors: Yuankui Ma

Coarse Freundenthal compactification and ends of groups

Historically, ends are the oldest coarse topological notion and were used by Freundenthal in 1930 in his famous compactification. Theorems of Hopf and Stallings are the beginning of geometric group theory. A coarse compactification of a proper metric space X is any compactification of X that is dominated by its Higson compactification. In this talk we describe the maximal coarse compactification of X whose corona is of dimension 0. In case of geodesic spaces X, it coincides with the Freundenthal compactification of X. As an application we extend the concept of the number of ends from finitely generated groups to arbitrary countable groups. We generalize Stallings' theorem by showing that any countable group of two ends contains an infinite cyclic subgroup of finite index.

Hanspeter Fischer
Ball State University
Coauthors: Jeremy Brazas

On the failure of the first Čech homotopy group to register geometrically relevant fundamental group elements

We present a space $\mathbb{P}$ for which the canonical homomorphism $\pi_1(\mathbb{P}, p) \to \check{\pi}_1(\mathbb{P}, p)$ from the fundamental group to the first Čech homotopy group is not injective, although it has all of the following properties:

1. $\mathbb{P} \setminus \{p\}$ is a 2-manifold with connected non-compact boundary;
2. $\mathbb{P}$ is connected and locally path connected;
3. $\mathbb{P}$ is strongly homotopically Hausdorff;
4. $\mathbb{P}$ is homotopically path Hausdorff;
5. $\mathbb{P}$ is 1-UV_0;
6. $\mathbb{P}$ admits a simply connected generalized covering space with monodromies between fibers that have discrete graphs;
7. $\pi_1(\mathbb{P}, p)$ naturally injects into the inverse limit of finitely generated free monoids otherwise associated with the Hawaiian Earring;
8. $\pi_1(\mathbb{P}, p)$ is locally free.

Greg Friedman
Texas Christian University
Coauthors: Dev Sinha, Anibal Medina-Mardones

Geometric cup products via flowing

It is well known in the category of smooth manifolds that if the Poincaré duals of two cohomology classes can be represented by immersed manifolds then their cup product in cohomology is Poincaré dual to the homology class represented by the transverse intersection of such manifolds. However, such representing manifolds do not always exist. Furthermore, the cochain-level structure of the cup product is much richer than the cohomological structure; the singular cochain complex is an E_∞-algebra, manifesting cohomologically in operations such as the Steenrod squares. The aim of this joint work with Dev Sinha (Oregon) and Anibal Medina-Mardones (Max Planck) is to exhibit this richer structure in the more geometric language of "submanifolds" (more precisely maps from other manifolds) and intersections. To represent all cohomology classes, we replace maps from manifolds with maps from manifolds with corners (modulo some critical relations), building on the geometric cohomology theory of Lipyanskiy. We then build a flow on the ambient space (with the help of a cubulation) that allows us to realize cochain-level cup products via flowing and intersecting, even when the representative manifolds with corners are not initially transverse. In future work we hope to extend these results to geometric manifestations of the rest of E_∞-structure.

Jonah Gaster
University of Wisconsin-Milwaukee

Vertical arcs on the modular torus and the Markov Uniqueness Conjecture

The Markov Uniqueness Conjecture concerns a correspondence on the modular torus that ties together geometry, topology, and number theory. I will describe some new geometric reformulations of the conjecture, and present some intriguing experimental data.

Burns Healy
University of Wisconsin-Milwaukee
Coauthors: Mark Pengitore and Jingyin Huang

Higher Rank Extensions of Nilpotent Lie Groups

Heintze groups are one-dimensional extensions of nilpotent Lie groups that admit Riemannian metrics of negative curvature. It is well known that these spaces only admit geometric actions by discrete groups when they are symmetric spaces. We define a higher rank analog of these Lie groups and discuss some of the geometric properties of their Riemannian metrics.

Dubravko Ivanšić
Murray State University

Kirby diagrams of general Cappell-Shaneson 4-spheres

Since the '70s, the topological Cappell-Shaneson 4-spheres have been considered as possible counterexamples to the differentiable Poincaré conjecture in dimension 4. Over the years, increasingly larger subfamilies of these 4-spheres have been shown to be diffeomorphic to the standard 4-sphere, some by simplifying their Kirby diagram (so far available only for a special class), and some by other means.

By representing a Cappell-Shaneson 4-sphere as the result of a side-pairing of the 4-cube, we obtain a Kirby diagram for the general case and simplify it to two 1-handles and two 2-handles. The diagrams for the special class simplify to the standard 4-sphere in a straightforward way, suggesting our approach may be promising for the general case.

Matthew Lynam
East Central University
Coauthors: Leonard R. Rubin

Inverse systems and (m, n)-dimension

In 2012, V. Fedorchuk, using m-pairs and n-partitions, introduced the notion of the (m, n)-dimension of a space. It generalizes covering dimension; Fedorchuk showed that (m, n)-dimension is preserved in inverse limits of compact Hausdorff spaces. We separately have characterized those approximate inverse systems of compact metric spaces whose limits have a specified (m, n)-dimension. Our characterization is in terms of internal properties of the system. Here we are going to give a parallel internal characterization of those inverse systems of compact Hausdorff spaces whose limits have a specified (m, n)-dimension. Fedorchuk's limit theorem will be a corollary to ours.

Didac Martinez Granado
University of California, Davis
Coauthors: Maxime Fortier Bourque, Franco Vargas Pallete

The extremal length systole

Extremal length is a conformal invariant that plays an important role in Teichmueller theory, the study of the geometry of Riemann surfaces. For each essential closed curve on a Riemann surface, it furnishes a function on the Teichmueller space of that surface. The extremal length systole of a Riemann surface is defined as the infimum of the extremal lengths of all essential closed curves. In contrast with the hyperbolic systole (infimum of the hyperbolic lengths of all essential closed curves) the extremal length systole has not been studied much so far. In this talk we introduce the extremal length systole and describe a local maximum of the function extremal length systole on the Teichmueller space of genus 2 surfaces.

Mike Mihalik
Vanderbilt University
Coauthors: Matt Haulmark

Relatively Hyperbolic Groups with Semistable Fundamental Group at Infinity

We are interested in two long standing questions concerning the asymptotic behavior of finitely presented groups. The first, attributed to H. Hopf (probably in the 1940's) asks: Is $H^2(G; \mathbb{Z}G)$ free abelian for all finitely presented groups G? The second arose in the late 1970's and asks: Do all finitely presented groups have semistable fundamental group at ∞? We consider these questions for relatively hyperbolic groups. In 2017, we answered both questions in the affirmative when the boundary of the relatively hyperbolic group did not have a cut point. In the presence of cut points, one outstanding problem remained. We solved the cohomology version of that problem in 2018 and recently we have shown: If G is a finitely presented group that is hyperbolic relative to a finite collection of finitely presented groups P_i and each P_i has semistable fundamental group at ∞, then G has semistable fundamental group at ∞. A key idea is that of nearly geodesic proper homotopies in a cusped space for G.

Christian Millichap
Furman University

Symmetries and Hidden Symmetries of Sufficiently Twisted Knot Complements

Coauthors: Neil Hoffman and William Worden

A hidden symmetry of a hyperbolic 3-manifold M is a symmetry of a finite-sheeted cover of M that does not come from a symmetry of M. When we restrict to hyperbolic knot complements, hidden symmetries seem to be quite rare though it is difficult to show that an infinite set of knot complements admits no hidden symmetries. In this talk, we will examine how the geometric structures of sufficiently twisted knot complements can be exploited to show that such knot complements have no hidden symmetries and very few symmetries. As a result, these knot complements are usually the only knot complements in their respective commensurability classes.

Atish J. Mitra
Montana Tech

The space of persistence diagrams on n points coarsely embeds into Hilbert Space

Coauthors: Žiga Virk

We prove that the space of persistence diagrams on n points (with either the Bottleneck distance or a Wasserstein distance) coarsely embeds into Hilbert space. Such an embedding enables utilisation of Hilbert space techniques on the space of persistence diagrams. We also discuss various non-embeddability results when the number of points is not bounded.

Molly Moran
Colorado College

Coarse Group Boundaries

Coauthors: Craig Guilbault

Bestvina defined a Z-structure on a group G to generalize the theory of boundaries of CAT(0) and hyperbolic groups. It is an open question if admitting a Z-structure is a quasi-isometry invariant. In response to this question, we generalize the definition of a Z-structure to that of a coarse Z-structure and show that previously established results along with quasi-isometry invariance hold in this more general setting.

Christoforos Neofytidis
Ohio State University

Endomorphisms of mapping tori

One of the most fundamental results in 3-dimensional topology, proved in works of Gromov, Mostow, Wang and Waldhausen, is that any self-map of non-zero degree of a mapping torus of a closed hyperbolic surface is homotopic to a homeomorphism if and only if the monodromy is not periodic. Key properties for the proof were the existence of hyperbolic structures or of non-vanishing semi-norms (such as the simplicial volume). Using Algebra, we give a new, unified proof and generalise the above result in every dimension, by replacing the hyperbolic surface with a corresponding higher dimensional aspherical manifold. More generally, we will classify in terms of Hopf-type properties mapping tori of residually finite Poincaré Duality groups with non-zero Euler characteristic. It turns out that the rigidity behavior of these mapping tori with trivial center is similar to that of non-elementary torsion-free hyperbolic groups.

Margaret Nichols
University at Buffalo
Coauthors: William W. Menasco

Surface embeddings in $\mathbb{R}^2 \times \mathbb{R}$ through the lens of the crease set

The crease set of a surface embedded in $\mathbb{R}^3$ captures where the surface folds under a choice of projection $\mathbb{R}^3 \to \mathbb{R}^2$. In forthcoming work, we develop tools to characterize the crease set of an embedded sphere and its behavior under isotopy of the embedding. In this talk, we introduce some of these tools, explore a few examples, and discuss potential applications.

Leonard Rubin
University of Oklahoma
Coauthors: Vlasta Matijević

Čech Systems and Approximate Systems

Čech homology for a space X is obtained from the Čech system of projections $p : |N(\mathcal{V})| \to |N(\mathcal{U})|$ of the polyhedra of the nerves of the normal open covers of X. This means that p is a simplicial map induced by a projection of $\mathcal{V}$ to $\mathcal{U}$. It is known that any two such projections are homotopic. Using this fact, it turns out that if one applies the n-th homology functor with respect to a given abelian group to each of these projections, one arrives at an inverse system of abelian groups; its limit is called the n-th Čech homology group of X.

It might be asked if it is possible to select just one projection from the set of projections of $\mathcal{V}$ to $\mathcal{U}$ for every such pair $(\mathcal{U}, \mathcal{V})$ so that the resulting "system" would be a commutative system, that is, an inverse system of polyhedra with simplicial bonding maps. Already the first author has shown that for a large class of spaces this cannot be true. Indeed, she proved more strongly that for these spaces one cannot even use such a process to create an approximate inverse system in the sense of Mardešić and Watanabe.

A space X is called strongly 0-dimensional if each of its open covers has a refinement by a pairwise disjoint open cover. For example, every 0-dimensional metrizable space is strongly 0-dimensional. Our main result in this paper shows that if a strongly 0-dimensional space X has at least one limit point, then it has a Čech system that is an approximate inverse system in the sense of Mardešić and Watanabe and whose limit is X; moreover, we prove that this system admits a sub-inverse system consisting of 0-dimensional polyhedra and whose limit is also X.

Chandrika Sadanand
University of Illinois Urbana-Champaign
Coauthors: Viveka Erlandsson, Christopher J. Leininger

Hyperbolic cone surfaces and billiards

Consider a polygon-shaped billiard table in the hyperbolic plane on which a ball can roll along geodesics and reflect off of edges infinitely. In joint work with Viveka Erlandsson and Chris Leininger, we have characterized the relationship between the shape of the polygon and the set of possible sequences of edges visited consecutively by billiard balls rolling and reflecting around the polygon. In order to do this, we made an arguably more interesting characterization: when a hyperbolic metric with cone points on a surface is determined by the geodesics that do not pass through cone points . In this talk, we will explore these characterizations and the tools used to prove them.

Nick Salter
Columbia University
Coauthors: Corey Bregman

Simple closed curves in covers of surfaces and unitary K-theory

Let $f : X \to Y$ be a regular covering of surfaces. Which homology classes on X can be represented as (components of) lifts of simple closed curves on Y? This innocuous-looking question leads to some tremendously deep waters. Even the coarser problem of determining the *subspace* generated by all such classes is not solved in general, although some obstructions in terms of the representation theory of the deck group are now known. In this talk, I will discuss the more refined version of the question, present the answer for cyclic coverings, and explain what this has to do with (a) unitary K-theory and (b) the Burau representation. This incorporates ongoing work with Corey Bregman.

Kevin Schreve
University of Chicago
Coauthors: Grigori Avramidi, Boris Okun

Homology growth of right-angled Artin groups

By Lück's approximation theorem, the L^2-Betti numbers of a residually finite group measure the rational homology growth of residual sequences of finite index normal subgroups. In this talk, we are interested in two related residual invariants, the $\mathbb{F}_p$-homology growth and the torsion growth in integral homology. We will compute these for right-angled Artin groups, and discuss some consequences.

Jamie Scott
University of Florida
Coauthors: Alexander Dranishnikov

A Surgery Approach to Rudyak's Conjecture

Rudyak's conjecture is the following statement: if $f : M \to N$ is a degree 1 map between closed orientable manifolds, then $cat(M) \geq cat(N)$ where $cat(M)$ is the Lusternik-Schnirelmann category. Rudyak proved his conjecture when M and N are stably parallelizable, N is $(r-1)$-connected, and N satisfies the inequality $dim(N) \leq 2rcat(N) - 4$. In this talk, we discuss use surgery theoretic techniques to generalize Rudyak's theorem: we increase the upper bound on dimension by one and replace the stably parallelizable assumption by assuming f is a normal map. This research is joint work with Alexander Dranishnikov.

Mathew Timm
Bradley University

Baumslag-Solitar Groups and Solenoids

We explore a geometric connection between the class of generalized Baumslag-Solitar groups and the classical solenoids.

Bena Tshishiku
Brown University
Coauthors: Mauricio Bustamante

Symmetries of exotic negatively curved manifolds

In this talk we consider smooth manifolds N that are homeomorphic but not diffeomorphic to a hyperbolic manifold M, and ask "How much symmetry does N have? For example, does Isom(M) act on N by diffeomorphisms?" In general the answer is "No" by work of Farrell-Jones. We will discuss this problem, explain its relation to Nielsen realization, and give a generalization of the Farrell-Jones result.

Sahana Vasudevan
MIT

Large genus bounds for the distribution of triangulated surfaces in moduli space

Triangulated surfaces are compact hyperbolic Riemann surfaces that admit a conformal triangulation by equilateral triangles. They arise naturally in number theory as Riemann surfaces defined over number fields, in probability theory as conjecturally related to Liouville quantum gravity, and in metric geometry as a model to understand arbitrary hyperbolic surfaces. Brooks and Makover started the study of the geometry of random large genus triangulated surfaces. Mirzakhani later proved analogous results for random hyperbolic surfaces. These results, along with many others, suggest that the geometry of random triangulated surfaces mirrors the geometry of random hyperbolic surfaces especially in the large genus setting. In this talk, I will describe an approach to show that triangulated surfaces are asymptotically well-distributed in moduli space.

Angela Wu
Indiana University Bloomington

Non-quasispheres with Euclidean weak tangents

In this talk we discuss the problem of local characterization of the quasispheres, or metric spaces that are quasisymmetrically equivalent to S^n. Contrary to previous result for $n = 1$, we show that for all $n \geq 2$, there exists a doubling linearly locally contractible metric space X that is topologically a n-sphere such that every weak tangent is isometric to R^n but X is not quasisymmetrically equivalent to the standard n-sphere. Moreover, our construction gives spaces of Hausdorff dimension n. When $n = 2$, our result shows that Ahlfors 2-regularity condition in Bonk and Kleiner's result is necessary and optimal.

Nicolò Zava
University of Udine
Coauthors: Thomas Weighill, Takamitsu Yamauchi

Coarse infinite-dimensionality of hyperspaces of finite subsets

We consider infinite-dimensional properties in coarse geometry, which apply to Novikov and coarse Baum-Connes conjectures, for hyperspaces consisting of finite subsets of metric spaces endowed with the Hausdorff metric. We see that several infinite-dimensional properties are preserved by taking the hyperspace of subsets with at most n points. On the other hand, we show that, if a metric space contains a sequence of long intervals coarsely (for example, if it is unbounded and geodesic), then its hyperspace of finite subsets is not coarsely embeddable into any uniformly convex Banach space.

Set-Theoretic Topology

Leandro Aurichi
University of São Paulo
Coauthors: Maddalena Bonanzinga and Gabriel Asmat Medina

Some variations of the Banach-Mazur game

The classical Banach-Mazur game is directly related to the Baire property and the property of being a productively Baire space. In this work, we discuss two variations of this classic game that are even more related to these properties.

Liljana Babinkostova
Boise State University
Coauthors: Marion Scheepers

Countable Dimensionality, Games and Haver Property

We characterize the countable dimensionality of metric spaces in terms of a game-theoretic version of a covering property of Haver, and conjecture a game-theoretic equivalent of Haver's covering property for metric spaces.

Zeinab Bandpey
Morgan State University
Coauthors: Bhamini M. P. Nayar

Compact and extremally disconnected spaces via generalized continuous functions

In [2], the class of compact and extremally disconnected spaces were studied using several investigative tools such as filters, graphs, functions, multifunctions and subsets of the space. These different approaches of investigation produced significant characterizations and properties of this important class of spaces. In our previous paper, "generalized continuous fuctions" we introduced three forms of generalized continuous functions by studying the class of u-continuous functions of Joseph, Kwack and Nayar [1] using the concepts of an α-set of Njastad [3]. The generalized continuous forms introduced there are: αu-continuous, semi-αu-continuous and strongly u-continuous functions. In the present study we investigate the class of compact and extremally disconnected spaces using these generalized continuous functions.

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Serhii Bardyla
University of Vienna
Coauthors: A. Osipov, L. Zdomskyy

On regular countably compact $\mathbb{R}$-rigid spaces

A space X is called Y-rigid if any continuous map $f : X \to Y$ is constant. For each cardinal κ we construct an infinite κ-bounded (and hence countably compact) regular space R_κ such that R_κ is Y-rigid for any T_1 space Y of pseudo-character $\leq \kappa$. This result resolves two problems posted by Tzannes in Open Problems from Topology Proceedings and extends results of Ciesielski and Wojciechowski, and Herrlich. Also, we discuss (consistent) examples of regular separable countably compact $\mathbb{R}$-rigid spaces. In particular, we construct a consistent example of regular separable first-countable countably compact $\mathbb{R}$-rigid space. Finally, we construct a ZFC example of regular separable sequentially compact space which is not Tychonoff. The latter example resolves a problem of Banakh, Bardyla and Ravsky. The results are contained in joint works with Osipov and Zdomskyy.

Will Brian
UNC Charlotte

Covering versus partitioning with Polish spaces

Given a completely metrizable space X, let $\mathfrak{par}(X)$ denote the smallest possible size of a partition of X into Polish spaces, and $\mathfrak{cov}(X)$ the smallest possible size of a covering of X with Polish spaces. Observe that $\mathfrak{cov}(X) \leq \mathfrak{par}(X)$ for every X, because every partition of X is also a covering.

I will outline a proof that it is consistent relative to a huge cardinal for the strict inequality $\mathfrak{cov}(X) < \mathfrak{par}(X)$ to hold for some completely metrizable space X. Using large cardinals is necessary for obtaining this strict inequality, because if $\mathfrak{cov}(X) < \mathfrak{par}(X)$ for any completely metrizable X, then $0^\dagger$ exists.

Nathan Carlson
California Lutheran University
Coauthors: Angelo Bella

On the cardinality of a homogeneous compactum

Motivated by results of Juhász and van Mill, the weak tightness $wt(X)$ of a space X was introduced by Carlson with the property $wt(X) \leq t(X)$ where $t(X)$ is the tightness of X. The cardinal function $wt(X)$ encodes tightness-like properties of a space that prove sufficient to replace $t(X)$ with $wt(X)$ in certain cardinal inequalities. For example, it was shown that if X is Hausdorff then $|X| \leq 2^{L(X)wt(X)\psi(X)}$, giving an improvement of a result of Arhangel'skiĭ and Šapirovskiĭ. In 2006 De la Vega proved that $|X| \leq 2^{t(X)}$ for any homogeneous compactum. In the countably tight case this result was extended in a result of Juhász and van Mill. We introduce the notion of an S-free sequence and show that $|X| \leq 2^{wt(X)\pi\chi(X)}$ for any homogeneous compactum X. As $\pi\chi(X) \leq t(X)$ for compacta, this is a general refinement of De la Vega's Theorem. In the case where the cardinal invariants are countable, this represents a variation of the result of Juhász and van Mill. We show further that $w(X) \leq 2^{wt(X)}$ for a homogeneous compactum X. However, whether $|X| \leq 2^{wt(X)}$ or $|X| \leq 2^{\pi\chi(X)}$ for such spaces remain open questions.

Christopher Caruvana
Indiana University Kokomo
Coauthors: Jared Holshouser

Selection Games with Compact Sets

We discuss selection principles and games involving hyperspaces and demonstrate that k-covers of the space of compact subsets with the Vietoris topology can be refined to covers consisting of a certain kind of open set. From this, we derive implications for selection games involving k-covers. We also apply these techniques to extend results relating *omega*-covers of a space to open covers of the finite powers of that space.

William Chen-Mertens
(no affiliation)
Coauthors: Paul Szeptycki

Selectivity properties of spaces

We address several questions of Feng, Gruenhage, and Shen which arose from Michael's theory of continuous selections from countable spaces. This theory is concerned with the following general question: given a map from a space Y to the subsets of another space X, under what conditions is it possible to find a continuous selection?

We construct an example of a space which is $(\omega+1)$-selective but not $\mathbb{Q}$-selective from $\mathfrak{d}=\omega_1$, and an $(\omega+1)$-selective space which is not selective for a P-point ultrafilter from the assumption of CH. We also produce ZFC examples of Fréchet spaces where countable subsets are first countable which are not $(\omega+1)$-selective.

Alan Dow
UNC Charlotte
Coauthors: K. P. Hart

Martin's Axiom and converging ω_1-sequences

We continue the investigation of the possible dichotomy raised in a question by Istvan Juhasz: Is a compact space first countable if and only if it contains no converging ω_1-sequences. An ω_1-sequence is converging in a compact space if it contains a unique complete accumulation point. We prove that the question is not decided by the axiom MA + $\neg$CH. In particular PFA implies that the dichotomy does hold.

Ziqin Feng
Auburn University
Coauthors: Alan Dow

Compact Spaces with a P-base

We'll discuss (scattered) compact spaces with a P-base for some poset P. We show that any compact space with an ω^ω-base is metrizable and any scattered compact space with an ω^ω-base is countable under the assumption $\omega_1<\mathfrak{b}$. Using forcing, we also prove that in a model of $\omega_1<\mathfrak{b}$, there is a non-first-countable compact space with a P-base for some poset P with calibre ω_1.

David J. Fernández-Bretón
Universidad Nacional Autónoma de México
Coauthors: Nicholas Vlamis, Mathieu Baillif

Ends of nonmetrizable manifolds: a generalized bagpipe theorem

A non-metrizable manifold is an object satisfying the definition of a manifold, minus paracompactness (so, it is a connected topological space such that each point has an open neighbourhood homeomorphic to $\mathbb{R}^n$ for some $n \in \mathbb{N}$ — for objects satisfying this definition, paracompactness is equivalent to metrizability). An old theorem of Nyikos, known as the Bagpipe Theorem, characterizes those non-metrizable manifolds that are bagpipes — a connected sum of a compact manifold plus finitely many "long pipes". In joint work with Nicholas Vlamis, we started a study of the space of ends of nonmetrizable manifolds — the space of ends is the remainder of the Freudenthal compactification, and is widely used in recent research in metrizable manifolds — and use this machinery to find a new characterization of bagpipes, as well as a characterization of what we call "generalized bagpipes" — type I manifolds that can be written as the connected sum of a metrizable manifold plus countably many long pipes ("type I" refers to a technical condition only satisfied by nonmetrizable manifolds that are especially well-behaved). In further work along with Vlamis and Mathieu Baillif, we proved that the "type I" requirement cannot be removed from our characterization.

Sergio García-Balán
York University
Coauthors: Javier Casas-de la Rosa

(Absolute) Star selection principles on small spaces

Bonanzinga and Matveev showed that a Mrówka Ψ-space is strongly star-Menger if and only if the size of the associated almost disjoint family is smaller than the dominating number and, it is strongly star-Hurewicz if and only if the size of the associated almost disjoint family is smaller than the bounding number.

In this talk we introduce definitions that will allow us to reproduce this result in a more general setting. In particular, it includes the selective and absolute versions of these star selection principles and some selective versions of property (a).

K. P. Hart
TU Delft
Coauthors: Alan Dow

Soft compactifications of $\mathbb{N}$

It is shown that, assuming the Continuum Hypothesis, every compact Hausdorff space of weight at most $\mathfrak{c}$ is a remainder in a soft compactification of $\mathbb{N}$.

We also exhibit an example of a compact space of weight $\aleph_1$ — hence a remainder in some compactification of $\mathbb{N}$ — for which it is consistent that is not the remainder in a soft compactification of $\mathbb{N}$.

Jared Holshouser
Norwich University
Coauthors: Chris Caruvana

Selection Games in Hyperspace Topologies

In this talk we will generalize work of Kočinac et. al.(2005) and Li (2016) which connects selective separability in the Fell and Vietoris hyperspace topologies to Rothberger-like principles in the corresponding ground space. We make use of and expand on a general game translation tool kit. This unifies and simplifies the methods of Kočinac and Li.

Tetsuya Ishiu
Miami University

A proof of Čertanov's Theorem by using countable elementary submodels

L. B. Treybig showed that if X and Y are infinite Hausdorff spaces such that $X \times Y$ is the continuous image of a compact linearly ordered topological space, then both X and Y are metrizable. Later, G. I. Čertanov showed that this theorem holds when we replace a compact linearly ordered space by a countably compact GO space. In this talk, we shall give an outline of a totally different proof of this theorem by using countable elementary submodels.

David Milovich
Welkin Sciences

Homeomorphism classes of hypergraph spaces

Given $n < k < \omega \leq \lambda$, let $X(n, k, \lambda)$ denote the subspace of the product space $2^{[\lambda]^n}$ consisting of all n-uniform hypergraphs on λ that contain no copy of $[k]^n$. We show that $X(n, k, \lambda) \cong 2^\lambda$ if $\lambda < \omega_n$ but $X(n, k, \lambda) \ncong X(n', k', \lambda)$ if $\lambda \geq \omega_n$ and $n < n' < k' < \omega$.

The topological property we use in our proof is the existence of a certain kind of limited-information winning strategy for II in an infinite-length team game with n players per team.

The most interesting related open problem is, is the space $X(2, 3, \omega_2)$ of triangle-free graphs on ω_2 homeomorphic to the space $X(2, 4, \omega_2)$ of K_4-free graphs on ω_2?

Sonia Navarro Flores
(no affiliation)

Borel ideals and Ramsey spaces

It is known that the Ellentuck space, which is forcing equivalent to the Boolean algebra $P(\omega)/\text{Fin}$ forces a selective ultrafilter. The Ellentuck space is the prototypical example of a Ramsey space. The connection between Ramsey spaces, ultrafilters, and ideals has been explored in different ways. Ramsey spaces theory has shown to be crucial to investigate Tukey order, Karetov order, and combinatorial properties. This is why we investigate which ideals are related to a Ramsey space in the same sense that the ideal Fin is related to the Ellentuck space. In this talk, we present some results obtained.

Peter Nyikos
University of South Carolina

Two to one closed preimages of ω_1 with big differences

The informal term "sprats" is used here for 2-1 closed Hausdorff preimages of ω_1. These spaces are locally compact, countably compact, first countable, and noncompact.

There is not enough room in a sprat for more than two disjoint copies of ω_1, and examples are given using $\clubsuit$ and its weakenings that do not have any copies. But it is also consistent that there must be at least one.

Theorem 1. It is consistent, both with and without CH, that every first countable, countably compact Hausdorff space is either compact or contains a copy of ω_1.

Balogh showed (1987) the "without" part holds under the PFA, while Eisworth and the speaker showed (2005) that the statement is consistent with CH.

The following results will be the focus of the talk. The first two use only the usual (ZFC) axioms.

Theorem 2. If a sprat does not contain two disjoint copies of ω_1, then it is normal.

Example 1. There is a non-normal sprat.

The following example uses an axiom that is compatible with a very strong form of MA+not-CH, and shows how much of the power of PFA is used in Theorem 1.

Example 2. If $\mho_2$, then there is a sprat in which every uncountable subset has the fibers (i.e., point inverses) over a stationary set in its closure.

No sprat with this property can contain a copy of ω_1. Under the somewhat stronger axiom Club Guessing (which is still compatible with a strong form of MA+not-CH) one can improve "stationary set" to "club subset".

Ivan Ongay Valverde
York University
Coauthors: Juris Steprans

Questions about the Clopen Coloring Axiom

In the 80's, both Abraham-Rudin-Shelah and Todorčević, propose an axiom extending Ramsey Theorem to the uncountable case: the Open Coloring Axiom (OCA). Due to an example given by Sierpiński, it is not possible to have a full generalization of of Ramsey Theorem, so Topology plays an important roll here. In this talk we will investigate what happens to a weakening of these axioms (the Clopen Coloring Axiom) and how it differs from OCA.

Marion Scheepers
Boise State University

Moving off families and a Ramseyan Theorem

Gruenhage and Ma connected Baireness of function spaces with combinatorial properties of objects called moving off families. In this talk these combinatorial properties are are featured, and connected with among other things, a version of Ramsey's theorem.

Alexander Shibakov
Tennessee Tech University
Coauthors: Michael Hrušák

Invariant Ideals in groups

We present a new set-theoretic axiom we call the Invariant Ideal Axiom and discuss how it can be used to study convergent sequences in sequential and almost sequential groups.

Santi Spadaro
University of Palermo, Italy
Coauthors: Arkady Leiderman and Stevo Todorčević

Dense metrizable subspaces in powers of Corson compacta

We characterize when the countable power of a Corson compactum has a dense metrizable subspace and construct consistent examples of Corson compacta whose countable power does not have a dense metrizable subspace.

Petra Staynova
University of Derby
Coauthors: Ibai Aedo, Uwe Grimm, Yasushi Nagai

From van der Waerden to Combinatorics on Words

'You can't teach an old dog new tricks,' a popular saying goes. However, can you use old proofs in new contexts? In this talk, I will present results on the existence of long arithmetic progressions in a class of generalised Thue-Morse words. Moreover, I will show how the arguments are inspired by van der Waerden's now classic proof from 1927 of the existence of arbitrary long monochromatic arithmetic progressions in any finite colouring of the (positive) integers.

Paul Szeptycki
York University
Coauthors: Sergio García-Balán

Weak normality properties in Ψ-spaces

The property of being a normal space can be naturally weakened by requiring that pairs of certain types of closed sets can be separated (e.g., Shchepin defined a space to *near-normal* if any pair of regular closed sets can be separated by disjoint open sets). We consider a number of different such weakenings in the context Ψ-spaces over almost disjoint families of subsets of ω.

Piotr Szewczak
Cardinal Stefan Wyszyński University in Warsaw

Abstract colorings, games and ultrafilters

During the talk we consider various kinds of Ramsey-type theorems. Bergelson and Hindman investigated finite colorings of the complete graph $[\mathbb{N}]^2$ with vertices in natural numbers, involving an algebraic structure of $\mathbb{N}$. It follows from their result that for each finite coloring of $[\mathbb{N}]^2$, there are pairwise disjoint sets $F_1, F_2, \ldots$ such that each set F_n contains an arithmetic progression of length n and all edges between vertices from different sets F_n have the same color. Colorings of graphs appear also in the context of combinatorial covering properties. Scheepers proved that some of these properties (including Menger and Rothberger) can be characterized using finite colorings of complete graphs whose vertices are open sets of spaces.

The aim of the talk is to present a theorem that captures many results in a similar spirit. To this end, we use topological games and some special ultrafilters in the Stone–Čech compactification of semigroups.

Vladimir Tkachuk
Universidad Autónoma Metropolitana

Polish cofinality and some completeness properties

We prove that, for any cofinally Polish space X, every locally finite family of non-empty open subsets of X is countable. It is also established that Lindelöf domain representable spaces are cofinally Polish and domain representability coincides with subcompactness in the class of σ-compact spaces. It turns out that, for a topological group G whose space has the Lindelöf Σ-property, the space G is domain representable if and only if it is Čech-complete. Our results solve several published open questions.

Jerzy Wojciechowski
West Virginia University
Coauthors: Gbrel Albkwre and Chris Ciesielski

Lineability cardinals for various families of Darboux-like functions

Let $\mathcal{A} \subseteq \mathbb{R}^{\mathbb{R}}$ and λ be a cardinal. We say that $\mathcal{A}$ is λ-lineable if there exists a linear subspace of $\mathbb{R}^{\mathbb{R}}$ of dimension λ contained in $\mathcal{A} \cup \{0\}$. We obtain new lineability results for several families $\mathcal{A} \subseteq \mathbb{R}^{\mathbb{R}}$ that are defined using various properties of continuous functions. Such families are usually referred to as families of "Darboux-like functions". Many of those results are proved in ZFC, but some require additional axioms. For example, we show that assuming the Martin's Axiom, the family of functions that are everywhere surjective, have Strong Cantor Intermediate Value Property, and are not connectivity functions is $\mathfrak{c}^+$-lineable.

Alfredo Zaragoza
UNAM

A characterization of the product of the rational numbers and complete Erdős space

Coauthors: Rodrigo Hernández

Erdős space $\mathfrak{E}$ and complete Erdős space $\mathfrak{E}_c$ have been previously shown to have topological characterizations. In this talk, we provide a topological characterization of the topological space $\mathbb{Q} \times \mathfrak{E}_c$, where $\mathbb{Q}$ is the space of rational numbers. As a corollary, we show that the Vietoris hyperspace of finite sets $\mathcal{F}(\mathfrak{E}_c)$ is homeomorphic to $\mathbb{Q} \times \mathfrak{E}_c$. We also characterize the factors of $\mathbb{Q} \times \mathfrak{E}_c$. An interesting open question that is left open is whether $\sigma\mathfrak{E}_c^\omega$, the σ-product of countably many copies of $\mathfrak{E}_c$, is homeomorphic to $\mathbb{Q} \times \mathfrak{E}_c$.

Lyubomyr Zdomskyy
Institute of Mathematics, University of Vienna

Frechet-Urysohn and Pytkeev properties are not equivalent for C_p-spaces

Coauthors: Serhii Bardyla, Jaroslav Supina

The talk will be devoted to weaker versions of the covering property γ of Gerlits and Nagy, obtained by introducing ideals as parameters. Under CH all of these properties are strictly weaker than being γ. As a consequence we get the result stated in the title, thus answering a question of M. Sakai.

Contributed Talks

(CT) Lucero Madrid-Mendoza
Universidad Autónoma del Estado de México
Coauthors: José G. Anaya, Félix Capulín, and David Maya

On g-pseudo-contractibility of continua

A topological space X is said to be g-pseudo-contractible provided that there exists a pseudo-homotopy between an onto map from X to X and a constant map. This concept generalizes the notions of g-contractibility and pseudo-contractibility. In this talk we present some basic results related to the g-pseudo-contractibility of a continuum.

(CT) Mónica Sánchez-Garrido
Universidad Autónoma del Estado de México
Coauthors: Félix Capulín, Francisco R. Ruiz del Portal

The Cantor set as generalized inverse limit

A general problem is to determine conditions under an inverse sequence such that its generalized inverse limit is the Cantor set. We present sufficient conditions on the factor space X and the upper semicontinuos bonding function F such that the generalized inverse limit of the inverse sequence (X, F) is the Cantor set.

(DS) Abdul Gaffar Khan
University of Delhi, India
Coauthors: Tarun Das

Persistence and topological stability in pointwise dynamics

Finding a relationship between persistence and topological stability of a dynamical system is one of the important problems in the theory of topological dynamics. We use pointwise dynamics to show that persistent property is equivalent to pointwise weak topological stability for equicontinuous pointwise minimally expansive homeomorphisms of compact metric spaces. The forward implication is obtained by proving Walters stability theorem in the setting of pointwise dynamics.

(DS) Padmapriya V Prakash
Central University of Kerala, India
Coauthors: Ali Akbar K

Dense Set of Large Periodic Points of Chaotic Group Actions

In this paper, we prove that a chaotic group action has a dense set of large periodic points. A group action is said to have a dense set of large periodic points (DSLP) if for every positive integer n, the set of all periodic points of period greater than or equal to n is dense in X. The action of a group G on a Hausdorff topological space X is said to be chaotic if it is topologically transitive and has a dense set of periodic points.

(GT) Manuel Chacón-Ochoa
Universidad Nacional Autónoma de México
Coauthors: Sergey A. Antonyan

Some hyperspaces of compact convex sets and their orbit spaces

Let $cc(\mathbb{R}^n)$ denote the hyperspace of all nonempty compact convex subsets of the Euclidean space $\mathbb{R}^n$ endowed with the Hausdorff metric, and let $cc(\mathbb{B}^n) = \{A \in cc(\mathbb{R}^n) \mid A \subset \mathbb{B}^n\}$, where $\mathbb{B}^n$ is the closed unit ball of $\mathbb{R}^n$. In the talk we describe the topological structure of several peculiar subspaces of $cc(\mathbb{R}^n)$ and $cc(\mathbb{B}^n)$, and their orbit spaces under the natural action of the orthogonal group $O(n)$.

(GT) Luisa F. Higueras-Montaño
Universidad Nacional Autónoma de México
Coauthors: N. Jonard-Pérez

On the homeo. type of a hyperspace of convex bodies associated to tensor norms

In this talk, we will describe the topological structure of a hyperspace of convex compacta in the Euclidean space arising from the theory of tensor products of Banach spaces. Such a hyperspace is denoted by $\mathcal{B}_{\otimes}(d_1, \ldots, d_l)$, $d_1, \ldots, d_l \geq 2$ are integers, and it consists of the convex bodies in $\mathbb{R}^d$, $d = d_1 \cdots d_l$, that are closed unit balls of reasonable crossnorms on $\mathbb{R}^{d_1} \otimes \cdots \otimes \mathbb{R}^{d_l}$. The hyperspace $\mathcal{B}_{\otimes}(d_1, \ldots, d_l)$ is endowed with the Hausdorff distance and it is called *the space of tensorial bodies.* We will show that $\mathcal{B}_{\otimes}(d_1, \ldots, d_l)$ is an Absolute Retract for the class of metrizable spaces. Then, we will prove that it is a Hilbert cube manifold homeomorphic to $\mathcal{Q} \times \mathbb{R}^p$, with $p = \frac{d_1(d_1+1)+\cdots d_l(d_l+1)}{2}$. Here, $\mathcal{Q}$ denotes the Hilbert cube. It is noteworthy that $\mathcal{B}_{\otimes}(d_1, \ldots, d_l)$ is a closed and non-convex subset of the hyperspace of centrally symmetric convex bodies $\mathcal{B}(d)$.

(GT) Artur Piekosz
Cracow University of Technology

Grothendieck topology and Stone duality

In semialgebriac geometry, one often takes the real spectrum of some commutative ring or of a semialgebraic set. The appearing topological spaces are spectral and the procedure depends only on some lattice of subsets of a certain set. Smopologies allow constructing similar spectra in the case of some infinite gluing of semialgebraic sets (a locally semialgebraic space over a real closed field) or even in a more general setting (a locally definable space over an o-minimal expansion of a field). We get the notion of a locally small space that evolved from some kind of Grothendieck sites through generalized topological spaces. Locally small spaces played a hidden role in o-minimal homotopy theory and non-Archimedean analysis. I will present new variants of Stone duality for Kolmogorov locally small spaces. It appears that locally small spaces correspond to certain patch dense subsets of spectral spaces or strongly locally spectral spaces.

(STT) Saak Gabriyelyan
Ben-Gurion University of the Negev, Israel

Topological properties of inductive limits of closed towers of metrizable groups

Let $\{G_n\}_{n\in\omega}$ be a closed tower of metrizable groups. Under a mild condition called (GC) and which is strictly weaker than PTA condition introduced in [26], we show that:

1. the inductive limit $G = \text{g-}\varinjlim G_n$ of the tower is a Hausdorff group,
2. every G_n is a closed subgroup of G,
3. if K is a compact subset of G, then $K \subseteq G_m$ for some $m \in \omega$,
4. G has countable tightness and a $\mathfrak{G}$-base,
5. G is an $\aleph$-space,
6. G is a sequentially Ascoli space if and only if either (i) there is an $m \in \omega$ such that G_n is open in G_{n+1} for every $n \geq m$, so G is metrizable, or (ii) all groups G_n are locally compact and G is a sequential non-Fréchet–Urysohn space.

(STT) José F. Gálvez-Rodríguez
Universidad de Almería

Distribution functions and probability measures on linearly ordered topological spaces

Coauthors: Miguel Ángel Sánchez-Granero

In this work we describe a theory of a cumulative distribution function (in short, cdf) on a separable linearly ordered topological space (LOTS) from a probability measure defined in this space. This function can be extended to the Dedekind-MacNeille completion of the space where it does make sense to define the pseudo-inverse. Moreover, we study the properties of both functions (the cdf and the pseudo-inverse) and get results that are similar to those which are well-known in the classical case. We also give conditions such that there is an equivalence between probability measures and distribution functions defined on a separable LOTS. From this theory, some applications have arisen, such as a goodness-of-fit test.

(STT) Frédéric Mynard
New Jersey City University

Special subsets of βX and non-topological convergence properties characterized topologically

The interrelations between various classes of convergence spaces defined by countability conditions are studied. Remarkably, they all find characterizations in the usual space of ultrafilters in terms of classical topological properties. This is exploited to produce relevant examples in the realm of convergence spaces from known topological examples.