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2024 NORTH AMERICAN ANNUAL MEETING OF THE ASSOCIATION FOR SYMBOLIC LOGIC

Iowa State University
Ames, IA, USA

May 14–17, 2024

Please note: This program is a draft for the upcoming ASL North American meeting and is subject the change. Updated versions will be posted on the ASL website and the conference website.

Program Committee: Barbara Csima (chair), Nick Galatos, Alex Kruckman, Tim McNicholl and Itay Neeman.
Local Organizing Committee: Samik Basu, Tim McNicholl (chair), Konstantin Slutsky, Eric Weber and Kristin Yvonne-Rozier.

The 10th Carol Karp Prize was awarded to John Steel in 2023 for his work in set theory, especially for his book *A Comparison Process for Mouse Pairs.* Grigor Sargsyan will give the Karp Prize Lecture on the work of John Steel.

The conference will take place in Carver Hall, home of the Mathematics Department at Iowa State University. Room information will be included in a later draft of the program. The welcoming reception will be held at 6pm on Tuesday May 14 at the North Prairie Room of the Gateway Hotel.

TUESDAY, May 14

Morning

8:30 – 9:00	Registration.
9:00 – 9:50	Invited Lecture: **Phokion G. Kolaitis** (University of California Santa Cruz and IBM Research), *Characterizing rule-based languages.*
10:00 – 10:20	Coffee.
10:30 – 11:20	Tutorial Lecture 1: **Anush Tserunyan** (McGill University), *How a logician proves pointwise ergodic theorems, part 1.*
11:30 – 12:20	Invited Lecture: **Henry Towsner** (University of Pennsylvania), *Dividing lines in hypergraphs.*

Afternoon

2:00 – 3:50	Special Session AL1, CT1, LC1, MT1 and ST1. See pages 2–6.
4:00 – 4:20	Coffee.
4:30 – 5:20	Karp Prize Lecture: **Grigor Sargsyan** (Instytut Matematyczny Polskiej Akademii Nauk), *Descriptive inner model theory.*
6:00 – 9:00	Welcoming Reception. North Prairie Room, Gateway Hotel

WEDNESDAY, May 15

Morning

8:30 – 9:00	Registration.
9:00 – 9:50	Tutorial Lecture 1: **Ross Willard** (University of Waterloo), *The constraint satisfaction problem dichotomy theorem, part 1.*

10:00 – 10:20 Registration and coffee.
10:30 – 11:20 Tutorial Lecture 2: **Anush Tserunyan** (McGill University), *How a logician proves pointwise ergodic theorems, part 2.*
11:30 – 12:20 Invited Lecture: **Monroe Eskew** (Kurt Gödel Research Center), *Dense ideals.*

Afternoon

2:00 – 3:50 Special Session AL2, CT2, MT2, ST2 and UA1. See pages 2–6.
4:00 – 4:20 Coffee.
4:30 – 5:20 Invited Lecture: **Katherine Kosaian** (Iowa State University), *Formalizing mathematics in Isabelle/HOL, ft. algorithms for real quantifier elimination*

THURSDAY, May 16

Morning

8:30 – 9:00 Registration.
9:00 – 9:50 Tutorial Lecture 2: **Ross Willard** (University of Waterloo), *The constraint satisfaction problem dichotomy theorem, part 2.*
10:00 – 10:20 Coffee.
10:30 – 11:20 Tutorial Lecture 3: **Anush Tserunyan** (McGill University), *How a logician proves pointwise ergodic theorems, part 3.*
11:30 – 12:20 Invited Lecture: **Joel Nagloo** (University of Illinois Chicago), *Model theory and automorphic functions.*

Afternoon

2:00 – 3:50 Special Session CT3, LC2, MT3 and UA2. See pages 2–6.
4:00 – 4:20 Coffee.
4:30 – 5:20 Invited Lecture: **Tommaso Moraschini** (Universitat de Barcelona), *Spectra of Heyting algebras.*
5:30 – 6:50 Contributed Talks.

FRIDAY, May 17

Morning

8:30 – 9:00 Registration.
9:00 – 9:50 Tutorial Lecture 3: **Ross Willard** (University of Waterloo), *The constraint satisfaction problem dichotomy theorem, part 3.*
10:00 – 10:20 Coffee.
10:30 – 12:20 Special Session AL3, LC3, ST3 and UA3. See pages 2–6.

SPECIAL SESSIONS

AL. Algebraic Logic

(Organized by Guram Bezhanishvili and José Gil-Ferez)

Session AL1: Tuesday, May 14

2:00 – 2:20 **Alasdair Urquhart** (University of Toronto), *Two results for the logic* **KR**.
2:30 – 2:50 **Isis A. Gallardo** (University of Denver), *Decidability and generation of the variety of distributive ℓ-pregroups.*

3:00 – 3:20 **Melissa Sugimoto** (Chapman University), *Integrality: A local perspective on residuated structures.*
3:30 – 3:50 **Adam Přenosil** (Universitat de Barcelona), *Unital lattice subreducts of integral residuated lattices.*

Session AL2: Wednesday, May 15

2:00 – 2:20 **James Madden** (Louisiana State University), *Preservation of subfitness of semilattices under certain constructions.*
2:30 – 2:50 **Papiya Bhattacharjee** (Florida Atlantic University), $Max(dL)$ *and fusible frames.*
3:00 – 3:20 **Marco Abbadini** (University of Birmingham), *A duality for metrically complete lattice-ordered ordered groups.*
3:30 – 3:50 **Xavier Caicedo** (Universidad de los Andes), *The model completion of projectable abelian* ℓ*-groups.*

Session AL3: Friday, May 17

10:30 – 10:50 **Wesley H. Holliday** (University of California, Berkeley), *Modal logic, fundamentally.*
11:00 – 11:20 **Chase Meadors** (University of Colorado), *Local finiteness in varieties of MS4-algebras.*
11:30 – 11:50 **Amanda Vidal** (Artificial Intelligence Research Institute), *Modal fuzzy logics: general and standard semantics.*
12:00 – 12:20 **Sara Ugolini** (Artificial Intelligence Research Institute), *Equational anti-unification.*

CT. Computability Theory

(Organized by Rachael Alvir and Steffen Lempp)

Session CT1: Tuesday, May 14

2:00 – 2:20 **Matthew Harrison-Trainor** (University of Illinois Chicago), *A return to degree spectra of relations on a cone.*
2:30 – 2:50 **Meng-Che "Turbo" Ho** (California State University, Northridge), *Word problem of groups as ceers.*
3:00 – 3:20 **Russell Miller** (Queens College – CUNY), *Computability for absolute Galois groups of computable fields.*
3:30 – 3:50 **Isabella Scott** (University of Chicago), *Constructions surrounding existentially closed groups.*

Session CT2: Wednesday, May 15

2:00 – 2:20 **David Gonzalez** (University of California, Berkeley), *Scott sentence complexities of linear orderings.*
2:30 – 2:50 **Josiah Jacobsen-Grocott** (University of Wisconsin-Madison), *Strong minimal pairs in the enumeration degrees.*
3:00 – 3:20 **Bjørn Kjos-Hanssen** (University of Hawaiʻi at Mānoa), *Formal marginalia in computability theory.*
3:30 – 3:50 **Luca San Mauro** (University of Bari), *On the learning power of equivalence relations.*

Session CT3: Thursday, May 16

2:00 – 2:20 **Damir Dzhafarov** (University of Connecticut), *The Ginsburg-Sands theorem and computability theory.*

2:30 – 2:50 **Keng Meng Ng** (Nanyang Technological University), *Separating notions in effective topology and analysis.*
3:00 – 3:20 **Jan Reimann** (Penn State University), *Complexity notions on monoids and pointwise dimension.*
3:30 – 3:50 **Don Stull** (University of Chicago), *Dimensions of pinned distance sets.*

LC. Logic in Computer Science

(Organized by Larry Moss and Scott Weinstein)

Session LC1: Tuesday, May 14

2:00 – 2:50 **Siddharth Bhaskar** (James Madison University), *Transfinite semantics for programming languages.*
3:00 – 3:50 **Elsa L. Gunter** (University of Illinois, Urbana - Champaign), *A biased overview of influences of symbolic logic on computer science.*

Session LC2: Thursday, May 16

2:00 – 2:50 **Rohit Parikh** (City University of New York), *How logic and computation can help us understand society.*
3:00 – 3:50 **Giorgi Japaridze** (Villanova University), *Strong alternatives to weak theories.*

Session LC3: Friday, May 17

10:30 – 11:20 **György Turán** (University of Illinois at Chicago), *Explanations in AI and connections to logic.*
11:30 – 12:20 **Wei-Lin Wu** (University of California, Santa Cruz), *A study of the expressive power of homomorphism counts.*

MT. Model Theory

(Organized by Chris Laskowski and Adele Padgett)

Session MT1: Tuesday, May 14

2:00 – 2:50 **Maryanthe Malliaris** (University of Chicago), *On stability.*
3:00 – 3:20 **Scott Mutchnik** (University of Illinois Chicago), *Identifying genericity.*
3:30 – 3:50 **Léo Jimenez** (The Ohio State University), *Bounding non-orthogonality using algebraic groups.*

Session MT2: Wednesday, May 15

2:00 – 2:50 **Bradd Hart** (McMaster University), *An update on the model theory of operator algebras.*
3:00 – 3:20 **Benjamin Castle** (University of Maryland), *Advances on Zilber's trichotomy and its applications.*
3:30 – 3:50 **Gabriel Conant** (The Ohio State University), *Stable arithmetic regularity for functions.*

Session MT3: Thursday, May 16

2:00 – 2:50 **Margaret E.M. Thomas** (Purdue University), *Definable topological spaces in o-minimal structures.*
3:00 – 3:20 **Sebastian Eterović** (University of Leeds), *Geometric properties of transcendental holomorphic functions.*
3:30 – 3:50 **Elliot Kaplan** (McMaster University), *Generic derivations on o-minimal structures.*

ST. Set Theory

(Organized by Clinton Conley and Nam Trang)

Session ST1: Tuesday, May 14

2:00 – 2:50 **John Krueger** (University of North Texas), *Forcing over a free Suslin tree.*
3:00 – 3:50 **Robin Tucker-Drob** (University of Florida), *TBA.*

Session ST2: Wednesday, May 15

2:00 – 2:30 **Farmer Schlutzenberg** (TU Vienna), *Correctness of inner models and optimal wellorders.*
2:40 – 3:10 **Forte Shinko** (University of California Berkeley), *Hyperfiniteness of generic actions on Cantor space.*
3:20 – 3:50 **Trevor M. Wilson** (Miami University), *Characterizing large cardinals in terms of Löwenheim–Skolem and weak compactness properties of strong logics.*

Session ST3: Friday, May 17

10:30 – 11:00 **Iian Smythe** (University of Winnipeg), *A descriptive approach to manifold classification.*
11:10 – 11:40 **Tom Benhamou** (Rutgers University), *Cofinal types of ultrafilters on measurable and non-measurable cardinals.*
11:50 – 12:20 **Sumun Iyer** (Cornell University), *Extremely amenable groups of homeomorphisms.*

Universal Algebra

(Organized by Charlotte Aten and Keith Kearnes)

Session UA1: Wednesday, May 15

2:00 – 2:30 **Michael Kinyon** (University of Denver), *Loops with squares in two nuclei.*
2:40 – 3:10 **William DeMeo** (Formal Methods Division, IOHK), *Formal verification of the Cardano blockchain ledger.*
3:20 – 3:50 **Andrew Moorhead** (TU Dresden), *When are bounded arity polynomials enough?*

Session UA2: Thursday, May 16

2:00 – 2:30 **Peter Mayr** (University of Colorado Boulder), *Filtered Boolean powers of simple algebras.*
2:40 – 3:10 **Patrick Wynne** (University of Colorado Boulder), *The subpower membership problem for nilpotent Mal'cev algebras.*
3:20 – 3:50 **Andrei A. Bulatov** (Simon Fraser University), *Operator CSP and satisfiability gap.*

Session UA3: Friday, May 17

10:30 – 11:00 **John Harding** (New Mexico State University), *Monadic ortholattices.*
11:10 – 11:40 **Andreja Tepavčević** (Serbian Academy of Sciences and Arts), *Axiomatic approach to lattice characterization of groups.*
11:50 – 12:20 **Jonathan Smith** (Iowa State University) *Quasilattices and complex concept analysis.*

Abstract of the Karp Prize Lecture

▸ GRIGOR SARGSYAN, *Descriptive inner model theory.*
Department of Foundations of Mathematics, Instytut Matematyczny Polskiej Akademii Nauk.
E-mail: gsargsyan@impan.pl.

The talk is a tribute to Steel's *A Comparison Process for Mouse Pairs.*

Abstract of invited tutorials

▸ ANUSH TSERUNYAN, *How a logician proves pointwise ergodic theorems.*
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Descriptive set theory offers methods for studying global properties of sets and functions on a Polish space via local combinatorics on the level of points of the space. I will illustrate this mantra by showing how to reduce pointwise ergodic theorems to finitary tiling problems. We will give an elementary proof of the classical pointwise ergodic theorem for a probability measure preserving (pmp) transformation, and hint at a similar proof of Lindenstraus's ergodic theorem for pmp actions of amenable groups using a finitary tiling lemma of Kerr and Li. We will then discuss a more recent "backward" ergodic theorem for one pmp transformation and pointwise ergodic theorems for pmp actions of free semigroups (joint work with Jenna Zomback). If time permits, we will also consider the broader setting of Borel graphs on probability spaces and discuss a general pointwise ergodic theorem for them.

▸ ROSS WILLARD, *The constraint satisfaction problem dichotomy theorem.*
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URL Address: www.math.uwaterloo.ca/~rdwillar/.

In the late 1990s, T. Feder and M. Vardi [3] isolated the class of "constraint satisfaction problems with fixed (finite) template," or CSPs, as an interesting and robust class of computational problems, and they conjectured that every problem in this class is either in P or is NP-complete (or both if P = NP). CSPs are parametrized by finite relational structures in finite signatures, and (as it turns out) the computational problems they encode are profitably studied via techniques coming from universal algebra. Interest in the CSP dichotomy conjecture brought (some) computer scientists and universal algebraists together starting in the early 2000s, culminating in 2017 with two independent proofs of the conjecture by A. Bulatov [1, 2] and D. Zhuk [4, 5].

Given a finite structure M, the computational problem CSP(M) is just the problem which, given a formula φ which is a conjunction of atomic formulas in the signature of M, asks whether φ^M is nonempty. There is an "obvious reason" for CSP(M) to be NP-complete: M pp-inteprets the two-element structure encoding 3-SAT. Bulatov and Zhuk proved that, if M fails to be NP-complete for this obvious reason, then CSP(M) is tractable. To do this, they used algebra (old and new) to develop rudimentary structure theories for sets definable by conjunction-of-atomic formulas in the relevant finite structures M.

In this tutorial I will introduce CSPs, explain the universal algebraic perspective, and attempt to give at least an impression of one of the two structure theories (Zhuk's) and how it is used to prove tractability of CSP(M).

[1] Andrei A. Bulatov, *A dichotomy theorem for nonuniform CSPs*, ***58th Annual IEEE Symposium on Foundations of Computer Science–FOCS 2017*** (Berkeley, CA), IEEE Computer Society, 2017, pp. 319–330.

[2] ———, *A dichotomy theorem for nonuniform CSPs simplified*, arXiv:2007:09099 (2020), 42 pp.

[3] Tomás Feder and Moshe Y. Vardi, *The computational structure of monotone monadic SNP and constraint satisfaction: a study through Datalog and group theory*, ***SIAM Journal on Computing***, vol. 28 (1999), no. 1, pp. 57–104.

[4] Dmitriy Zhuk, *A proof of CSP dichotomy conjecture*, ***58th Annual IEEE Symposium on Foundations of Computer Science–FOCS 2017*** (Berkeley, CA), IEEE Computer Society, 2017, pp. 331–342.

[5] ———, *A proof of the CSP dichotomy conjecture*, ***Journal of the ACM***, vol. 67 (2020), no. 5, Art. 30, 78 pp.

Abstracts of invited plenary lectures

▶ MONROE ESKEW, *Dense ideals.*
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We present recent work with Yair Hayut showing that, relative to a huge cardinal, it is consistent that simultaneously for all $n \geq 1$, there is an ω_n-complete I on ω_n such that $\mathcal{P}(\omega_n)/I \cong \mathrm{Col}(\omega_{n-1}, \omega_n)$. This answers some questions of Foreman [2] and has several striking combinatorial consequences. By theorem of Woodin, our model satisfies a certain "transfer principle" that copies structures on ω_m to ω_n for $m < n$, enabling the solution to several problems in infinite combinatorics concerning graph colorings [3] and partition principles [1].

[1] Nathaniel Bannister, Jeffrey Bergfalk, Justin Tatch Moore, and Stevo Todorcevic, *A descriptive approach to higher derived limits*, ***Journal of the European Mathematical Society***, to appear.

[2] Matthew Foreman, *Ideals and generic elementary embeddings*, ***Handbook of set theory, Vol. 2*** (Matthew Foreman and Akahiro Kanamori, editors), Springer, Dordrecht, 2010, pp. 885–1147.

[3] Stevo Todorcevic, *Combinatorial dichotomies in set theory*, ***The Bulletin of Symbolic Logic***, vol. 17 (2011), no. 1, pp. 1–72.

▶ PHOKION G. KOLAITIS, *Characterizing rule-based languages.*
Computer Science and Engineering Department, University of California Santa Cruz and IBM Research.
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There is a mature body of work in logic aiming to characterize logical formalisms in terms of their structural or model-theoretic properties. The origins of this work can be traced to Alfred Tarski's program to characterize metamathematical notions in "purely mathematical terms" and to Per Lindström's abstract characterizations of first-order logic. For the past forty years, rule-based logical languages have been widely used in databases and in related areas of computer science to express integrity constraints and to specify transformations in data management tasks, such as data exchange and ontology-based data access. The aim of this talk is to present an overview of more recent results that characterize various classes of rule-based logical languages in terms of their structural or model-theoretic properties.

▶ KATHERINE KOSAIAN, *Formalizing mathematics in Isabelle/HOL, ft. algorithms for*

real quantifier elimination.
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There are many mathematical algorithms that are used in safety-critical contexts. Correctness of these algorithms, and the mathematical results underlying them, is crucial. In formal methods, a piece of software called a theorem prover can used to formally verify algorithms. In this approach, code for an algorithm is accompanied by a rigorous proof of correctness that only depends on the logical foundations of the theorem prover. Algorithms that have been verified in this way are highly trustworthy and thus safe for use in safety-critical applications.

The theorem prover Isabelle/HOL is well-suited for formalizing mathematics. This talk will motivate formalized mathematics, exhibit how mathematics is formalized in Isabelle/HOL, and discuss work on formalizing algorithms for real quantifier elimination as a use case.

▸ TOMMASO MORASCHINI, *Spectra of Heyting algebras.*
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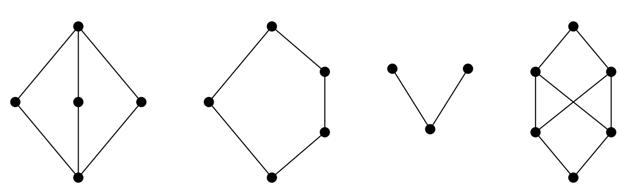
The *prime spectrum* of a Heyting algebra is the poset of its prime filters. In view of Esakia duality [3, 4], a poset is isomorphic to the prime spectrum of a Heyting algebra if and only if it can be endowed with a topology that turns it into an Esakia space. Because of this, posets isomorphic to the prime spectrum of some Heyting algebra have been called *Esakia representable*. The problem of describing Esakia representable posets was first raised in [4] and echoes analogous problems for distributive lattices [5] and commutative rings [6].

While the problem of describing Esakia representable posets remains open, we will describe the Esakia representable well-ordered trees. Furthermore, we shall tackle the problem of determining which posets are the top parts of some Esakia space. More precisely, a poset is said to be *image finite* when its principal upsets are finite. A poset X is the *image finite part* of a poset Y when X is the subposet of Y consisting of all the elements whose principal upset is finite. The problem of determining whether every image finite poset is the image finite part of some Esakia space was raised in [1]. Notably, it can be equivalently phrased as follows: is every profinite Heyting algebra the profinite completion of some Heyting algebra? We answer this problem negatively by showing that every profinite member of an equational class K of Heyting algebra is a profinite completion if and only if K omits the Heyting algebras of upsets of the four posets depicted below.

This talk is based on joint work with G. Bezhanishvili, N. Bezhanishvili, D. Fornasiere, and M. Stronkowski. Some of these results have been collected in [2].



[1] G. Bezhanishvili and P. J. Morandi, *Profinite Heyting algebras and profinite*

completions of Heyting algebras, ***Georgian Mathematical Journal***, vol. 16(2009), pp. 29–47.

[2] G. Bezhanishvili, N. Bezhanishvili, T. Moraschini and M. Stronkowski, *Profiniteness and representability of spectra of Heyting algebras*, ***Advances in Mathematics***, vol. 391 (2021), 107959, 47 pp.

[3] L. Esakia, *Topological Kripke models*, ***Soviet Mathematics Doklady***, vol. 15 (1974), pp. 147–151.

[4] L. Esakia, ***Heyting Algebras. Duality Theory***, (Anton Evseev, translator), Springer, 2019.

[5] G. Grätzer, ***Lattice Theory. First Concepts and Distributive Lattices***, W. H. Freeman and Company, 1971.

[6] I. Kaplansky, ***Commutative rings***, revised edition, The University of Chicago Press, 1974.

▸ JOEL NAGLOO, *Model theory and automorphic functions.*
University of Illinois Chicago, Department of Mathematics, Statistics, and Computer Science, 851 S. Morgan Street, Chicago, IL, USA, 60607-7045..
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Roughly speaking, an automorphic function is a function on a space that is invariant under the action of some group and as such, a function on the quotient space. These functions appear centrally in many areas of mathematics, especially in Diophantine geometric problems such as the André-Oort and the Zilber-Pink conjectures.

Over the past two decades, automorphic functions - and more generally covering maps - have been studied from a variety of model theoretic perspectives. In this talk, I will discuss three such interactions:

1. Definability of (restrictions of) automorphic functions in o-minimal expansions of the reals.
2. Strong minimality, in differentially closed fields, of the definable sets/differential equations satisfied by automorphic functions.
3. $L_{\omega_1,\omega}$-categoricity in power of the theory of a fixed automorphic function.

I will highlight the history of those approaches and point out some of the connections between them.

▸ HENRY TOWSNER, *Dividing lines in hypergraphs.*
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Dividing lines are properties which separate structures which are, in some way, tame or orderly from those which are, in some complementary way, wild or random. Inspired by connections to graph theory, it turns out that important dividing lines like NIP and stability can be viewed as characterizing when a binary (or higher-arity) relation is "approximately unary"—when the question of whether (x, y) satisfies a relation can be almost reduced to the properties of the individual values x and y.

Higher order analogs of these dividing lines, therefore, should identify when the question "does (x, y, z) satisfy the relation?" can be almost reduced to purely binary questions about the pairs (x, y), (x, z), and (y, z) separately. Viewed through this lens, the two notions of stability and NIP generalize to a family of distinct properties that a ternary relation might have.

This talk will give an outline of our current picture of what these properties are, focusing on the informal picture of how we can describe the idea of being "approximately binary" in different ways and how they lead to distinct properties.

Abstracts of invited talks in the Special Session on Algebraic Logic

▸ MARCO ABBADINI*, VINCENZO MARRA AND LUCA SPADA, *A duality for metrically complete lattice-ordered ordered groups*.
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Just like Boolean algebras are the algebraic semantics of classical propositional logic, Abelian lattice-ordered groups provide an algebraic tool for certain nonclassical logics. For example (due to their equivalence with MV-algebras), they are fundamental for the algebraic investigation of Łukasiewicz many-valued logic.

In a landmark paper in 1936, Stone obtained a representation theorem for Boolean algebras. In modern terms, his result amounts to a dual equivalence between Boolean algebras and Stone spaces. We provide an analogous duality for a class of Abelian lattice-ordered groups (with a designated element called unit). Our work takes inspiration from Yosida's duality (1941) between compact Hausdorff spaces and metrically complete unital vector lattices. We extend Yosida's theorem to metrically complete unital lattice-ordered groups, thus dropping the structure of real vector spaces. This calls for a generalised notion of compact Hausdorff space whose points carry an arithmetic character. The arithmetic character of a point is a metrically complete additive subgroup of $\mathbb{R}$ containing 1—namely, either $\frac{1}{n}\mathbb{Z}$ for an integer $n = 1, 2, \ldots$, or $\mathbb{R}$. The original Yosida duality is obtained by considering the full subcategory of spaces every point of which is assigned $\mathbb{R}$.

This presentation is based on [1].

[1] Marco Abbadini, Vincenzo Marra and Luca Spada, *Stone-Gelfand duality for metrically complete lattice-ordered groups*, arXiv/2210.15341.

▸ PAPIYA BHATTACHARJEE, *$Max(dL)$ and fusible frames.*
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The space of maximal d-ideals of $C(X)$ is well known and the concept of d-elements has been generalized for algebraic frames with the FIP by J. Martìnez and E. Zenk. In a recent article, maximal d-subgroups of a lattice-ordered group has been introduced and studied by the speaker along with W. McGovern. Finally, the space of maximal d-elements and some properties of this topological space with respect to the hull-kernel topology has been studied for algebraic frames with FIP (by the speaker). It turns out that even though certain behaviors of Max_d-objects hold for $C(X)$ and any W-objects, these behaviors do not follow through in frames. The speaker will discuss different properties of $Max(dL)$ objects and introduce the concept of "fusibility" for frames. It will be revealed that fusible frames play an important role in the study of $Max(dL)$.

[1] Bhattacharjee, P., *Maximal d-elements of an algebraic frame*, ***Order***, vol. 36

(2019), pp. 377–390.

[2] Bhattacharjee, P. and W. Wm. McGovern, *Maximal d-subgroups and ultrafilters*, ***Rendiconti del Circolo matematico di Palermo***, vol. 67 (2018), no. 3, pp. 421–440.

[3] Henriksen, M., J. Vermeer, and R. G. Woods., *Quasi F-covers of Tychonoff spaces*, ***Transactions of the American Mathematical Society***, vol. 303 (1987), no. 2, pp. 779–803.

[4] Huisjmans, C.B. and B. de Pagter, *Maximal d-ideals in a Riesz space*, ***Canadian Journal of Mathematics***, vol. 35 (1983), no. 6, pp. 1010–1029.

[5] Martìnez, J. and E. Zenk, *When an algebraic frame is regular*, ***Algebra Universalis***, vol. 50 (2003), pp. 231–257.

▶ XAVIER CAICEDO, *The model completion of projectable abelian ℓ-groups.*
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Projectable abelian lattice ordered groups are Boolean products of linearly ordered abelian groups, and they have a model completion which consists on the divisible members of the class, without weak units, and having atomless Boolean skeleton of each closed interval. This allows us to identify the model completion of the variety of abelian lattice ordered groups supporting an additional operation, $(AL)_{\triangleright}$, introduced recently by Metcalfe and Reggio (*Model completions for universal classes of algebras: necessary and sufficient conditions*, JSL 2022).

▶ NIKOLAOS GALATOS AND ISIS A. GALLARDO*, *Decidability and generation of the variety of distributive ℓ-pregroups..*
Department of Mathematics, University of Denver, Denver, CO, USA.
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Lattice-ordered pregroups (ℓ-pregroups) represent a natural generalization of lattice-ordered groups (ℓ-groups). It is well-established that every ℓ-group can be embedded into a symmetric one, as demonstrated by Cayley-Holland's embedding theorem. Analogously, a Cayley-Holland's embedding theorem exists for distributive ℓ-pregroups, asserting that any distributive ℓ-pregroup can be embedded into a functional one.

In this work, we enhance this result by establishing that any distributive ℓ-pregroup can be embedded into a functional one over a chain that is locally isomorphic to $\mathbb{Z}$. Utilizing this, we demonstrate that the variety of distributive ℓ-pregroups is generated by the (single) functional algebra over the integers. We will later use this to prove the decidability of the variety.

▶ WESLEY H. HOLLIDAY, *Modal logic, fundamentally.*
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Non-classical generalizations of classical modal logic have been developed in the contexts of constructive mathematics and natural language semantics. In this talk, we will discuss a general approach to the semantics of non-classical modal logics via algebraic representation theorems. We begin with complete lattices L equipped with an antitone operation $\neg$ sending 1 to 0, a completely multiplicative operation $\Box$, and a completely additive operation $\Diamond$. Such lattice expansions can be represented by means of a set X together with binary relations $\lhd$, R, and Q, satisfying some first-order conditions, used to represent $(L, \neg)$, $\Box$, and $\Diamond$, respectively. Indeed, any lattice L equipped with such a $\neg$, a multiplicative $\Box$, and an additive $\Diamond$ embeds into the lattice of propositions of a frame $(X, \lhd, R, Q)$. Building on our recent study of *fundamental logic* [1], we then focus on the case where $\neg$ is dually self-adjoint ($a \leq \neg b$ implies

$b \leq \neg a$) and $\Diamond\neg a \leq \neg\Box a$. In this case, our representations can be constrained so that $R = Q$, i.e., we need only add a single relation to $(X, \lhd)$ to represent both $\Box$ and $\Diamond$. Using these results, we can prove that a system of fundamental modal logic is sound and complete with respect to an elementary class of bi-relational structures $(X, \lhd, R)$.

[1] Wesley H. Holliday, *A fundamental non-classical logic*, ***Logics***, vol. 1 (2023), pp. 36–79.

▸ JAMES MADDEN, *Preservation of subfitness of semilattices under certain constructions.*
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Let $(S, \vee, 0)$ be a join-semilattice with 0. S said to be *subfit* if S has a largest element 1 and for all $x, x' \in S$, if $\forall y \in S$ $(x \vee y = 1 \iff x' \vee y = 1)$, then $x = x'$. Subfitness was first introduced in 1938 (under a different name) by Wallman [3] as a condition on the semilattice of open sets of a topological space, and it was studied in a purely algebraic setting by Piece in 1954 [2].

For $a \in S$, let $(a) := \{ x \in S \mid x \leq a \}$. Recall that S is said to be *distributive* if, whenever $z \leq x \vee y$ in S, there are $x', y' \in S$ such that $x' \leq x$, $y' \leq y$ and $z = x' \vee x'$. At the 2022 BLAST Conference, Madden posed the following question: *Suppose S is a distributive semilattice, $a, b \in S$ and $a \vee b = 1$. If the subsemilattices (a) and (b) are subfit, does it follow that S is subfit?*

A simple finite example shows that the distributive hypothesis is necessary. When the problem was announced, the answer was known to be "Yes" for finite semilattices. In late 2022, Tressl proved that if S is a distributive lattice, then the answer is, "Yes," and in late 2023, Bezhanishvili produced an example showing that in general, the answer is "No."

Subfitness is an important separation property in the theory of locales; see [1]. The question above is the simplest of a family of local-global questions concerning preservation of separation properties in (pointfree) topology. Tressl's result implies that if a locale L is the union of two open sublocales, each subfit, then L is subfit. Contrast this with regularity: if X is the union of two open subspaces, each regular, then X need not be regular, as the line with two origins shows. Subfitness is also an important idea in algebra. A commutative ring with 1 is said to be *Jacobson* if every radical ideal in it is an intersection of maximal ideals. A ring is Jacobson if and only if its frame of radical ideals (i.e., the frame of opens of in its Zariski spectrum) is conjunctive. Our results are relevant to questions about the preservation of the Jacobson property under ring-theoretic constructions.

This is joint work with Guram Bezhanishvili, Andrew Moshier, Marcus Tressl, and Joanne Walters-Wayland.

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[3] H. Wallman, *Lattices and topological spaces*, ***Annals of Mathematics***, vol. 39 (1938), pp. 112–126.

▸ CHASE MEADORS, *Local finiteness in varieties of MS4-algebras.*
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It is a classic result of Segerberg and Maksimova that a variety of $\mathsf{S4}$-algebras is locally finite iff it is of finite depth. Since the logic $\mathsf{MS4}$ (monadic $\mathsf{S4}$) axiomatizes the one-variable fragment of $\mathsf{QS4}$ (predicate $\mathsf{S4}$), it is natural to try to generalize the

Segerberg–Maksimova theorem to this setting. We obtain several results in this direction. We provide a semantic criterion for local finiteness in $\mathsf{MS4}$ that is in general hard to verify, but provide an application showing a direct generalization of the Segerberg–Maksimova theorem holds for a family of varieties containing $\mathsf{S4}_u$ ($\mathsf{S4}$ with a universal modality). Our main negative result is a translation of varieties of $\mathsf{S5}_2$-algebras into semisimple varieties of $\mathsf{MS4}$-algebras of depth-2 which preserves and reflects local finiteness (the fusion $\mathsf{S5}_2 = \mathsf{S5} \oplus \mathsf{S5}$ is the bimodal logic of two $\mathsf{S5}$ modalities). In particular, this shows that the problem of characterizing locally finite varieties of $\mathsf{MS4}$-algebras is at least as hard as that of characterizing locally finite varieties of $\mathsf{S5}_2$-algebras, a well-known open problem in modal logic. Furthermore, we demonstrate with an example that our translation does not naturally extend to depth-3 or higher, suggesting that the problem is strictly harder. Finally, we end by discussing some conjectures and ongoing work concerning another natural extension of $\mathsf{MS4}$ where an analogue of Segerberg–Maksimova may hold. This is joint work with Guram Bezhanishvili.

► ADAM PŘENOSIL, *Unital lattice subreducts of integral residuated lattices.*
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Integral residuated lattices form a large variety of algebras whose subclasses provide algebraic semantics for various non-classical logics. A particular subvariety of interest is the variety of integral cancellative residuated lattices, which was first systematically studied in [1]. The authors of that paper in particular show that each lattice is a subreduct of a simple integral cancellative residuated lattice. This in particular means that integral cancellative residuated lattices do not satisfy any non-trivial quasi-equation in the signature of lattices. Whether the same holds for *commutative* integral cancellative residuated lattices has, however, long remained an open problem.

We provide an affirmative answer to this problem. In addition, we describe the subreducts of commutative integral cancellative residuated lattices in the signature of *unital* lattices (lattices equipped with a constant designating the top element) and show that they coincide with the unital lattice subreducts of integral residuated lattices, and therefore also of integral commutative and integral cancellative residuated lattices. This class is the quasivariety generated by unital lattices with a join irreducible top element, which is axiomatized by the quasi-equation

$$x \vee y \approx \mathbf{1} \Longrightarrow (x \wedge z) \vee (y \wedge z) \approx z.$$

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► MELISSA SUGIMOTO, *Integrality: A local perspective on residuated structures.*
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Residuated lattices are the algebraic semantics of substructural logics. Integrality ($x \leq 1$) is an important property for residuated lattices since it is equivalent to the proof-theoretical rule called weakening. In this talk, we investigate a class of structures that decompose into integral components and hence are referred to as *locally integral.*

In particular, we focus on *involutive partially ordered semigroups* (*ipo-semigroups*), which are structures of the form $\mathbf{A} = (A, \leq, \cdot, \sim, -)$ such that $(A, \leq)$ is a partially ordered set and $(A, \cdot)$ is a semigroup with two order-reversing operations $\sim$ and $-$

satisfying *involution* $\sim\!-x = x = -\!\sim x$ and *rotation* $x \cdot y \leq z \iff y \cdot \sim z \leq \sim x \iff -z \cdot x \leq -y$. In the case that the semigroup has an identity, we call it an *ipo-monoid*.

We show that every locally integral ipo-semigroup $\mathbf{A}$ decomposes in a unique way into a family of integral ipo-monoids. We also solve the reverse problem, that is, we provide necessary and sufficient conditions so that the glueing of a system of integral ipo-monoids becomes an ipo-semigroup. This is joint work with José Gil-Férez and Peter Jipsen.

▸ SARA UGOLINI, *Equational anti-unification*.
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The problem of finding a common generalization or *anti-unifier* of a set of terms has first been formalized around 1970 by Plotkin [2], Popplestone [3], and Reynolds [4]. Let us fix some algebraic language $\mathcal{L}$; we call an *anti-unification problem* a finite set $T = \{t_1, \ldots, t_k\}$ of terms of $\mathcal{L}$, and a solution, or *generalization*, of T is another term t of $\mathcal{L}$ for which there exist substitutions $\sigma_1, \ldots, \sigma_k$ such that $\sigma_i(t) = t_i$ for all $i = 1, \ldots, k$. In this contribution we are interested in anti-unification *up to some equational theory* $\mathcal{E}$; i.e., given an anti-unification problem $T = \{t_1, \ldots, t_k\}$, a solution is given by a term t for which there exist $\sigma_1, \ldots, \sigma_k$ such that for all $i = 1, \ldots, k$

$$\mathcal{E} \models \sigma_i(t) = t_i.$$

Given the fact that anti-unification problems always have a solution (mapping a fresh variable to each term), it becomes relevant to know whether there is a *least general solution*: a solution that can be obtained by all other possible solutions by further substitution. We can then define a notion of anti-unification type, which intuitively gives the cardinality of the set of least general solutions.

We show that both equational anti-unification problems and their type can be studied algebraically, in analogy with Ghilardi's approach to equational unification [1], with the use of projective algebras in the variety determined by the equational theory under consideration. Moreover, we show that in varieties where the finitely generated subalgebras of free algebras are projective (e.g., Boolean algebras and Heyting algebras), the study of the anti-unification type can be reduced to the study of the congruence lattice of the 1-generated free algebra.

This contribution is based on joint work with Tommaso Flaminio.

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▸ ALASDAIR URQUHART, *Two results for the logic* **KR**.
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The logic **KR** results from the logic **R** of relevant implication by adding the axiom $(A \wedge \neg A) \rightarrow B$. We prove two results for this logic. First, the decision problem in three variables is solvable, while the problem in four variables is unsolvable. Second, there is no free associative connective in **KR**. These are proved by adapting ideas from the theory of modular lattices. The corresponding problems for $\mathbf{R}$ remain open.

▶ AMANDA VIDAL, *Modal fuzzy logics: general and standard semantics.*
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Fuzzy logics arise as the 1-assertional logics of classes of bounded integral residuated lattices with a continuous monoidal operation. There are three main subvarieties which allow to generate any other algebra in the class though the so-called ordinal sum construction: the varieties of Gödel ($\mathbb{G}$), MV ($\mathbb{MV}$) and Product ($\mathbb{P}$) algebras, respective algebraic semantics of Gödel (G), Łukasiewicz (Ł) and Product (Π) logics. It is immediate that the previous logics are complete with respect to the corresponding linearly ordered algebras of their respective classes, but turns out that each one of them is complete with respect to the 1-assertional logic arising from a particular single algebra of its corresponding class, named the standard algebra, whose universe is $[0, 1]$.

The F.O. versions of the previous logics behave, however, differently. The logics arising from F.O. models evaluated over all algebras in the corresponding variety do coincide with those arising from F.O. models evaluated over the corresponding chains, which is usually referred to as the *general semantics*. The *standard semantics* are those arising from F.O. models evaluated over the corresponding standard algebras. In the Gödel case, the general and the standard semantic coincide. However, this is not the case for the Łukasiewicz nor Product logics: for the Łukasiewicz case, it follows as a corollary from the fact that the general logic is recursively enumerable (R.E), but the set of theorems of the standard logic is not [4], and an analogous proof can be done for the product case.

Modal fuzzy logics can be understood as the restriction of the previous F.O. logics to the fragment resulting from the usual translation of modal operators (and formulas in variables $\mathcal{V}$) to the formulas in the predicates language $\{R/2\} \cup \{P/1 \colon P \in \mathcal{V}\}$ as it is done in the classical case. This approach yields the so-called valued Kripke models, which are Kripke models where the accessibility relation and the variables at each world are evaluated over an algebra from the ones above. It is interesting to point out that, over the same class of models, two modal logics (i.e., consequence relations) are defined: the local and the global one. In the latter one, the truth of the premises is taken to be global (in the whole model), while in the former it is only world-wise. Nevertheless, their sets of theorems coincide.

Analogously to the F.O. case, we can refer to the *general* or *standard modal fuzzy logics* whenever the evaluation is considered over all algebras (or equivalently, chains) of the corresponding variety, or only over the standard one. Furthermore, the particular cases when the accessibility relation in the Kripke model is taken as a classical binary relation (crisp) are also of special interest, since the underlying Kripke frames are the classical ones.

In this talk we will compare the previous general and standard modal fuzzy logics. While in the Gödel case, the F.O. behavior immediately implies that, in all cases, the general and standard modal Gödel logics coincide, we will see how for the other two logics, the results are more varied. For what concerns the global modal logics, they behave as the F.O. ones, namely, the general and standard logics differ. For the crisp-accessibility cases, a reasoning similar to the one from F.O. can be done: on the one hand, we know that global modal standard Łukasiewicz and product logics with crisp accessibility relation are not R.E. [5]; on the other, since the general F.O. Łukasiewicz and Product logics are axiomatizable, the corresponding general modal logics are R.E.

The previous implies that the standard and general logics do not coincide. This approach cannot be used to tackle the question for global logics with valued accessibility, since their computational classification is not known. Nevertheless, two non-trivial examples can be built to prove that also these logics differ, exploiting peculiarities of a model over the Chang algebra for the Łukasiewicz logic, and of models over the analogous product algebra (arising from the same group) for the Product logic.

For what concerns local modal logics, however, we will see that the general and standard logics coincide, both for the crisp accessibility and for the valued one. This implies that the theorems of these logics (which are the same as the ones from the global logics) coincide too. In the Łukasiewicz cases, this equality can be proven relying in the F.O. completeness with respect to witnessed models (those in which, for each quantified formula, there is an assignment in the model where the formula without the quantifier takes the same value as the quantified one) [1]. For the Product logic, we can prove the claim for the models with valued accessibility relation by relying in the details of a proof of decidability of the Description Logic over the standard product algebra [3]. This approach, however, does not help to answer the case with crisp accessibility, which can nevertheless be proven by a different approach using the completeness of F.O. product logic with respect to models evaluated over a particular single algebra (the one arising via Cignoli-Torrens functor from the lexicographic sum $\mathbb{R}^{Q}$) [2]). Using models valued over this algebra we can identify certain conditions about infinite models, that can nevertheless be expressed with finitely many propositional formulas, and that capture all relevant information about the modal operations. In this fashion, the modal general product logic can be faithfully encoded within the the propositional one, and so, it is possible to rely in the standard completeness of the latter to prove that the general and standard modal logics also coincide.

As a corollary of this latter proof, the decidability of (local) crisp-accessibility modal product logic is also established.

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Abstracts of invited talks in the Special Session on Logic in Computer Science

▸ SIDDHARTH BHASKAR, *Transfinite semantics for programming languages.*
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The Turing-Church analysis of effective computation is claimed as an origin story by both recursion theory and the theory of programming languages, yet the two fields diverged sharply from there. While the latter considers a much richer family of models of computation than does the former, none of these model *transfinite* computation. On the other hand, the most common models of transfinite computation are machines, such as infinite-time Turing or register machines, rather than languages. In this talk I shall attempt to bridge the gap by describing a transfinite operational and denotational semantics for a simple language of while-programs, and prove them equivalent.

▸ ELSA L. GUNTER, *A biased overview of influences of symbolic logic on computer science*.
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Symbolic logic (and abstract algebra) has been overtly influencing computer science for more than 50 years. Obvious early influences were in the development of formal systems for the specification and verification of program properties. Early systems included Axiomatic Logic (aka Floyd-Hoare Logic), the Logic of Computable Functions, and Linear Temporal Logic. Use of these systems gave rise to interactive theorem provers and model checkers for there implementation. From this grew general purpose theorem provers based on logical systems for the formal foundation of mathematics, ranging from classical simple type theory (HOL, Isabelle) to intuitionistic dependent type theory (NuPRL, Coq, Agda, LF and more). These have developed into extremely powerful, versatile tools for the rigorous development and checking of a wide range of mathematics as well as the specification and verification of properties of complex computer systems.

A somewhat (then) surprising side-effect of the creation of interactive theorem provers was the growth of new areas of programming language theory. This includes a shift from the imperative model of programming languages to the declarative model and the introduction of static type systems incorporating ideas from universal algebra via algebraic types, polymorphism and type inference. These type systems fundamentally are logics, with a natural deduction presentation. Evolving from these type systems has been a chain of other more specialized logics or guaranteeing an array of specialized properties.

But type systems are specification languages, and type checking is verification, of a form that can be fully automated. Symbolic logic has found its way deeper into computer systems in many ways. Just one that shows some of the richness brought to systems development though the incorporation of abstractions suggested by formal logics and abstract algebra is the area of compiler optimizations. A large class of optimizations may be understood as conditional graph rewrites, with conditions given by temporal logic formulae and implemented by model finding, with a composition system making it a Kleene algebra. And all this is buried out of sight in some modern compilers.

▸ GIORGI JAPARIDZE, *Strong alternatives to weak theories*.
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I shall briefly survey number theories based on Computability Logic, the game-semantically conceived alternative to classical logic and a conservative extension of the latter. Such theories, dubbed “clarithmetics”, allow us to naturally and systematically capture various computational complexity classes, and do this in a stronger sense than weak arithmetics (e.g. bounded arithmetic) do. Specifically, due to being extensions rather than restrictions of Peano Arithmetic, clarithmetics achieve not only extensional but also intensional completeness with respect to their target complexity classes. The underlying concept of computability in clarithmetics is also more general than the traditional one, in that it is about interactive problems rather than merely about functions. In this world of interactive computability, some unusual phenomena occur. E.g., space complexity is not necessarily upper-bounded by time complexity; not all computable problems have computable time complexities; interactive P can be provably separated from interactive PSPACE; and more.

► ROHIT PARIKH, *How logic and computation can help us understand society.*
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We are all familiar with mathematical algorithms, like the Euclidean algorithm for finding the GCD of two natural numbers. Or the more complex algorithm to find out if a given number is prime.

But there are algorithms in society all over the place. An election is an algorithm for finding the *will of the people*, an important issue until Kenneth Arrrow showed in 1950 that the project could not succeed. There is a more successful algorithm *Vickrey auction* which allows people to bid their true value for an object without fear that they might be bidding too much or too little.

But the theory of social algorithms (or social software as it was once called) has not been studied enough. It does occur in Economics as the theory of Mechanism Design, or in computer science as Distributed Computation.

One important project then is to study *social algorithms* as a field unto themselves, discover their properties and find out what is possible, what is easy, what is difficult and what is impossible.

A related area is *Epistemic Logic*. Even when agents, as with Adam Smith, are motivated by self interest they can evaluate their interest, and hence their best move, only in terms of what they know or believe. This field has been well studied since the mid 1980's and the TARK conferences, held biennially, have been devoted to it. And yet there is insufficient study of how knowledge influences behavior, both individual and social. Two plays of Shakespeare, *Hamlet* and *Othello* are both concerned with knowledge. Hamlet because of doubt, or lack of knowledge. Othello because of a false belief which causes him to murder Desdemona.

This phenomenon causes us to think of false beliefs created globally by various sources, the mass media, or the social media. How in these difficult times can we extract reliable information from the many sources available to us? And how can we protect ourselves from bad actions caused by false beliefs?

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▸ GYÖRGY TURÁN, *Explanations in AI and connections to logic.*
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Recent developments in AI are based on machine learning using complex learned models, such as deep neural networks. These models are black boxes in the sense that there is no understanding of why an input is decided to belong to a certain class. In several applications, including societal and scientific ones, it is necessary to have an explanation of the decisions.

What is an explanation? This is a difficult question, thoroughly studied in the philosophy of science. Finding a formal definition seems elusive. Yet, for the important goal of building trustworthy AI it is necessary to have an understanding of the notion(s) of explanation and of methods to find and evaluate explanations.

Logic seems to be a natural candidate for approaching this question. This talk will give an introduction to the machine learning background needed for explainability, survey various logic-based approaches, present some results and formulate open problems.

A historical note: at the first Logic in Computer Science (LICS) conference in 1986 Anil Nerode gave an invited talk titled "A Logician Looks at Expert Systems: Areas for Mathematical Research." A lot has changed since then, but the issues discussed in that talk remain relevant.

▸ WEI-LIN WU, *A study of the expressive power of homomorphism counts.*
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A theorem by Lovász [1] asserts that two graphs G and H are isomorphic if and only if $\hom(F,G) = \hom(F,H)$ for all graphs F, where $\hom(A,B)$ denotes the number of homomorphisms from A to B. This characterization of graph isomorphism in terms of graph homomorphism counts motivated a wealth of research that seeks to characterize different *relaxations of isomorphism* – equivalence relations that are coarser than isomorphism – in terms of the numbers of homomorphisms "from" certain graphs F. Symmetrically, a theorem by Chaudhuri and Vardi [2] says that two graphs G and H are isomorphic if and only if $\hom(G,F) = \hom(H,F)$ for all graphs F. This dual characterization prompts to characterize relaxations of isomorphism in terms of the numbers of homomorphisms "to" certain graphs F. We show that no relaxation of isomorphism sandwiched between C^1-equivalence and C^{k+1}-equivalence is characterized this way, however, where C^k is first-order logic with counting limited to $k \geq 1$ variables. A different view of these characterizations is that they give rise to *query algorithms* for testing membership in a class that answer "yes" or "no" based on the evaluation of homomorphism-count queries [3]. As a variant, *homomorphism-existence* queries have values 0 or 1. We prove that for classes closed under homomorphic-equivalence, an algorithm of queries that are homomorphism counts from certain structures exists precisely when there is an algorithm of queries that are homomorphism existence from certain structures, which is surprising since the former is more capable in general. This is joint work with Atserias, ten Cate, Dalmau and Kolaitis.

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Abstracts of invited talks in the Special Session on Computability Theory

► DAMIR DZHAFAROV, *The Ginsburg-Sands theorem and computability theory.*
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In their 1979 paper "Minimal Infinite Topological Spaces", Ginsburg and Sands proved that every infinite topological space has an infinite subspace homeomorphic to exactly one of the following five topologies on ω: indiscrete, discrete, initial segment, final segment, and cofinite. The proof, while nonconstructive, features an interesting application of Ramsey's theorem for pairs (RT^2_2). We analyze this principle in computability theory and reverse mathematics, using Dorais's formalization of CSC spaces. Among our results are that the Ginsburg-Sands theorem for CSC spaces is equivalent to ACA_0, while for Hausdorff spaces it is provable in RCA_0. Furthermore, if we enrich a CSC space by adding the closure operator on points, then the Ginsburg-Sands theorem turns out to be equivalent to the Chain-antichain principle (CAC). The most surprising case is that of the Ginsburg-Sands theorem restricted to T_1 spaces. Here, we show that the principle lies strictly between ACA_0 and RT^2_2, yielding perhaps the first natural theorem of ordinary mathematics (i.e., conceived outside of logic) to occupy this interval. I will discuss the proofs of both the implications and separations, which feature several novel combinatorial elements, and survey a new class of purely combinatorial principles below ACA_0 and not implied by RT^2_2 revealed by our investigation. This is joint work with Heidi Benham, Andrew DeLapo, Reed Solomon, and Java Darleen Villano.

► DAVID GONZALEZ, *Scott sentence complexities of linear orderings.*
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The concept of Scott sentence complexity was introduced by Alvir, Greenberg, Harrison-Trainor and Turetsky and gives a way of assigning countable structures to elements of the Borel hierarchy. By calculating the Scott sentence complexities occurring in a class of structures we obtain a detailed picture of the descriptive complexity of its isomorphism relation. We study possible Scott sentence complexities of linear orderings using two approaches. First, we investigate the effect of the Friedman-Stanley embedding on Scott sentence complexity and show that it only preserves Π_α complexities. We then take a more direct approach and exhibit linear orderings of all Scott sentence complexities except Σ_3 and $\Sigma_{\lambda+1}$ for λ a limit ordinal. We show that the former can not be the Scott sentence complexity of a linear ordering. In the process we develop new techniques which appear to be helpful to calculate the Scott sentence complexities of structures in general.

This talk is based on joint work with Dino Rossegger.

► MATTHEW HARRISON-TRAINOR, *A return to degree spectra of relations on a cone.*
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Given an $\mathcal{L}$-structure $\mathcal{A}$, consider an additional relation R on $\mathcal{A}$ not in $\mathcal{L}$. Given an isomorphic copy $\mathcal{B} \cong_f \mathcal{A}$, there is a copy $R^{\mathcal{B}}$ of R on $\mathcal{B}$. The degree spectrum of R is the collection of all Turing degrees of $R^{\mathcal{B}}$ as $\mathcal{B}$ varies over all computable $\mathcal{B} \cong \mathcal{A}$. As is usual in computability theory, the degree spectra are quite wild and unclassifiable. Montalbán introduced degree spectra on a cone with the hope that, by reducing to structural properties of relations, some structure might be found. In my thesis, I showed that this was not the case, and the area lay dormant for some time. One of the primary open questions was to determine what happens in one of the simplest non-trivial cases, that of relations R on $(\omega, <)$. I will talk about recent joint work with Jad Damaj where we solved this question in an exciting way.

▸ URI ANDREWS, MENG-CHE "TURBO" HO* AND LUCA SAN MAURO, *Word problem of groups as ceers.*
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Since Dehn proposed the word problem in 1911 [1], it has been an important topic of study in both group theory and computability theory. Most naturally occurring groups are c.e., and their word problem is classically defined to be the c.e. set of words equal to the identity of the group and analyzed using Turing reductions. By the Higman embedding theorem, any c.e. degree is realized as a word problem of a finitely presented group [2].

In this talk, we consider the word problem of a group in the framework of computably enumerable equivalence relations (ceer), which has seen a lot of growth recently [3, 4, 5]. We compare ceers using computable reductions. We see that the Higman embedding theorem preserves only the Turing degrees of word problems but not the ceer degrees, thus failing to prove that every ceer degree is realized as a word problem. Indeed, not every ceer degree is realized as the word problem of some group. We will investigate some natural questions about the ceer degrees which contain a word problem and discuss some recent results.

[1] Dehn, M., *Über unendliche diskontinuierliche Gruppen*, ***Mathematische Annalen***, (1911), no. 1, 116–144.

[2] Clapham, C. R. J., *An embedding theorem for finitely generated groups*, ***Proceedings of the London Mathematical Society. Third Series***, vol. 17 (1967), pp. 419–430.

[3] Gao, Su and Peter Gerdes, *Computably enumerable equivalence relations*, ***Studia Logica***, vol. 67 (2001), no. 1, pp. 27–59.

[4] Andrews, Uri, Steffen Lempp, Joseph S. Miller, Keng Meng Ng, Luca San Mauro and Andrea Sorbi, *Universal computably enumerable equivalence relations*, ***The Journal of Symbolic Logic***, vol. 79 (2014), no. 1, pp. 60–88.

[5] Andrews, Uri, Serikzhan Badaev and Andrea Sorbi, *A survey on universal computably enumerable equivalence relations*, ***Computability and complexity*** Springer, Cham, 2017, pp. 418–451.

▸ JOSIAH JACOBSEN-GROCOTT, *Strong minimal pairs in the enumeration degrees.*
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We prove that there are strong minimal pairs in the enumeration degrees and that the degrees of the left and right sides of strong minimal pairs include Σ^0_2 degrees, although it is unknown if there is a strong minimal pair in the Σ^0_2 enumeration degrees. We define a stronger type of minimal pair we call a strong super minimal pair, and show that there are none of these in the enumeration degrees, answering a question of Lempp, Slaman, and Soskova [1]. We leave open the question of the existence of a super minimal pair in the enumeration degrees.

[1] Steffen Lempp, Theodore A. Slaman and Mariya I. Soskova, *Fragments of the theory of the enumeration degrees*, ***Advances in Mathematics***, vol. 383 (2021), 107686, 39 pp.

► BJØRN KJOS-HANSSEN, *Formal marginalia in computability theory.*
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Formal marginalia are formal proofs of small parts of a mathematical theorem or publication. Research in computability theory makes extensive use of Church's thesis, making full formalization laborious. I present some examples of formal marginalia for sources such as [1, 3, 2].

[1] Bjørn Kjos-Hanssen, *The probability distribution as a computational resource for randomness testing*, ***Journal of Logic and Analysis***, vol. 2 (2010), no. 10, pp. 1–13.

[2] ——— *A tractable case of the Turing automorphism problem: bi-uniformly E_0-invariant Cantor homeomorphisms*, ***Higher recursion theory and set theory***, Lecture Notes Series, Institute of Mathematical Sciences, National University of Singapore 44 (2024), World Scientific Publishing, Hackensack, NJ.

[3] Robert I. Soare, ***Turing computability: Theory and Applications***, Theory and Applications of Computability, Springer, 2016.

► RUSSELL MILLER, *Computability for absolute Galois groups of computable fields.*
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Fix a computable presentation $\overline{F}$ of the algebraic closure of a computable field F. With such a presentation, the automorphisms of $\overline{F}$ are naturally given as paths through a strongly computable finite-branching tree. If F has a splitting algorithm, then this tree has no terminal nodes. The operations of composition and inversion on these automorphisms (i.e., on these paths) are both type-2 computable. Thus we have an effective way of presenting the absolute Galois group $\mathrm{Gal}(F)$ of F.

Each automorphism has a Turing degree, and for each Turing ideal I, the automorphisms with degrees in I form a subgroup G_I of $\mathrm{Gal}(F)$. When I is a Scott ideal, it is known that G_I is elementary for existential formulas within $\mathrm{Gal}(F)$. We consider whether this might hold for all Turing ideals I. This requires examining the usual method of building a computable infinite subtree of $2^{<\omega}$ with no infinite paths and asking whether this method can be applied in the context of $\mathrm{Gal}(F)$. The specific answers may differ for different computable fields, including the field $\mathbb{Q}$ of rational numbers.

This is joint work with the number theorist Debanjana Kundu.

► KENG MENG NG, *Separating notions in effective topology and analysis.*
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We discuss some results in effective topological spaces and present some attempts to classify spaces using computablity notions. We discuss notions such as universality, metrisability and presentability from the effective point of view. Specifically, we discuss a series of recent results separating the degree of presentability of Polish spaces.

▸ JAN REIMANN, *Complexity notions on monoids and pointwise dimension.*
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We study axiomatic complexity notions on monoids. We are particularly interested in conditions under which the complexity induces an admissible distance function in the sense of Bennett et al. Embedding complexity monoids into metric spaces induces a pointwise dimension notion as well as a function mapping a real a to the set of a reals of pointwise dimension a. We compute the Hausdorff dimension of this set for a class of well-behaved complexity notions and use this to give new proofs of some results in metric Diophantine approximation, such as the Jarnik-Besicovitch theorem.

▸ LUCA SAN MAURO, *On the learning power of equivalence relations.*
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Borel reducibility has proven to be a decisive tool in understanding whether familiar classes of countable structures may be nicely classified. However, isomorphism problems with countably many isomorphism types have all the same Borel complexity; thus, a finer notion is required to investigate them properly. We present a framework [1, 2] that borrows ideas from computational learning theory and is suitable for this task. In a nutshell, a learner is given increasingly larger pieces of an arbitrary copy of a structure and, at each stage, is required to output a conjecture about the observed isomorphism type. The learning is successful if the conjectures eventually stabilize into a correct guess.

It turns out that, in this framework, a countable family of countable structures is learnable if and only if the related isomorphism problem continuously reduces to E_0 (the relation of eventual agreements on reals). Then, by replacing E_0 with other Borel equivalence relations E, we unlock a natural hierarchy for ranking isomorphism relations that escape the Borel analysis.

We explore this hierarchy and the learning power of Borel equivalence relations, studying both well-established benchmark relations and relations associated to classic learning criteria. We also revisit the Friedman-Stanley tower through the lenses of learning.

The talk is based on a number of different projects pursued together with N. Bazhenov, V. Cipriani, E. Fokina, S. Jain, A. Marcone, and F. Stephan.

[1] N. Bazhenov, V. Cipriani and L. San Mauro, *Learning algebraic structures with the help of Borel equivalence relations*, ***Theoretical Computer Science*** vol. 951 (2023), 113762.

[2] N. Bazhenov, E. Fokina and L. San Mauro, *Learning families of algebraic structures from informant*, ***Information and Computation*** vol. 275 (2020), 104590.

▸ ISABELLA SCOTT, *Constructions surrounding existentially closed groups.*
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Existentially closed groups were introduced in 1951 in analogue with algebraically closed fields. Since then, they have been further studied by Neumann, Macintyre, and Ziegler, who elucidated deep connections with model theory and computability theory. We review some of the literature on existentially closed groups and present new results that further refine these connections.

▸ DON STULL, *Dimensions of pinned distance sets.*
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Recent work has shown that techniques from computability theory and algorithmic randomness can be used to understand questions in classical geometric measure theory. One of the central problems in geometric measure theory is Falconer's distance set problem. Give a set E in the plane, and a point $x \in \mathbb{R}^2$, the pinned distance set of E with respect to x is the set of distances between x and the points in E. In this talk, we will discuss ongoing progress on this problem, and present improved lower bounds for both the Hausdorff and packing dimensions of pinned distance sets. We also discuss the computability-theoretic methods used to achieve these bounds.

This is joint work with Jacob Fiedler.

Abstracts of invited talks in the Special Session on Model Theory

▸ BENJAMIN CASTLE, *Advances on Zilber's trichotomy and its applications.*
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The last two years have seen significant progress toward several open problems around Zilber's trichotomy for strongly minimal sets. Most notably, this included a complete proof of the trichotomy for strongly minimal structures interpreted in algebraically closed fields. Meanwhile, significant progress has been made on the analogous statements for algebraically closed valued fields (ACVF) and o-minimal expansions of fields. In this talk, I will give an overview of the various relevant conjectures and their status reports, highlighting new work in ACVF. Time permitting, I will also discuss some applications of the trichotomy over algebraically closed fields.

▸ GABRIEL CONANT, *Stable arithmetic regularity for functions.*
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I will present a structure theorem for stable functions on amenable groups, which mirrors the arithmetic regularity lemma for stable subsets of finite groups (proved first in [6] for $\mathbb{F}_p^n$, and generalized to all finite groups in [4]; see also [7, 2]). Here a function $f\colon G \to [-1, 1]$ is called stable if the binary function $f(x \cdot y)$ is stable in the sense of continuous logic. Roughly speaking, our main result says that if G is amenable, then any stable function on G is approximately constant on all translates of a unitary Bohr set in G of bounded complexity. The proof uses ingredients from topological dynamics and continuous model theory, along with an ultraproduct construction with metric structures. We also establish a fair amount of local stable group theory in continuous logic. The key difference compared to the discrete case is that the space of generic types is no longer finite (or even profinite), which explains the necessity for Bohr sets in the final structure theorem. Finally, I will explain how our main result can be used to obtain applications with no ambient assumption of stability. For example, as a quick corollary we obtain the uniform version of Bogolyubov's Lemma for general amenable groups (proved originally for finite abelian groups by Ruzsa [5], then for finite groups in [1], and finally for amenable groups in [3]). Further potential applications will be discussed as time permits.

This is joint work with Anand Pillay.

[1] G. Conant, *On finite sets of small tripling or small alternation in arbitrary groups*, ***Combinatorics, Probability and Computing***, vol. 29 (2020), no. 6, pp. 807–829.

[2] ———, *Quantitative structure of stable sets in arbitrary finite groups*, ***Proceedings of the American Mathematical Society***, vol. 149 (2021), no. 9, pp. 4015–4028.

[3] G. Conant, E. Hrushovski, and A. Pillay, *Compactifications of pseudofinite and pseudo-amenable groups*, arXiv:2308.08440, 2023.

[4] G. Conant, A. Pillay, and C. Terry, *A group version of stable regularity*, ***Mathematical Proceedings of the Cambridge Philosophical Society***, vol. 168 (2020), no. 2, pp. 405–413.

[5] I. Z. Ruzsa, *Generalized arithmetical progressions and sumsets*, ***Acta Mathematica Hungarica***, vol. 65 (1994), no. 4, pp. 379–388.

[6] C. Terry and J. Wolf, *Stable arithmetic regularity in the finite field model*, ***Bulletin of the London Mathematical Society***, vol. 51 (2019), no. 1, pp. 70–88.

[7] ———, *Quantitative structure of stable sets in finite abelian groups*, ***Transactions of the American Mathematical Society***, vol. 373 (2020), no. 6, pp. 3885–3903.

▸ SEBASTIAN ETEROVIĆ, *Geometric properties of transcendental holomorphic functions*.

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The complex exponential function has been studied extensively for centuries, but there are still important algebraic aspects of it that are not well-understood. For example, it is unknown whether the transcendental numbers e and π are algebraically independent over $\mathbb{Q}$.

Zilber's seminal work on pseudo-exponentiation [1, 2] proposes a possible explicit axiomatization of the algebraic properties of complex exponentiation which is $\aleph_1$-categorical. The proposed axioms expose natural connections between important problems in number theory and model-theoretic conditions. This impulsed a systematic model-theoretic study of many other important holomorphic maps, especially those arising in number theory such as the exponential maps of semi-abelian varieties, the modular j-function, automorphic functions, and the Γ-function.

In this talk I will introduce a few of the main problems in the model-theoretic study of these functions of interest, in particular we will discuss the categoricity and the existential closedness problems, and present some of the main results obtained recently.

[1] Boris Zilber, *Exponential sums equations and the Schanuel conjecture*, ***Journal of the London Mathematical Society. Second Series***, vol. 65 (2002), no. 1, pp. 27–44.

[2] ——— *Pseudo-exponentiation on algebraically closed fields of characteristic zero*, ***Annals of Pure and Applied Logic***, vol. 132 (2005), no. 1, pp. 67–95.

▸ BRADD HART, *An update on the model theory of operator algebras*.

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Over the past 15 years, the model theory of operator algebras has grown from what might have seemed like a one-off application of continuous model theory into a programme with many interesting branches. In this talk, I would like to review where we've been, what the status is now and highlight some of the current open problems.

▸ LÉO JIMENEZ, *Bounding non-orthogonality using algebraic groups.*
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It is a well-known stability theory result that if p and q are stationary non-orthogonal types over the same set of parameters, then there are n, m such that $p^{(n)}$ and $q^{(m)}$ are not weakly orthogonal. Is there a bound on the smallest such n and m?

In this talk, I will present such a bound for differentially closed fields of characteristic zero and give a differential-algebraic interpretation of the result. The proof uses geometric stability machinery to reduce the problem to a question about algebraic group actions. This is part of a joint work with James Freitag and Rahim Moosa.

▸ ELLIOT KAPLAN, *Generic derivations on o-minimal structures.*
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Let T be a model complete o-minimal theory that extends the theory of real closed ordered fields (RCF). We introduce T-derivations: derivations on models of T which cooperate with T-definable functions. The theory of models of T expanded by a T-derivation has a model completion, in which the derivation acts "generically." If $T =$ RCF, then this model completion is the theory of closed ordered differential fields (CODF) as introduced by Singer. We can recover many of the known facts about CODF (open core, distality) in our setting. We can also describe thorn-rank for models of T with a generic T-derivation. This is joint work with Antongiulio Fornasiero.

▸ MARYANTHE MALLIARIS, *On stability.*
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The talk will take a new look at model-theoretic stability from some very recent points of view.

▸ SCOTT MUTCHNIK, *Identifying genericity.*
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Independent indiscernible sequences, or Morley sequences, can tell us about genericity in a first-order theory. This leads us to ask: when can we define whether an indiscernible sequence is independent? If an indiscernible sequence is dependent, how close can it be to being independent - or how far? We discuss some applications to forking in supersimple homogeneous structures, Freitag and Moosa's degree of nonminimality, and the simple Kim-forking conjecture. This is on joint work with James Freitag.

▸ MARGARET E. M. THOMAS, *Definable topological spaces in o-minimal structures.*
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O-minimal structures have been analyzed extensively as a framework for tame topology, where the main focus has been on understanding the underlying euclidean order topology. Also key, however, to the development of o-minimality has been the study of the topological nature of various definable objects, such as groups, manifold spaces, orders, function spaces and metric spaces, where in many cases the topological spaces involved go beyond that of the underlying euclidean topology. We present some progress towards a more general understanding of the nature of topological spaces definable in this setting, in particular focussing on one-dimensional definable topological spaces. This is based on a long-term joint project with Pablo Andújar Guerrero and Erik Walsberg, and intersects with work carried out independently by Peterzil and Rosel. We consider various classification results given in terms of decomposition and embedding theorems and, in parallel, the identification of suitable definable analogues of classical properties such as separability, compactness and metrizability. This leads to a variety of applications, including definable versions of conjectures from classical topology due to Gruenhage and Fremlin (on the nature of regular Hausdorff and perfectly normal compact Hausdorff spaces), as well as universality results for certain classes of spaces.

Abstracts of invited talks in the Special Session on Set Theory

▸ TOM BENHAMOU, *Cofinal types of ultrafilters on measurable and non-measurable cardinals.*
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The Tukey order finds its origins in the concept of Moore-Smith convergence in topology, and is especially important when restricted to ultrafilters with reverse inclusion. The Tukey order of ultrafilters over ω was studied intensively by Blass, Dobrinen, Isbell, Raghavan, Shelah, Todorcevic and many others, but still contains fundamental unresolved problems. In the first part of this talk, I will present a recent development in the theory of the Tukey order restricted to ultrafilters on measurable cardinals, and explain how different the situation is when compared to ultrafilters on ω. Moreover, we will see an important application to the Galvin property of ultrafilters. In the second part of the talk we will demonstrate how ideas and intuition from ultrafilters over measurable cardinals lead to new results on the Tukey order restricted to ultrafilters over ω. This is joint with Natasha Dobrinen.

▸ SUMUN IYER, *Extremely amenable groups of homeomorphisms.*
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A topological group is *extremely amenable* if every continuous action of it on a compact, Hausdorff space has a fixed point. We discuss a construction due to Uspenskij which gives a condition equivalent to extreme amenability for the setting of homeomorphism groups of compact, metrizable spaces. We then show a Ramsey-type statement for subsets of simplices and discuss its connection with Uspenskij's construction and consequences for extreme amenability.

▸ JOHN KRUEGER, *Forcing over a free Suslin tree.*
Department of Mathematics, University of North Texas, 1155 Union Circle #311430 Denton, TX 76203 USA.
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This talk is based on joint work with Šárka Stejskalová. A Suslin tree is *free* if all of its derived trees are Suslin. We introduce a general framework for forcing over a

free Suslin tree and present several applications. Let T be a free Suslin tree. (1) We show how to specialize derived trees of T of dimension $n+1$ while preserving that T is n-free. (2) We force a sequence of almost disjoint subtrees of T of any length while preserving that T is Aronszajn. (3) We add any number of automorphisms to T while preserving that T is Suslin and not adding cofinal branches to ω_1-trees appearing in intermediate extensions. All of the above forcings are totally proper and ω_2-c.c. under CH. As a consequence, we are able to produce a model in which there exists a non-saturated Aronszajn tree and in which there does not exist a Kurepa tree, answering an open problem of Moore. And we are able to produce a model in which there exists an almost Kurepa Suslin tree but no Kurepa tree, answering open problems of Bilaniuk and Jin-Shelah.

▸ FARMER SCHLUTZENBERG, *Correctness of inner models and optimal wellorders*.
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John Steel and Mitch Rudominer conjectured, assuming AD + $V = L(\mathbb{R})$, that every mouse M has an "optimal" wellorder of its reals, definable right at the point that determinacy fails in $L(\mathbb{R})^M$. We will discuss recent progress on this conjecture and its current status. This is joint work with Steel.

[1] Farmer Schlutzenberg and John Steel, Σ_1 *gaps as derived models and correctness of mice*, arXiv:2307.08856.

[2] Mitch Rudominer and John Steel, *Inner models with wellorders in* $L(\mathbb{R})$, unpublished notes.

▸ FORTE SHINKO, *Hyperfiniteness of generic actions on Cantor space*.
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A countable discrete group is exact if it has a free action on Cantor space which is measure-hyperfinite, that is, for every Borel probability measure on Cantor space, there is a conull set on which the orbit equivalence relation is hyperfinite. For an exact group, it is known that the generic action on Cantor space is measure-hyperfinite, and it is open as to whether the generic action is hyperfinite; an exact group for which the generic action is not hyperfinite would resolve a long-standing open conjecture about whether measure-hyperfiniteness and hyperfiniteness are equivalent. We show that for any countable discrete group with finite asymptotic dimension, its generic action on Cantor space is hyperfinite. This is joint work with Sumun Iyer.

▸ IIAN SMYTHE, *A descriptive approach to manifold classification*.
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We propose a unified descriptive set-theoretic framework for studying the complexity of classification problems arising in geometric topology. We establish several precise complexity results, such as for the classification of surfaces up to homeomorphism, and for classes of hyperbolic manifolds up to isometry. The latter is intimately connected with the conjugation actions of certain Lie groups on their spaces of discrete subgroups. This work is joint with Jeffrey Bergfalk.

▸ TREVOR M. WILSON, *Characterizing large cardinals in terms of Löwenheim–Skolem*

and weak compactness properties of strong logics.
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We discuss characterizations of large cardinals in terms of properties of strong logics, such as Löwenheim–Skolem and weak compactness properties of certain fragments of infinitary second-order logic. For example, a cardinal κ is strong if and only if the Löwenheim–Skolem property holds for a certain fragment of infinitary second-order logic, namely for the sentences of $\mathcal{L}^2_{\infty,\infty}$ in negation normal form whose conjunctions and existential quantifiers have length less than κ.

We also discuss recent work with Jonathan Osinski obtaining similar results for weak compactness properties. Namely, a cardinal κ is Shelah if and only if a kind of weak compactness property holds for the dual of the aforementioned logic fragment, namely for theories consisting of sentences in $\mathcal{L}^2_{\infty,\infty}$ in negation normal form whose disjunctions and universal quantifiers have length less than κ. This property says that if such a theory T has size κ and every subtheory of T of size less than κ has a model of size less than κ, then T has a model. This connection to logic was somewhat unexpected because Shelah cardinals are sometimes thought to be a technical notion with few connections outside the large cardinal hierarchy.

Finally, we will mention some virtual analogues of these results, meaning results pertaining to large cardinal properties that are defined in terms of elementary embeddings existing in generic extensions of the universe.

Abstracts of invited talks in the Special Session on Universal Algebra

▸ ANDREI A. BULATOV, *Operator CSP and satisfiability gap.*
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The Constraint Satisfaction Problem (CSP) asks to find a satisfying assignment to a collection of variables subject to specified constraints. Graph Coloring and Graph Homomorphism problems are standard examples of CSPs. In the CSP and other homomorphism problems we are looking for an assignment of discrete values such as colors of vertices of a graph. However, one may follow the lead of quantum mechanics and convert bits to qubits, that is, look for satisfying assignments by matrices or linear operators. More precisely, constraints in a CSP are interpolated by polynomials (real or complex) that allows for using linear operators as values of variables. Sometimes a CSP that is not satisfiable 'classically' may have a satisfying operator assignment. In this talk we study what kind of CSPs demonstrate such a satisfiability gap.

▸ WILLIAM DEMEO, *Formal verification of the Cardano blockchain ledger.*
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We give a brief description of the Cardano blockchain and Utxo transaction model, and report on our ongoing work to formally verify the Cardano ledger specification in the Agda proof assistant. This is joint work of the formal ledger team at IOHK.

▸ JOHN HARDING, *Monadic ortholattices.*
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Halmos [1] introduced monadic algebras as an algebraic version of the one-variable fragment of predicate calculus, and extended this to polyadic algebras as an algebraic version of predicate calculus. At about the same time, Henkin, Monk and Tarski [3, 4] introduced cylindric algebras for the same purpose. A monadic algebra is a Boolean algebra with an additional operation called a quantifier that is a closure operator with the property that the complement of a closed element is closed. Polyadic and cylindric algebras are Boolean algebras with families of related quantifiers. Since then, quantifiers have been studied on various types of algebraic structures, most notably Heyting algebras [6], and also on orthomodular lattices [5].

We consider monadic and cylindric ortholattices and orthomodular lattices. A primary source of examples comes from operator algebras. Each von Neumann algebra provides a monadic orthomodular lattice, as does each von Neumann subfactor. Further, commuting squares of subfactors provide examples of cylindric orthomodular lattices. We describe some of the basic theory of monadic ortholattices. We also present an axiomatization of set cylindric orthomodular lattices, which are obtained in an obvious way from a tensor power of a Hilbert space. Finally, we consider MacNeille and canonical completions of monadic ortholattices, and a closely related duality theory.

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The varieties of loops (quasigroups with identity elements) of Bol-Moufang type are defined by identities with the following properties: (i) they involve three distinct variables, each occurring on both sides of the equal sign; (ii) the variables occur in the same order on both sides; (iii) exactly one of the variables appears twice on both sides. For example, the identity $(xy)(zx) = x((yz)x)$ is of Bol-Moufang type and defines the variety of Moufang loops. (This is half of the rationale for the name "Bol-Moufang type").

Various interesting varieties of loops (interesting, at least, to quasigroup theorists) – such as Moufang loops, Bol loops, C loops and others – can be defined by identities of Bol-Moufang type. There are others which, up until now, have not been garnered much interest because there does not seem to be much that can be said about them. For instance, the variety of loops with *left nuclear squares* is defined by $(xx)(yz) = ((xx)y)z$; essentially nothing interesting can be proven about these or the similarly defined varieties of loops with middle nuclear or right nuclear squares.

It turns out however, that one can say interesting things about the pairwise intersection of these varieties (from whence comes the title of this talk). This is a bit surprising because on the face of it, the condition that squares associate with all other elements in certain positions does not seem like a very strong property.

In particular, it turns out that in such loops, the intersection of the corresponding nuclei is a normal subloop. In addition, we consider the subvarieties of loops satisfying the automorphic inverse property (AIP) $(xy)\backslash 1 = (x\backslash 1)(y\backslash 1)$. These turn to have endomorphic squaring $(xy)^2 = x^2y^2$ and all squares lie in the center. In the finite case, these satisfy a direct product into an abelian group of odd order and a loop consisting of elements of order a power of 2. This is analogous to what happens in other Bol-Moufang type varieties in the presence of the additional assumption of the AIP.

This talk will not assume any background in loop theory beyond perhaps having seen the definition of loop. This is joint work with J.D. Phillips (Northern Michigan University).

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Let $\mathbf{A}$ be a finite simple non-abelian Mal'cev algebra, for example, a finite simple non-abelian (quasi)group or a matrix ring over a finite field. Then the class K of finite direct powers of $\mathbf{A}$ has the joint embedding property (JEP) and the amalgamation property (AP) but in general not the hereditary property (HP). There exists a (generalized) Fraïssé limit $\mathbf{D}$ of K, which we can describe as a filtered Boolean power (see [2]) of $\mathbf{A}$ and the countable atomless Boolean algebra.

The automorphism group $\mathbf{G}$ of the countable atomless Boolean algebra satisfies the following topological and combinatorial properties among others.

1. $\mathbf{G}$ has the small index property (SIP): every subgroup of $\mathbf{G}$ of index less than $2^{\aleph_0}$ is open in the topology of pointwise convergence (Truss [3]);
2. $\mathbf{G}$ has uncountable cofinality: $\mathbf{G}$ is not the union of a countable chain of proper subgroups (Droste and Göbel [1]);
3. $\mathbf{G}$ has the Bergman property: for each generating set E of $\mathbf{G}$ with $1 \in E = E^{-1}$ there exists $k \in \mathbb{N}$ such that $E^k = G$ (Droste and Göbel [1]).

We extend these results to show that the automorphism group of the filtered Boolean power $\mathbf{D}$ has the SIP, uncountable cofinality and the Bergman property as well.

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▸ ANDREW MOORHEAD* AND REINHARD PÖSCHEL, *When are bounded arity polynomials enough?*
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Equivalence relations appear everywhere in mathematics, in particular, if they are compatible with some mathematical structure (and therefore allow factor constructions). They have a remarkable property: An n-ary operation f preserves an equivalence relation ρ if and only if each unary polynomial function which can be obtained from f by substituting constants at all but one argument preserves ρ (such unary functions are called *basic translations* of f). This preservation criterion can be generalized to a condition that ranges over those n-ary polynomial functions that are obtained from f by substituting constants at all but n many arguments. In fact, there are many examples of such relations for each positive n which play an important role in higher commutator theory [2].

In [1], Jakubíková-Studenovská, Pöschel, and Radeleczki provide an essentially complete characterization of all finitary relations ρ with the property that f preserves ρ if and only if all basic translations of f preserve ρ. In this talk we will explain how to generalize this characterization to relations with the analogous 'higher dimensional' compatibility criterion with respect to n-ary polynomial functions for some positive n.

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► GAVIN NOP AND JONATHAN SMITH*, *Quasilattices and complex concept analysis.*
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Consider the following question: Why do we have tailbones, but no tail? Universal algebra provides a framework that underlies the answer to questions of this type.

Quasilattices are algebraic structures that comprise a semilattice-ordered system of lattices [4, 5]. In a forthcoming paper [3], certain quasilattices (that are characterized abstractly by a local completeness property) provide an extension of Wille's *concept analysis* from data science [1] and Hardegree's *logic of natural kinds* [2] to the study of complex systems that function on a number of distinct levels. In an important special case, a chain semilattice serves to represent a time series governing the evolution of a single system.

Natural set representations of locally complete quasilattices comprise *opposed* set inclusions describing order relations within a complete lattice, and *parallel* set inclusions tracking homomorphisms that connect distinct lattice fibers. In the time series model, the sets that appear within the set representation accumulate successive layers at each time step, establishing a logical basis for historical phenomena such as the presence of tailbones in the absence of a tail.

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► ANDREJA TEPAVČEVIĆ* AND BRANIMIR ŠEŠELJA, *Axiomatic approach to lattice characterization of groups.*
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We introduce a new class of algebraic lattices by a system of axioms. A subclass of these lattices can be modeled by weak-congruence lattices of groups. These lattices consist of all congruences on all subgroups of a group, equivalently, of all normal subgroups of all subgroups. It is possible to formulate main group properties in a lattice framework, e.g., normality among subgroups, homomorphism and quotient subgroups, particular chains, and systems of subgroups. In this way, we prove that many structural properties of groups turn out to be lattice-theoretic. This axiom system is not complete in the sense that not every lattice fulfilling the axioms represents a weak-congruence lattice of some group. Still, these axioms enable the characterization of many classes of groups. We give necessary and sufficient conditions that should be satisfied by the weak-congruence lattice of a group under which this group is Hamiltonian, abelian, solvable, nilpotent, and many others.

By our axioms, a special role in these lattices has a particular codistributive element which should correspond to a diagonal relation of the weak congruence lattice of a group (or any algebra in a more general setting). Therefore, we compare the axioms motivated by group properties with lattice properties of so-called suitable elements in algebraic lattices which should represent weak-congruence lattices of arbitrary algebras.

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► PATRICK WYNNE, *The subpower membership problem for nilpotent Mal'cev algebras*.
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The Subpower Membership Problem for an algebra $\mathbb{A}$, SMP($\mathbb{A}$), is the following computational problem: given tuples $a_1, \ldots, a_k, b \in \mathbb{A}^n$, is b in the subalgebra of $\mathbb{A}^n$ generated by $a_1, \ldots, a_k$? For certain finite algebras, SMP($\mathbb{A}$) has a polynomial time algorithm (such as Gaussian elimination for vector spaces) while for other finite algebras, SMP($\mathbb{A}$) is EXPTIME-complete. We investigate the structure of 2-nilpotent Mal'cev algebras by decomposing the term clone using an associated clonoid between abelian Mal'cev algebras. A clonoid from an algebra $\mathbb{A}$ to an algebra $\mathbb{B}$ is a set of finitary functions from $\mathbb{A}$ to $\mathbb{B}$ that is closed with respect to composition with term operations of $\mathbb{A}$ on the domain side and closed with respect to composition with term operations of $\mathbb{B}$ on the codomain side. We use this decomposition via clonoids to show that a large class of finite 2-nilpotent Mal'cev algebras have Subpower Membership Problem solvable in polynomial time.