2021 NORTH AMERICAN ANNUAL MEETING
OF THE ASSOCIATION FOR SYMBOLIC LOGIC

University of Notre Dame
South Bend, IN, USA
June 22–25, 2021

Program Committee: Guram Bezhanishvili, Curtis Franks, Selwyn Ng, Dima Sinapova, Margaret Thomas and Henry Towsner (chair).
Local Organizing Committee: Tim Bays, Jc Beall, Paddy Blanchette, Peter Cholak, Curtis Franks, Julia Knight (co-chair), Anand Pillay (co-chair) and Sergei Starchenko.

All events will be held via Zoom. Links will be sent to all registered participants.

TUESDAY, June 22

Morning

8:30 – 8:50	Welcome and social time.
8:50 – 9:00	Opening remarks.
9:00 – 10:00	Tutorial: **Justin Moore** (Cornell University), *The logic of Thompson's groups and their relatives I.*
10:00 – 10:30	Social break.
10:30 – 11:30	Tutorial: **Rahim Moosa** (University of Waterloo), *Some model theory of automatic sets I.*

Afternoon

1:00 – 2:00	Special Session A1, B1, C1, D1, and E1. See pages 3–6.
2:00 – 2:30	Social break.
2:30 – 3:30	Invited Lecture: **Agnes Szendrei** (University of Colorado), *Minimal abelian varieties of algebras.*
3:30 – 4:00	Social break.
4:00 – 5:00	Gödel Lecture: **Matthew Foreman** (University of California, Irvine), *Gödel diffeomorphisms.*
5:00 – 5:30	Social break.

WEDNESDAY, June 23

Morning

9:00 – 10:00	Tutorial: **Justin Moore** (Cornell University), *The logic of Thompson's groups and their relatives II.*
10:00 – 10:30	Social break.
10:30 – 11:30	Tutorial: **Rahim Moosa** (University of Waterloo), *Some model theory of automatic sets II.*

Afternoon

1:00 – 2:00	Special Session A2, B2, C2, D2, and E2. See pages 3–6.
2:00 – 2:30	Social break.

2:30 − 3:30	Diversity and Inclusion Parallel Session A, B, and C. See page 2.
3:30 − 4:00	Social break.
4:00 − 5:00	Invited Lecture: **Johanna Franklin** (Hofstra University), *Applications of lowness and highness.*
5:00 − 5:30	Social break.
5:30 − 6:30	Diversity and Inclusion Breakout Discussions. See page 2.

THURSDAY, June 24

Morning

8:10 − 9:00	Contributed talks A. See pages 6–6.
9:00 − 10:00	Invited Lecture: **Julia Wolf** (University of Cambridge), *Arithmetic combinatorics through the model-theoretic lens.*
10:00 − 10:30	Social break.
10:30 − 11:30	Special Session A3, B3, C3, D3, and E3. See pages 3–6.

Afternoon

1:00 − 2:00	Invited Lecture: **Nam Trang** (University of North Texas), *Sealing of the universally Baire sets.*
2:30 − 4:05	Contributed talks B and C. See pages 6–6.

FRIDAY, June 25

Morning

9:00 − 10:00	Invited Lecture: **Mai Gehrke** (University of Côte d'Azur), *Stone duality in computer science: preserving joins at primes.*
10:00 − 10:30	Social break.
10:30 − 11:30	Invited Lecture: **Cameron Hill** (Wesleyan University), *Towards a characterization of $\aleph_0$-categorical almost-sure theories.*

Afternoon

1:00 − 2:00	Special Session A4, B4, C4, D4, and E4. See pages 3–6.
2:00 − 2:30	Social break.
2:30 − 3:30	Invited Lecture: **Timothy McNicholl** (Iowa State University), *The computability theory of metric structures.*
3:30 − 4:00	Social break.
4:00 − 6:00	Special Session A5, B5 C5, D5, and E5. See pages 3–6.

SESSION ON DIVERSITY AND INCLUSION

Wednesday, June 23

2:30 − 3:30	A. Panel Discussion on Outreach and Diversity in Logic (moderated by Denis Hirschfeldt).
2:30 − 3:30	B. Promoting Diversity Early in an Academic Career (moderated by Carol Wood).
2:30 − 3:30	C. Reaching Out to Those Who Have Been Left Out (moderated by Amanda Serenevy).
5:30 − 6:30	Break-out discussion for small groups

SPECIAL SESSIONS

A. Model Theory

(Organized by Deirdre Haskell and Erik Walsberg)

Session A1: Tuesday, June 22

1:00 – 2:00 **Kobi Peterzil** (University of Haifa), *Interpretable fields in expansions of valued fields.*

Session A2: Wednesday, June 23

1:00 – 2:00 **Zoé Chatzidakis** (ENS), *Groups definable in difference-differential fields.*

Session A3: Thursday, June 24

10:30 – 11:00 **Sylvy Anscombe** (Université de Paris), *Turing degrees of existential theories of fields.*

11:00 – 11:30 **Nigel Pynn-Coates** (The Ohio State University), *An Ax–Kochen/Ershov theorem for differential-henselian pre-H-fields.*

Session A4: Friday, June 25

1:00 – 1:30 **Alexi Block Gorman** (University of Illinois at Urbana-Champaign), *Pathological examples of structures with o-minimal open core.*

1:30 – 2:00 **Pablo Andujar Guerrero** (Purdue University), *Types, transversals and definable compactness in o-minimal structures.*

Session A5: Friday, June 25

4:00 – 4:30 **Alex Kruckman** (Wesleyan University), *Higher dimensional obstructions for star reductions.*

4:30 – 5:00 **Minh Chieu Tran** (University of Notre Dame), *Minimal and nearly minimal measure expansions in locally compact groups.*

5:00 – 6:00 **Bradd Hart** (McMaster University), *Undecidability in continuous logic.*

B. Topology meets Philosophy and Logic

(Organized by Tamar Lando, Sonja Smets, and Aybüke Özgün)

Session B1: Tuesday, June 22

1:00 – 2:00 **Nina Gierasimczuk** (Technical University of Denmark), *Learning and modal Logic: there and back again.*

Session B2: Wednesday, June 23

1:00 – 2:00 **Achille Varzi** (Columbia), *TBA*

Session B3: Thursday, June 24

10:30 – 11:30 **Adam Bjorndahl** (Carnegie Mellon University), *Almost-logic.*

Session B4: Friday, June 25

1:00 – 2:00 **Aaron Cotnoir** (University of St Andrews), *Partial identity & mereotopology.*

Session B5: Friday, June 25

4:00 – 5:00 **Sophia Knight** (University of Minnesota Duluth), *Algebraic structures for distributed knowledge of potentially infinite groups of agents.*

5:00 – 6:00 **Geoffrey Hellman and Stewart Shapiro** (University of Minnesota and The Ohio State University), *Regions-based topology in geometry.*

C. Computability Theory

(Organized by Arno Pauly and Takayuki Kihara)

Session C1: Tuesday, June 22

1:00 – 2:00 **Vasco Brattka** (Universität der Bundeswehr München), *Duaility in Weihrauch complexity.*

Session C2: Wednesday, June 23

1:00 – 1:30 **Manlio Valenti** (University of Udine), *The uniform strength of descending sequences.*

1:30 – 2:00 **Antonin Callard** (Université Paris-Saclay), *Descriptive complexity on represented spaces.*

Session C3: Thursday, June 24

10:30 – 11:30 **Margarita Korovina** (Ershov Institute of Informatics Systems), *Ksmt for solving non-linear constraints*

Session C4: Friday, June 25

1:00 – 2:00 **Elvira Mayordomo** (Universidad de Zaragoza), *Extending the reach of the point-to-set principle.*

Session C5: Friday, June 25

4:00 – 5:00 **Neil Lutz** (Iowa State University), *Algorithmically optimal outer measures.*

5:00 – 5:30 **Linda Westrick** (Penn State University), *Two results by relativization.*

5:30 – 6:00 **Matthew de Brecht** (Kyoto University), *Computable functors on the category of quasi-Polish spaces.*

D. Algebraic Logic

(Organized by Nikolaos Galatos and Wesley Holliday)

Session D1: Tuesday, June 22

1:00 – 1:30 **George Metcalfe** (University of Bern), *From ℓ-groups to ℓ-monoids, and back again.*

1:30 – 2:00 **Alessandra Palmigiano** (Vrije Universiteit), *From unified correspondence to parametric correspondence: preliminary considerations.*

Session D2: Wednesday, June 23

1:00 – 1:30 **Nick Bezhanishvili** (University of Amsterdam), *Profinite Heyting algebras and profinite completions.*

1:30 – 2:00 **Tommaso Moraschini** (University of Barcelona), *Profiniteness and spectra of Heyting algebras.*

Session D3: Thursday, June 24

10:30 – 11:00 **Rosalie Iemhoff** (Utrecht University), *Uniform interpolation in universal proof theory.*

11:00 – 11:30 **Marta Bilkova** (Czech Academy of Sciences), *Many-valued paraconsistent logics for uncertainty.*

Session D4: Friday, June 25

1:00 – 1:30 **Wesley Fussner** (CNRS and Université Côte d'Azur), *Quantum and substructural logics: a unifying approach.*

1:30 – 2:00 **Sara Ugolini** (Artificial Intelligence Research Institute), *MV-algebras reason about probability.*

Session D5: Friday, June 25

4:00 – 4:30 **Alasdair Urquhart** (University of Toronto), *Failure of Beth's theorem in relevance logics.*

4:30 – 5:00 *CANCELLED*

5:00 – 5:30 **Peter Jipsen** (Chapman University), *Bunched implication algebras, Heyting algebras with a residuated unary operator and their Kripke semantics.*

5:30 – 6:00 **Luca Carai** (New Mexico State University), *Coalgebras for the powerset functor and Thomason duality.*

E. Set Theory

(Organized by James Cummings and Anush Tserunyan)

Session E1: Tuesday, June 22

1:00 – 1:30 **Noé de Rancourt** (Charles University), *A dichotomy for countable unions of smooth Borel equivalence relations.*

1:30 – 2:00 **Dakota Ihli** (University of Illinois at Urbana-Champaign), *What generic automorphisms of the random poset look like.*

Session E2: Wednesday, June 23

1:00 – 1:30 **Sandra Müller** (TU Wien), *The strength of determinacy when all sets are universally Baire.*

1:30 – 2:00 **Trevor Wilson** (Miami University), *Weak Vopěnka cardinals.*

Session E3: Thursday, June 24

10:30 – 11:00 **Yair Hayut** (The Hebrew University of Jerusalem), *The strength of filter completion.*

11:00 – 11:30 **Sarka Stejskalova** (Charles University), *Indestructibility of some compactness principles.*

Session E4: Friday, June 25

1:00 – 1:30 **Filippo Calderoni** (University of Illinois at Chicago), *Rotation equivalence and cocycle superrigidity for compact actions.*

1:30 – 2:00 **Assaf Shani** (Harvard University), *Actions of Polish wreath product groups.*

Session E5: Friday, June 25

4:00 – 4:30	**Konrad Wrobel** (Texas A&M University), *Orbit equivalence of wreath products.*
4:30 – 5:00	**Ronnie Chen** (University of Illinois at Urbana–Champaign), *Some results in descriptive locale theory.*
5:00 – 5:30	**Jeffrey Bergfalk** (Kurt Gödel Research Center), *Combinatorial principles of independent interest arising in recent research on higher derived limits and strong homology.*
5:30 – 6:00	**Gabe Goldberg** (University of California, Berkeley), *Predictions of the ultrapower axiom.*

CONTRIBUTED TALKS

THURSDAY, June 24

Session A, 8:10-9:00

8:10 – 8:30	**Joachim Mueller-Theys** (Independent researcher), *Similarity and equality.*
8:35 – 8:55	**Alexandr Bessonov** (Russian Academy of Sciences), *Gödel's incompleteness theorems from the perspective of a falsifiability predicate.*

Session B, 2:30-4:05

2:30 – 2:50	**Irfan Alam** (Louisiana State University), *Generalizing de Finetti's theorem using nonstandard methods.*
2:55 – 3:15	**Caleb Camrud***, **Isaac Goldbring, and Timothy McNicholl** (Iowa State University), *Diagram complexity of metric structures in continuous logic.*
3:20 – 3:40	**Caleb Camrud*****and Ranpal Dosanjh** (Iowa State University), *$[0, \infty]$-indexed multimodal logics with philosophical applications.*
3:45 – 4:05	**Landom D. C. Elkind and Richard Zach** (University of Alberta and University of Calgary), *The genealogy of $\vee$.*

Session C, 2:30-3:40

2:30 – 2:50	**Wim Ruitenburg** (Marquette University), *Kolmogorov translations into basic logic.*
2:55 – 3:15	**Russell Miller** (Queens College and CUNY Graduate Center), *Generic algebraic fields.*
3:20 – 3:40	**Josiah Jacobsen-Grocott** (University of Wisconsin–Madison), *Classification of classes of enumeration degrees of non-metrizable spaces by topological separation axioms.*

Abstract of the invited 32nd Annual Gödel Lecture

▶ MATTHEW FOREMAN, *Gödel diffeomorphisms*.
Department of Mathematics, University of California, Irvine.
E-mail: mforeman@math.uci.edu.

Motivated by problems in physics, solutions to differential equations were studied in the late 19th and early 20th centuries by people like Birkhoff, Poincaré and von Neumann. Poincaré's work was described by Smale in the 1960's as the *qualitative* study and von Neumann's own description was the study of the *statistical aspects* of differential equations. The explicit goal was to classify this behavior. A contemporaneous problem was whether *time forwards* could be distinguished from *time backwards*.

The modern formulation of these problems is to classify diffeomorphisms of smooth manifolds up to *topological conjugacy* and *measure isomorphism* and to ask, for a given diffeomorphism, whether $T \cong T^{-1}$. Very significant progress was made on both classes of problems, in the first case by people like Birkhoff, Morse and Smale and in the second case by Birkhoff, Poincare, von Neumann, Halmos, Kolmogorov, Sinai, Ornstein and Furstenberg.

This talk applies techniques developed by Kechris, Louveau and Hjorth to these problems to show that the relevant equivalence relations are complete analytic. Moreover the collection of T that are measure theoretically isomorphic to their inverses is also complete analytic. Finally, the whole story can be miniaturized to show that the collection of diffeomorphisms of the 2-torus that are measure theoretically isomorphic to their inverses is Π_1^0-hard.

As a consequence of the latter, one can extend the results about Hilbert's 10th problem to diffeomorphisms of the 2-torus: There is a recursive map that associates to each Π_1^0 sentence ϕ a recursive diffeomorphism T_ϕ such that ϕ is true if and only if $T_\phi \cong T_\phi^{-1}$. Examples of interesting ϕ include the Riemann Hypothesis, Goldbach's Conjecture and Con(ZFC).

This talk covers joint work with Anton Gorodetski and Benjamin Weiss.

Abstract of invited tutorials

▶ JUSTIN TATCH MOORE, *The logic of Thompson's groups and their relatives*.
Cornell University, Malott Hall, 301 Tower Road, Ithaca, NY 14853.
E-mail: justin@math.cornell.edu.

While a graduate student in logic at Berkeley in the 1960s and 70s, Richard Thompson introduced three groups now known as F, T, and V in order to give new examples of finitely presented groups with unsolvable word problems. All three are groups of homeomorphisms of the Cantor set. T and V were early examples of finitely presented infinite simple groups. F is perhaps the simplest example of a nonelementary amenable group which does not contain the free group on two generators.

Since the 1980s, these groups have played an important role in group theory and topology due largely to their exotic properties. More recently, their study has touched on different parts of logic and set theory. This tutorial will give an introduction to these groups, as well as their relatives such as the groups of piecewise linear and piecewise projective homeomorphisms of the unit interval. The focus will be on their interaction with logic, ranging from set theory to proof theory to automata theory. The talks will also highlight a number of open problems.

▶ RAHIM MOOSA, *Some model theory of automatic sets*.
Pure Mathematics, University of Waterloo, Canada.

E-mail: `rmoosa@uwaterloo.ca`.

Automatic sets arise at the intersection of computer science and number theory. A subset $S \subseteq \mathbb{N}$ is said to be *d-automatic* if the set of base-d expansions of the elements of S form a regular set of words on the alphabet $\{0, \ldots, d-1\}$. *Regularity* here refers to the property of being the set of words recognised by a finite automaton. A few years ago, Jason Bell and I realised that this notion (or rather a generalisation of it to finitely generated abelian groups) was closely related to much earlier work of Thomas Scanlon and myself on a certain diophantine problem in positive characteristic, the Mordell-Lang problem over finite fields. Jason Bell and I, along with Dragos Ghioca recently, have been exploiting this connection.

In these tutorial lectures, however, I will follow the work of my student Christopher Hawthorne who has begun a systematic study of the model-theoretic properties of automatic sets and their generalisations. For example, he answers the question of which automatic subsets of the integers are stable. These lectures will be largely self-contained and aimed at a general logic audience including graduate students.

Abstracts of invited plenary lectures

▶ JOHANNA N.Y. FRANKLIN, *Applications of lowness and highness.*
Department of Mathematics, Hofstra University, Room 306, Roosevelt Hall, Hempstead, NY 11549-0114, USA.
E-mail: `johanna.n.franklin@hofstra.edu`.

While the concepts of lowness and highness originated in degree theory, they have been studied in other contexts as well. Lowness for various algorithmic randomness notions has been investigated for decades, and, more recently, lowness has found applications in computable structure theory and computable analysis. Similarly, highness was studied in the context of algorithmic randomness before it was studied in the context of computable structure theory. We present a survey of lowness and highness results in computability theory beyond degree theory, focusing on recent work in computable structure theory that is joint with Solomon, Turetsky, McNicholl, and Calvert and Turetsky.

▶ MAI GEHRKE, *Stone duality in computer science: preserving joins at primes.*
Laboratoire Jean Alexandre Dieudonné, CNRS & UCA, Parc Valrose 06108 NICE CEDEX 2, France.
E-mail: `mgehrke@unice.fr`.
URL Address: `https://math.unice.fr/~mgehrke/`.

Stone duality for bounded distributive lattices [7] and its extension to lattices with additional operations [6] have played an important rôle in propositional logic, but also in logic applications in computer science. We review two such applications: in domain theory [1, 2] and in automata theory [4, 3], both of which may be seen to hinge on a very special property of additional operations on a lattice, namely that of preserving joins at primes. See [5] for a survey article with a similar point of view.

[1] S. ABRAMSKY, *Domain theory in logical form*, **Annals of Pure and Applied Logic**, vol. 51, pp. 1–77.

[2] S. ABRAMSKY AND A. JUNG, **Domain Theory**, Handbook of logic in computer science (vol. 3): semantic structures, Oxford University Press, 1995.

[3] M. GEHRKE, *Stone duality, topological algebra, and recognition*, **Journal of Pure and Applied Algebra**, vol. 220 (2016), no. 7, pp. 2711–2747.

[4] M. GEHRKE, S. GRIGORIEFF, AND J.-É. PIN, *Duality and equational theory of regular languages*, **Automata, languages and programming ICALP 2008**, Lecture

Notes in Computer Science, vol. 5126, Springer, 2008, pp. 246–257.

[5] M. Gehrke, T. Jakl, and L. Reggio, *A Cook's tour of duality in logic: from quantifiers, through Vietoris, to measures*, **Samson Abramsky on Logic and Structure in Computer Science and Beyond**, Outstanding Contribution to Logic, (A. Palmigiano and M. Sadrzadeh, editors), Springer, to appear.

[6] B. Jónsson and A. Tarski, *Boolean algebras with operators I*, **American Journal of Mathematics**, vol. 73 (1951), pp. 891–939.

[7] M. H. Stone, *Topological representations of distributive lattices and Brouwerian logics*, **Časopis pro pěsiování matematiky a fysiky**, vol. 67 (1938), pp. 1–25.

▶ CAMERON DONNAY HILL, *Towards a characterization of $\aleph_0$-categorical almost-sure theories.*
Department of Mathematics and Computer Science, Wesleyan University.
E-mail: cdhill@wesleyan.edu.

In [1, 2], it was discovered that the theory of the random graph is *almost-sure*, meaning that for every sentence in that theory, the probability that it is true of a uniformly random finite graph tends 1 as the size of the graph increases. This is the 01-Law for First-order Logic over Graphs. We would like to characterize $\aleph_0$-categorical almost-sure theories in purely structural, model-theoretic terms, without mentioning probability distributions. In this talk, we will discuss some questions that seem essential in this project, among them:

1. Is it appropriate to restrict attention to probability distributions on finite structures that correspond to invariant measures as studied in [3]?
2. When we think of almost-sure $\aleph_0$-categorical theories, we always think of rank-1 super-simple theories, like the theory of the random graph. Is that really what we should think of?
3. When we sit down to prove a 01-law for first-order logic over some class of structures, we usually grant ourselves probability distributions with extremely powerful and convenient conditional independence properties. Is this appropriate?

Our answers at the moment are (1) "Roughly yes," (2) "Likely yes," and (3) "No, not really."

[1] Ronald Fagin, *Probabilities on Finite Models*, **The Journal of Symbolic Logic**, vol. 41 (1976), no. 1, pp. 50–58.

[2] Y. V. Glebsky, D. I. Kogan, M. I. Liogonky, and V. A. Talanov, *Rank and Degree of Realizability of Formulas in the Restricted Predicate Calculus*, **Kibernetika**, vol. 2 (1969), pp. 17–28.

[3] N. Ackerman, C. Freer, and R. Patel, *Invariant measures concentrated on countable structures*, **Forum of Mathematics, Sigma**, vol. 4 (2016), DOI: https://doi.org/10.1017/fms.2016.15.

▶ TIMOTHY H. MCNICHOLL, *The computability theory of metric structures.*
Department of Mathematics, Iowa State University, Ames, Iowa 50010, USA.
E-mail: mcnichol@iastate.edu.

Continuous logic is the model theory of metric structures such as Banach spaces, probability spaces, and C^* algebras. Effective metric structure theory blends the frameworks of computable structure theory and computable analysis to study the computability theory of metric structures. Thus, effective metric structure theory is to the model theory of metric structures (continuous logic) as computable structure theory is to the model theory of algebraic and combinatorial structures. The foundation of effective metric structure theory blends the frameworks of computable analysis and computable structure theory. While implicit in the work of Pour-El and Richards, effective metric structure theory was brought to light and put on a solid foundation in

the work of Melnikov and Nies starting in 2013. Since then, the field has developed a number of surprising results, challenging questions, and beautiful connections with classical analysis and probability. I will survey the development of the field so far, and then cover recent developments on index sets (complexity of classification problems), C^* algebras, and Stone spaces. I will conclude by discussing the major open problems at this point and possible paths to their solutions.

▶ AGNES SZENDREI, *Minimal abelian varieties of algebras*.
Department of Mathematics, University of Colorado Boulder, 2300 Colorado Ave., Boulder, Colorado, USA.
E-mail: szendrei@colorado.edu.

I will discuss results on the classification of minimal abelian varieties of algebras. A minimal variety of algebras is the class $\text{Mod}(\Sigma)$ of models of an equationally complete theory Σ. A variety is abelian if all of its members $\mathbf{A}$ are abelian in the sense that the diagonal of $\mathbf{A}^2$ is the class of a congruence of $\mathbf{A}$. The simplest examples of abelian varieties are varieties of modules and varieties of unary algebras.

Minimal abelian varieties that are locally finite were classified about 25 years ago. In a recent joint paper with K. A. Kearnes and E. W. Kiss [1] we proved that the dichotomy known in the locally finite case holds in general: every minimal abelian variety is either affine or strongly abelian. Minimal affine varieties are close to minimal varieties of modules, and are well-understood. The talk will focus on minimal strongly abelian varieties, which include widely different kinds of varieties, like minimal strongly abelian varieties of finite essential arity as well as the variety of Jónsson–Tarski algebras.

[1] K. A. Kearnes, E. W. Kiss, and Á. Szendrei, *Minimal abelian varieties of algebras I*, **International Journal of Algebra and Computation**, Online Ready, 2020.

▶ NAM TRANG, *Sealing of the universally Baire sets*.
Department of Mathematics, University of North Texas, Denton, TX, USA.
E-mail: Nam.Trang@unt.edu.

A set of reals is *universally Baire* if all of its continuous preimages in compact Hausdorff spaces have the Baire property. Sealing is a type of generic absoluteness condition introduced by H. W. Woodin that asserts in strong terms that the theory of the universally Baire sets cannot be changed by set forcings.

The Largest Suslin Axiom (LSA) is a determinacy axiom isolated by Woodin. It asserts that the largest Suslin cardinal is inaccessible for ordinal definable bijections. Let LSA-over-uB be the statement that in all (set) generic extensions there is a model of LSA whose Suslin, co-Suslin sets are the universally Baire sets.

The main result connecting these notions is: over some mild large cardinal theory, Sealing is equiconsistent with LSA-over-uB (cf. [1]). As a consequence, we obtain that Sealing is weaker than the theory "ZFC+there is a Woodin cardinal which is a limit of Woodin cardinals". This significantly improves upon the earlier consistency proof of Sealing by Woodin (cf. [4]) and shows that Sealing is not a strong consequence of supercompactness as suggested by Woodin's result. We also show that Sealing is not equivalent to LSA-over-uB (cf. [2]).

We discuss some history that leads up to these results as well as the role these notions and results play in recent developments in descriptive inner model theory, an emerging field in set theory that explores deep connections between descriptive set theory, in particular, the study of canonical models of determinacy and its HOD, and inner model theory, the study of canonical inner models of large cardinals. A more detailed discussion of these topics is given in [3].

This talk is based on joint work with G. Sargsyan.

[1] Grigor Sargsyan and Nam Trang, *The exact consistency strength of generic absoluteness for universally Baire sets*, submitted.

[2] ———, *Sealing from iterability*, **Transactions of the American Mathematical Society**, to appear.

[3] ———, *Sealing of the universally Baire sets*, **The Bulletin of Symbolic Logic**, to appear.

[4] Paul B. Larson, **The stationary tower**, University Lecture Series, vol. 32 American Mathematical Society, 2004.

▶ JULIA WOLF, *Arithmetic combinatorics through the model-theoretic lens.*
Department of Pure Mathematics and Mathematical Statistics, University of Cambridge, UK.
E-mail: Julia.Wolf@dpmms.cam.ac.uk.

This talk will survey some of the recent ways in which model theory has interacted with arithmetic combinatorics, focusing in particular on the combinatorial notion of "regularity" in model-theoretically tame contexts.

Abstracts of Session on Diversity and Inclusion

▶ SESSION A: PANEL DISCUSSION ON OUTREACH AND DIVERSITY IN LOGIC,
The aim of this panel is to contribute to the conversation on how we as a community of logicians and logic educators might work toward justice in our field. While it will focus on the North American context, it is intended as part of an ongoing effort to make our discipline as broad and inclusive as possible. The participants are mathematicians with a wide range of experience in teaching, research, and service in different kinds of academic institutions, and in work aimed at equity in mathematics.

Moderator: Denis Hirschfeldt

Participants:

Concha Gómez, Professor of Mathematics at Diablo Valley College in the SF Bay Area
Cameron Hill, Associate Professor of Mathematics, Wesleyan University
Roman Kossak, Professor Emeritus at the Graduate enter of CUNY
Rehana Patel, African Institute for Mathematical Sciences, Senegal

▶ SESSION B: PROMOTING DIVERSITY EARLY IN AN ACADEMIC CAREER,
The panel will aim to provide practical advice and to suggest steps an academic mathematician may consider to foster diversity in our community.. The intended audience is comprised of graduate students and postdoctoral mathematicians. Participants include mathematics faculty with commitments and interest in diversity matters, an NSF program officer who will describe broader impact requirements in grant proposals, and current job applicants.

Moderator: Carol Wood

Participants:

Shaun Allison, Carnegie Mellon University
Tomek Bartoszynski, Division of Mathematical Sciences. National Science Foundation
Gabriel Conant, Cambridge University
Thomas Scanlon, University of California at Berkeley
Lynn Scow, California State University, San Bernardino

▶ SESSION C: REACHING OUT TO THOSE WHO HAVE BEEN LEFT OUT, Amanda Serenevy
Riverbend Community Math Center.
Many students in the United States never have access to a teacher who is comfortable

with math content at the 4th through 8th grade level. Even if they do have access to a teacher with this knowledge, students in high poverty schools still may not have the opportunity to learn grade level material if most of their peers are several grade levels behind. In-school and after-school math enrichment programs are often not available in high poverty schools and neighborhoods. During this talk, I will describe several examples of programs designed to reach students who would not otherwise have access to high quality math education. I will talk about some of the joys, struggles, and lessons learned from these efforts.

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**Abstracts of invited talks in the Special Session on
Algebraic Logic**

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▶ NICK BEZHANISHVILI, *Profinite Heyting algebras and profinite completions.*
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In this talk I will first recall a characterization of profinite Heyting algebras as algebras of upsets of image finite posets [1]. I will also discuss how to extend this result to bi-Heyting algebras. I will then concentrate on the notion of profinite completion of a Heyting algebra [2] and review a problem whether every profinite Heyting algebra A is the profinite completion of some Heyting algebra B. This problem was stated in [3]. I will discuss how to restate this problem in terms of Esakia spaces and will formulate a variant of this problem for varieties of Heyting algebras. A full characterization of varieties of Heyting algebras where each profinite algebra is isomorphic to a profinite completion is given in [4] and will be discussed in the talk of T. Moraschini in this session. Consequently, there exist profinite Heyting algebras which cannot be isomorphic to the profinite completion of some Heyting algebra.

[1] G. Bezhanishvili and N. Bezhanishvili, *Profinite Heyting algebras*, **Order**, vol. 25 (2008), no. 3, pp. 211–227.

[2] G. Bezhanishvili, M. Gehrke, R. Mines, and P. J. Morandi, *Profinite completions and canonical extensions of Heyting algebras*, **Order**, vol. 23 (2006), no. 2–3, pp. 143–161.

[3] G. Bezhanishvili and P. J. Morandi, *Profinite Heyting algebras and profinite completions of Heyting algebras*, **Georgian Mathematical Journal**, vol. 16 (2009), no. 1, pp. 29–47.

[4] G. Bezhanishvili, N. Bezhanishvili, T. Moraschini and M. Stronkowski *Profiniteness and representability of spectra of Heyting algebras*, submitted and available on the ArXiv.

▶ GURAM BEZHANISHVILI, LUCA CARAI*, AND PATRICK J. MORANDI, *Coalgebras for the powerset functor and Thomason duality.*
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The celebrated Jónsson-Tarski duality establishes a dual equivalence between the category of descriptive frames and the category of modal algebras. It has been proved in [1] that such a duality can be obtained from Stone duality via the use of algebras and coalgebras for endofunctors.

In this talk we show that a similar approach can be employed to obtain Thomason duality between the category KFr of Kripke frames and the category CAMA of complete and atomic boolean algebras with completely multiplicative modal operators. As descriptive frames correspond to coalgebras for the Vietoris endofunctor on the category of Stone spaces, KFr is isomorphic to the category $\mathsf{Coalg}(\mathcal{P})$ of coalgebras for the powerset endofunctor $\mathcal{P}$ on Set. We define an endofunctor $\mathcal{H}$ on the category CABA of complete and atomic boolean algebras and we show that CAMA is isomorphic to the category $\mathsf{Alg}(\mathcal{H})$ of algebras for $\mathcal{H}$. We show that Tarski duality between Set and CABA can be extended to a dual equivalence between $\mathsf{Coalg}(\mathcal{P})$ and $\mathsf{Alg}(\mathcal{H})$. As a consequence, we obtain Thomason duality between KFr and CAMA.

[1] KUPKE, C. AND KURZ, A. AND VENEMA, Y., *Stone coalgebras*, **Theoretical Computer Science**, vol. 327 (2004), no. 1-2, pp. 109–134.

▶ MARTA BÍLKOVÁ, *Many-valued paraconsistent logics for uncertainty*.

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When it comes to information, its potential incompleteness, uncertainty, and contradictoriness needs to be dealt with adequately. Separately, these characteristics have been taken into account by various appropriate logical formalisms and (classical) probability theory. While incompleteness and uncertainty are typically accommodated within one formalism, e.g. within various models of imprecise probability, contradictoriness and uncertainty less so — conflict or contradictoriness of information is rather chosen to be resolved than to be reasoned with. To reason with conflicting information, positive and negative support—evidence in favour and evidence against—a statement are quantified separately in the semantics. This two-dimensionality gives rise to logics interpreted over twisted-product algebras or bi-lattices [4, 5], e.g. the well known Belnap-Dunn logic [1, 3] of First Degree Entailment.

In this contribution, we introduce logics which are interpreted over twisted-product algebras based on the $[0, 1]$ real interval. They can be seen to account for the two-dimensionality of positive and negative component of (the degree of) belief based on potentially contradictory information. The logics include extensions of Łukasiewicz or Gödel logic with a de-Morgan negation which swaps between the positive and negative component. The extensions of Gödel logic in particular turn out to be extensions of Nelson's paraconsistent logic $N4$ [6], or Wansing's paraconsistent logic I_4C_4 [7], with the prelinearity axiom. The logics inherit completeness and decidability properties of Łukasiewicz or Gödel logic respectively. They can be applied to model belief based on evidence: In [2], a logical framework in which belief is based on potentially contradictory information obtained from multiple, possibly conflicting, sources and is of a probabilistic nature, has been suggested, using a two-layer modal logical framework to account for evidence and belief separately. The logics we describe in this contribution are the logics used on the upper level in this framework.

(Based on joint work with S. Frittella, D. Kozhemiachenko, O. Majer and S. Nazari.)

[1] N. D. BELNAP, *How a Computer Should Think*, **New Essays on Belnap-Dunn**

Logic, Synthese Library, Studies in Epistemology, Logic, Methodology, and Philosophy of Science, vol. 418, (H. Omori and H. Wansing, editors), Springer, 2019, pp. 35–53.

[2] M. Bílková, S. Frittella, O. Majer and S. Nazari, *Belief based on inconsistent information*, **DaLi 2020: Dynamic Logic. New Trends and Applications**, Lecture Notes in Computer Science, vol. 12569, (M.A. Martins and I. Sedlár, editors), Springer, 2020, pp. 68–86.

[3] J. M. Dunn, *Intuitive semantics for first-degree entailments and 'coupled trees'*, **Philosophical Studies**, vol. 29 (1976), no. 3, pp. 149–168.

[4] M. L. Ginsberg, *Multivalued logics: A uniform approach to reasoning in AI*, **Computer Intelligence**, vol. 4 (1988), pp. 256–316.

[5] R. Jansana and U. Rivieccio, *Residuated bilattices*, **Soft Computing**, vol. 16 (2012), no. 3, pp. 493–504.

[6] D. Nelson, *Constructible Falsity*, **The Journal of Symbolic Logic**, vol. 14 (1949), pp. 16–26.

[7] H. Wansing, *Constructive negation, implication, and co-implication*, **Journal of Applied Non-Classical Logics**, vol. 18 (2008), no. 2-3, pp. 341–364.

▶ WESLEY FUSSNER, *Quantum and substructural logics: a unifying approach.*
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The logical foundation of quantum mechanics has been a prominent topic since Birkhoff and von Neumann's groundbreaking work on the subject [1]. Orthomodular lattices provide a popular and elegant algebraic perspective on quantum logic [3], and have been explored in connection with quantum computation [5]. Meanwhile, substructural logics comprise a thoroughly-studied class of logical systems with applications in the management of computational resources [4]. Recent efforts to unify quantum and substructural logics have opened new directions through considering left-residuated ℓ-groupoids as common algebraic models [2].

This talk discusses this line of research in the context of *residuated ortholattices*, certain involutive lattices endowed with a residuated structure. We will sketch ongoing work regarding residuated ortholattices, and discuss how they provide algebraic models of an "intuitionistic" variant of quantum logic. Along these lines, we will exhibit a double-negation translation of orthomodular lattices into residuated ortholattices in the spirit of the well-known translation of Boolean algebras into Heyting algebras.

[1] G. Birkhoff and J. von Neumann, *The Logic of Quantum Mechanics*, **Annals of Mathematics**, vol. 37 (1936), no. 4, pp. 823–843.

[2] I. Chajda and H. Länger, *Orthomodular lattices can be converted into left-residuated ℓ-groupoids*, **Miskolc Mathematical Notes**, vol. 18 (2007), no. 2, pp. 685–689.

[3] M.L. Dalla Chiara, R. Giuntini, and R. Greechie, **Reasoning in Quantum Theory**, Trends in Logic, Springer, Dordrecht, 2004.

[4] P. O'Hearn and D. Pym, *The Logic of Bunched Implications*, **The Bulletin of Symbolic Logic**, vol. 5 (1999), no. 2, pp. 215–244.

[5] M. Ying, *A theory of computation based on quantum logic (I)*, **Theoretical Computer Science**, vol. 344 (2005), no. 2–3, pp. 134–207.

▶ ROSALIE IEMHOFF, *Uniform interpolation in universal proof theory.*
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In this talk I explain how a property of logics, such as uniform interpolation, can

be used to establish that a logic does not have proof systems of a certain kind, in this case sequent calculi with good structural properties and other desirable qualities. This connection between the properties of a logic and its proof systems is based on a proof method for uniform interpolation that applies to any intermediate, substructural, modal or intuitionistic modal logic that has a sequent calculus of that kind. I illustrate this method by proving uniform interpolation for Lax Logic, an intuitionistic modal logic with applications in a number of areas, ranging from algebraic logic to hardware verification.

▶ PETER JIPSEN, *Bunched implication algebras, Heyting algebras with a residuated unary operator and their Kripke semantics.*
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A *Heyting algebra* $\mathbf{A} = (A, \wedge, \vee, \rightarrow, \top, \bot)$ is a bounded lattice such that $\rightarrow$ is the *residual* of $\wedge$, i.e., $x \wedge y \leq z \iff y \leq x \rightarrow z$. A Heyting algebra *with operators* is of the form $(\mathbf{A}_0, \{f_i : i \in I\})$ such that $\mathbf{A}_0$ is a Heyting algebras and f_i is an n_i-ary *operator* on A for all $i \in I$. Here "operator" means f_i is join-preserving, meet-preserving or maps all joins to meets, or all meets to joins in each argument. A unary operation p on A is residuated by p' if $px \leq y \iff x \leq p'y$, and in this case p is join-preserving and p' is meet-preserving, hence they are both operators. A *bunched implication algebra* (BI-algebra) is of the form $(\mathbf{A}_0, *, {-\!*}, 1)$ such that $\mathbf{A}_0$ is a Heyting algebra, $(A, *, 1)$ is a commutative monoid and ${-\!*}$ is the residual of $*$, i.e.,

$$ x * y \leq z \iff y \leq x {-\!*} z. $$

We stipulate that $*, {-\!*}$ bind more strongly than $\wedge, \vee$. BI-algebras are the algebraic semantics of bunched implication logic, which is applied in computer science to reason about pointer structures and concurrent programs.

We show that the variety of BI-algebras that satisfy $x * y = (x * \top \wedge y) \vee (x \wedge \top * y)$ and $x * x = x$ is term-equivalent to the variety of Heyting algebras with a constant 1 and a unary operator p with residual p' that satisfy the identities $px \wedge 1 \leq x \leq px$, $p1 = \top$ and $px \wedge py \leq p((px \wedge y) \vee (x \wedge py))$. We also provide Kripke semantics for the algebras under consideration, which leads to more efficient algorithms for constructing all finite models of a given size.

This generalizes previous results on the structure of commutative doubly idempotent semirings [1], and also provides insight into a subvariety of distributive idempotent residuated lattices. We conclude with some noncommutative generalizations of these results to Brouwerian algebras with operators and distributive lattices with operators.

[1] N. ALPAY AND P. JIPSEN, *Commutative doubly-idempotent semirings determined by chains and by preorder forests*, **Proceedings of the 18th International Conference on Relational and Algebraic Methods in Computer Science (RAMiCS)**, Lecture Notes in Computer Science, vol. 12062, (Uli Fahrenberg, Peter Jipsen and Michael Winter, editors), Springer, 2020, pp. 1–14.

▶ GEORGE METCALFE, *From ℓ-groups to ℓ-monoids, and back again.*
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Removing the inverse operation from any ℓ-group, such as the ordered group of integers or pointwise-ordered group of automorphisms of the real number line, reveals a distributive ℓ-monoid structure. However, not every distributive ℓ-monoid admits an ℓ-group structure. Indeed, every ℓ-group embeds into the pointwise-ordered group of automorphisms of some chain and is either trivial or infinite, whereas every distributive

ℓ-monoid embeds into the (possibly finite) pointwise-ordered monoid of endomorphisms of some chain. In this talk, based on joint work with Almudena Colacito, Nikolaos Galatos, and Simon Santschi, we will see that an inverse-free equation is valid in all ℓ-groups if and only if it is valid in all distributive ℓ-monoids. This contrasts with the fact that there exist inverse-free equations that are valid in all Abelian ℓ-groups but not in all commutative distributive ℓ-monoids, and inverse-free equations that hold in all totally ordered groups but not in all totally ordered monoids. We will also see that the class of distributive ℓ-monoids has the finite model property and a decidable equational theory, and that the validity of an ℓ-group equation can be reduced to the validity of a (constructible) finite set of distributive ℓ-monoid equations.

▶ TOMMASO MORASCHINI, *Profiniteness and 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 [5, 6], a poset $\mathbb{X} = \langle X; \leqslant \rangle$ is isomorphic to the prime spectrum of a Heyting algebra if and only if it can be endowed with a topology τ such that $\langle X, \leqslant, \tau \rangle$ is 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 [6] and echoes analogous problems for distributive lattices [4, 7] and commutative rings [8].

In this talk we will provide a solution to this problem in the setting of well-ordered forests. Recall that a poset whose principal downsets are totally ordered is said to be a *tree* and that disjoint unions of (well-ordered) trees are called (well-ordered) *forests*. We prove that a well-ordered forest $\mathbb{X}$ is Esakia representable if and only if every nonempty chain has a supremum in $\mathbb{X}$.

While the problem of describing arbitrary Esakia representable forests remains open, the analogous problem where forests are replaced by their ordered duals, sometimes called *root systems*, admits a transparent solution. More precisely, we introduce a class of posets, called *diamond systems*, which extends the class of root systems, and prove (cf. [1, 9]) that a diamond system $\mathbb{X}$ is Esakia representable if and only if suprema and infima of nonempty chains exist in $\mathbb{X}$ and, for every $x, y \in X$,

if $x < y$, there are $x' \geqslant x$ and $y' \leqslant y$ such that $x' < y'$ and $[x', y'] = \{x', y'\}$.

Notably, the class of Heyting algebras whose prime spectra are diamond systems forms an equational class, denoted by DHA, which can be axiomatized by the Jankov's formulas of the Heyting algebras of upsets of the four posets depicted below. Furthermore, we prove that the profinite members of a variety K of Heyting algebras are profinite completions if and only if $\mathsf{K} \subseteq \mathsf{DHA}$, answering a problem from [2].

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 [3].
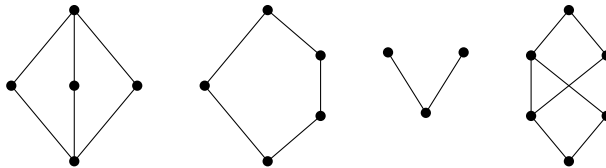
[1] R. BALBES, *On the partially ordered set of prime ideals of a distributive lattice*, **Canadian Journal of Mathematics**, vol. 23 (1971), pp. 866–874.

[2] G. BEZHANISHVILI AND P. J. MORANDI, *Profinite Heyting algebras and profinite completions of Heyting algebras*, **Georgian Mathematical Journal**, vol. 16 (2009), pp. 29–47.

[3] G. BEZHANISHVILI, N. BEZHANISHVILI, T. MORASCHINI AND M. STRONKOWSKI, *Profiniteness and representability of spectra of Heyting algebras*, submitted and available on the ArXiv.

[4] C.C. CHEN AND G. GRÄTZER, *Stone lattices. II. Structure theorems*, **Canadian Journal of Mathematics**, vol. 21 (1969), pp. 895–903.

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

[6] L. ESAKIA, **Heyting Algebras. Duality Theory** (English translation), Springer, 2019.

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

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

[9] W.J. LEWIS, *The Spectrum of a Ring as a Partially Ordered Set*, **Journal of Algebra**, vol. 25 (1973), no. 3, pp. 419–434.

▶ ALESSANDRA PALMIGIANO, *From unified correspondence to parametric correspondence: preliminary considerations.*

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Correspondence theory is the research area in mathematical logic which seeks to establish systematic connections between the axiomatic definability of classes of structures when seen both as models of first-order (or higher-order) logics and as models of propositional (non-classical) logics. Well known results in this area include Sahlqvist-van Benthem's correspondence theorem for classical modal logic [18], Rodenburg's correspondence theory for intuitionistic logic [16], the Goldblatt-Thomason theorem [14], Sambin-Vaccaro's topo-algebraic proof of Sahlqvist theorem [17], Jónsson's algebraic canonicity of Sahlqvist identities [15], and Ghilardi-Meloni's constructive canonicity for intuitionistic modal logic [13].

On the basis of insights stemming from duality theory and the theory of canonical extensions, a more recent research program, referred to as *unified correspondence theory* [5], has sought to distill the algebraic and order-theoretic underpinning of the (Sahlqvist) correspondence phenomenon, which makes it possible to abstract away from specific logical signatures, and is formulated purely in terms of the order-theoretic properties of the algebraic interpretation of logical connectives and their interaction.

This move towards abstraction has required a uniform definition of Sahlqvist-type (in)equalities which has successfully extended the benefits of correspondence theory from a very selected handful of modal and intuitionistic logics to the logics algebraically captured by (normal [6], regular [7], and monotone [11]) lattice expansions, hybrid expansions [9], fixed points expansions [4] and many-valued modal logic [1].

The algebraic and duality-theoretic perspective has also brought about added modularity to Sahlqvist correspondence results, in that the first order correspondent of a formula/inequality in a given propositional language is computed by syntactic manipulations in a certain algebraic augmentation of the language to which the given formula pertains, and is then translated into the first order languages of any class of

structures (possibly more than one class for a given logic) suitably connected (via adjunctions/dualities) with the class of algebras that constitute the algebraic semantics of the given logic.

To illustrate this point more concretely with an example, consider the axiom $\Box p \vdash p$ in the language of (positive) modal logic. As is well known, this axiom corresponds to (defines) the class of reflexive classical Kripke frames. However, first-order correspondents for this axiom exist in the first-order languages of e.g: (a) Fischer Servi's frames for intuitionistic modal logic [10]; (b) Celani-Jansana's frames for positive modal logic [2]; (c) Gehrke-Nagahashi-Venema's frames for distributive modal logic [12]; (d) Conradie-Craig's graph-based frames for lattice-based modal logic [3]; (e) the polarity-based semantics of the logics of normal lattice expansions [8]. The list could go on. As expected, in each of these contexts, the first order condition corresponding to $\Box p \vdash p$ is different, and when a comparison can be established, is strictly weaker than reflexivity; in fact, the more general the context, the weaker the condition.

So a natural question is how to describe the relationship between a given correspondence-theoretic result in one semantic setting and the analogous results in neighbouring semantic settings.

In this talk I will try and argue, by means of examples, that this relationship can be described via an enhanced and more refined notion of *parametric correspondence theory*, which involves not only the logical languages but also the models.

[1] Cecelia Britz, ***Correspondence Theory in Many-valued Modal Logic***, MSc dissertation, University of Johannesburg, 2016.

[2] Sergio Celani, Ramon Jansana, *A new semantics for positive modal logic*, **Notre Dame Journal of Formal Logic**, vol. 38 (1997), no. 1, pp. 1–18.

[3] Willem Conradie, Andrew Craig, *Relational semantics via TiRS graphs*, **TACL 2015: Topology, Algebra and Categories in Logic** (Ischia, Italy), 2015 pp. 69.

[4] Willem Conradie, Andrew Craig, Alessandra Palmigiano, Zhiguang Zhao, *Constructive canonicity for lattice-based fixed point logics*, **International Workshop on Logic, Language, Information, and Computation** (Juliette Kennedy and Ruy de Queiroz, editors), Lecture Notes in Computer Science vol. 10388, Springer, 2017, pp. 92–109.

[5] Willem Conradie, Silvio Ghilardi, Alessandra Palmigiano, *Unified correspondence*, **Johan van Benthem on logic and information dynamics** (Alexandru Baltag and Sonja Smets, editors), Springer, 2014, pp. 933–975.

[6] Willem Conradie, Alessandra Palmigiano, *Algorithmic correspondence and canonicity for non-distributive logics*, **Annals of Pure and Applied Logic**, vol. 170 (2019), no. 9, pp. 923–974.

[7] —— *Constructive canonicity of inductive inequalities*, **Logical Methods in Computer Science**, vol. 16 (2020), no. 3, pp. 1–39.

[8] Willem Conradie, Alessandra Palmigiano, Claudette Robinson, Nachoem Wijnberg, *Non-distributive logics: from semantics to meaning*, **Contemporary Logic and Computing** (Adrian Rezus editor), College Publications Series, London, 2020, pp. 38–86.

[9] Willem Conradie, Claudette Robinson, *On Sahlqvist theory for hybrid logics*, **Journal of Logic and Computation**, vol. 27 (2017), no. 3, pp. 867–900.

[10] Gisèle Fischer Servi, *Semantics for a class of intuitionistic modal calculi*, **Italian studies in the philosophy of science**, Springer, Dordrecht, 1980, pp. 59–72.

[11] Sabine Frittella, Alessandra Palmigiano, Luigi Santocanale, *Dual Characterizations for Finite Lattices via Correspondence Theory for Monotone Modal Logic*, **Journal of Logic and Computatio**, vol. 27 (2017), no. 3, pp. 639–678.

[12] MAI GEHRKE, HIDEO NAGAHASHI, YDE VENEMA, *A Sahlqvist theorem for distributive modal logic*, **Annals of pure and applied logic**, vol. 131 (2005), no. 1-3, pp. 65-102.

[13] SILVIO GHILARDI, GIANCARLO MELONI, *Constructive canonicity in non-classical logics*, **Annals of Pure and Applied Logic**, vol. 86 (1997), no. 1, pp. 1–32.

[14] ROBERT GOLDBLATT, STEVE THOMASON, *Axiomatic classes in propositional modal logic*, **Algebra and logic**, Springer, Dordrecht, 1975, pp. 163–173.

[15] BJARNI JÓNSSON, *On the canonicity of Sahlqvist identities*, **Studia Logica**, vol. 53 (1994), no. 4, pp. 473–491.

[16] PIET RODENBURG, **Intuitionistic correspondence theory**, PhD dissertation, ILLC Historical Dissertation (HDS) Series, 2016.

[17] GIOVANNI SAMBIN, VIRGINIA VACCARO, *A new proof of Sahlqvist's theorem on modal definability and completeness*, **The Journal of Symbolic Logic**, vol. 54 (1989), no. 3, pp. 992–999.

[18] JOHAN F. A. K. VAN BENTHEM, **Modal Logic and Classical Logic**, Bibliopolis (Naples), 1985.

▶ CONSTANTINE TSINAKIS, *Strongly simple residuated lattices.*

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This talk focuses on structural properties of residuated lattices and is based on [3] (co-authored with Michal Botur and Jan Kühr). It is a natural continuation of [2, 8, 12, 9, 10], which have demonstrated that large parts of the *Conrad Program* for lattice-ordered groups can be profitably extended in the setting of e-cyclic residuated lattices – namely residuated lattices that satisfy the equation $x\backslash e \approx e/x$. The restriction to e-cyclic residuated lattices is motivated by the fact that only in the e-cyclic case lattices of convex subuniverses are known to have satisfactory algebraic properties – for example, they are distributive lattices [2]. This variety of e-cyclic residuated lattices encompasses most varieties of notable significance in algebraic logic, including ℓ-groups and, more generally, all cancellative residuated lattices, MV algebras, pseudo-MV algebras, GMV algebras, GBL algebras, BL algebras, Heyting algebras, commutative residuated lattices, and integral residuated lattices. The term *Conrad Program* traditionally refers to P. F. Conrad's approach to the study of ℓ-groups aimed at capturing the structure of individual ℓ-groups, or classes of ℓ-groups, by primarily using strictly lattice theoretic properties of their lattices of convex ℓ-subgroups. Conrad's papers [4, 5, 6, 7] in the 1960s pioneered this approach and amply demonstrated its usefulness.

In the ensuing discussion we refer to the equation $(x\backslash y \wedge e) \vee (y\backslash x \wedge e) \approx e$ as the *prelinearity law*. Although this equation is not equivalent to the "right" prelinearity law $(x/y \wedge e) \vee (y/x \wedge e) \approx e$, all the properties of concern in the present paper hold for the later law as well.

This talk pays particular attention to strongly simple algebras in varieties of e-cyclic residuated lattices. An e-cyclic residuated lattice **L** is *strongly simple* provided its only convex subuniverses are $\{e\}$ and L. The structure of strongly simple members of some prominent varieties of residuated lattices is well-understood. For example, a strongly simple ℓ-group is an Archimedean totally ordered group, and hence, due to Hölder's classical result (see, e.g., [1]), it is order isomorphic to an ℓ-subgroup of the additive reals $\mathbb{R}$. Strongly simple GMV algebras and GBL algebras coincide and are also completely described. Namely, each such algebra is isomorphic to a subalgebra of the reals $\mathbb{R}$, or a subalgebra of negative reals $\mathbb{R}^-$, or a subalgebra of the standard MV algebra.

Strongly simple members of varieties of e-cyclic residuated lattices that satisfy the

prelinearity law have a particularly desirable structure, as they are residuated chains. A careful analysis of strongly simple integral residuated chains leads to the following far reaching description: If such a residuated chain $\mathbf{L}$ does not have a coatom, then it is a commutative GMV algebra. If $\mathbf{L}$ is an integral GBL chain and has a coatom, say $a \in L$, then $\mathbf{L}$ is a commutative GMV algebra and $L = \{a^n : n \in \mathbb{Z}^+\}$. (Here, $\mathbb{Z}^+$ denotes the set of nonnegative integers $\{0, 1, 2, \dots\}$.)

The preceding results are put to good use in the study of a normal-valued residuated lattice. Varieties of normal-valued residuated lattices are important for our considerations because they possess a plethora of strongly simple members. A convex subuniverse H of an e-cyclic residuated lattice $\mathbf{L}$ is said to be a *value* of an element $a \in L \setminus \{e\}$ provided H is maximal in $\mathcal{C}(\mathbf{L})$, the lattice of convex subuniverses of $\mathbf{L}$, with respect to not containing a. Alternatively, $H \in \mathcal{C}(\mathbf{L})$ is a value of some element if and only if it is completely meet-irreducible in $\mathcal{C}(\mathbf{L})$. A residuated lattice $\mathbf{L}$ is said to be *normal-valued* provided each value $H \in \mathcal{C}(\mathbf{L})$ is normal in its cover $H^\sharp \in \mathcal{C}(\mathbf{L})$. It has been known that normal-valued ℓ-groups form the largest proper variety of ℓ-groups, axiomatized relative to the variety of ℓ-groups by the equation $(x \wedge e)^2(y \wedge e)^2 \leq (y \wedge e)(x \wedge e)$ (see [11]). However, this equation does not alone axiomatize the class of normal-valued e-cyclic residuated lattices. We show however that the class of all e-cyclic normal-valued residuated lattices that satisfy the prelinearity law is indeed a variety. Further we provide an infinite equational basis for this variety and leave open the question as to whether it is finitely based.

[1] M. ANDERSON AND T. FEIL, *Lattice-Ordered Groups: An Introduction*. D. Reidel, 1988.

[2] M. BOTUR, J. KÜHR, L. LIU, AND C. TSINAKIS, *The Conrad program: From ℓ-groups to algebras of logic*, **Journal of Algebra**, vol. 450 (2016), pp. 173–203.

[3] M. BOTUR, J. KÜHR, AND C. TSINAKIS, *Strong simplicity and states in ordered algebras: Pushing the limits*, submitted.

[4] P. CONRAD, *The structure of a lattice-ordered group with a finite number of disjoint elements*, **Michigan Mathematics Journal**, vol. 7 (1960), pp. 171–180.

[5] ———, *Some structure theorems for lattice-ordered groups*, **Transactions of the American Mathematical Society**, vol. 99 (1961), pp. 212–240.

[6] ———, *The lattice of all convex ℓ-subgroups of a lattice-ordered group*, **Czechoslovak Mathematical Journal**, vol. 15 (1965), pp. 101–123.

[7] ———, *Lex-subgroups of lattice-ordered groups*, **Czechoslovak Mathematical Journal**, vol. 18 (1968), pp. 86–103.

[8] J. GIL-FÉREZ, A. LEDDA, F. PAOLI, AND C. TSINAKIS, *Lattice-theoretic properties of algebras of logic*, **Journal of Pure and Applied Algebra**, vol. 218 (2014), pp. 1932–1952.

[9] ———, *Projectable ℓ-groups and algebras of logic: Categorical and algebraic connections*, **Journal of Pure and Applied Algebra**, vol. 220 (2016), pp. 3514–3532.

[10] J. GIL-FÉREZ, A. LEDDA, AND C. TSINAKIS, *Hulls of ordered algebras: Projectability, strong projectability and lateral completeness*, **Journal of Algebra**, vol. 483 (2017), pp. 429–474.

[11] W.C. HOLLAND, *The largest proper variety of lattice ordered groups*, **Proceedings of the American Mathematical Society**, vol. 57 (1976), pp. 25–28.

[12] A. LEDDA, F. PAOLI, AND C. TSINAKIS, *The Archimedean property: New horizons and perspectives*, **Algebra Universalis**, vol. 79 (2018), pp. 78–91.

▶ SARA UGOLINI, *MV-algebras reason about probability*.
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Łukasiewicz logic and its equivalent algebraic semantics, MV-algebras, have a fruitful connection to polyhedral topology: finitely presented MV-algebras correspond to rational polyhedra, that coincide with one-sets of McNaughton functions, which represent formulas of Łukasiewicz logic. This connection between algebra, geometry and logic has been used both to prove logical properties, such as interpolation, and to study algebraic properties, such as projectivity [3]. We can show that the same geometrical intuition can be used to study Wajsberg hoops.

MV-algebras are also convincingly used to provide the foundations of the probability theory of many-valued events, seen as formulas of Łukasiewicz logic, via their *theory of states* introduced in [2]. In joint work with Tommaso Flaminio, we show how the quasiequational theory of MV-algebras contains, modulo an appropriate translation, probabilistic theorems and deductions of one of the most well-known formal systems for probabilistic reasoning, first introduced in [1]. In order to interpret probabilistic formulas, we introduce a notion of *reasoning under coherence* in which the algebraic models correspond to particular projective MV-algebras. The geometrical approach allows one to describe the algebra of probabilistic formulas and study purely logical properties.

[1] P. HÁJEK, L. GODO AND F. ESTEVA, *Probability and Fuzzy Logic*, **Proceedings of the Eleventh Conference on Uncertainty in Artificial Intelligence** (San Francisco, CA, USA), (P. Besnard and S. Hanks, editors), Morgan Kaufmann, 1995, pp. 237–244.

[2] D. MUNDICI, *Averaging the truth-value in Łukasiewicz logic*, **Studia Logica**, vol. 55 (1995), no. 1, pp. 113–127.

[3] D. MUNDICI, **Advanced Łukasiewicz calculus and MV-algebras**, Trends in Logic, Springer, 2011.

▶ ALASDAIR URQUHART, *Failure of Beth's theorem in relevance logics*.
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Beth's theorem equating explicit and implicit definability fails in all logics between Meyer's basic logic **B** and the logic **R** of Anderson and Belnap. This result has a simple proof that depends on the fact that these logics do not contain classical negation; it does not extend to logics such as **KR** that contain classical negation. Jacob Garber, however, showed that Beth's theorem fails for **KR** by adapting Ralph Freese's result showing that epimorphisms may not be surjective in the category of modular lattices. We extend Garber's result to show that the Beth theorem fails in all logics between **B** and **KR**.

<center>**Abstracts of invited talks in the Special Session on
Computability Theory**</center>

▶ FRANZ BRAUSSE, MARGARITA KOROVINA*, KONSTANTIN KOROVIN, AND NORBERT TH. MULLER, *Ksmt for solving non-linear constraints*.
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We give a detailed overview of the **ksmt** calculus developed in a conflict driven clause learning framework for checking satisfiability of non-linear constraints over the reals. Non-linear constraint solving naturally arises in the development of formal methods for verification of safety critical systems, program analysis and information management. Implementations of formal methods are widely used to approve in advance that designed systems satisfy all specification requirements, such as reliability, safety and reachability. Historically, there have been two main approaches to deal with non-linear constrains: the symbolic one originated by Tarski's decision procedure for the real closed fields and the numerical one based on interval constraint propagations. It is well known that both approaches have their strength and weakness concerning completeness, efficiency and expressiveness. Nowdays, merging strengths of symbolical and numerical approaches is one of the challenging research aria in theoretical and applied computer science.

The **ksmt** calculus successfully integrates strengths of symbolical and numerical methods. The key steps of the decision procedure based on this calculus contain assignment refinements, inferences of linear resolvents driven by linear conflicts, backjumping and constructions of local linearisations of non-linear components initiated by non-linear conflicts. In [1] we showed that the procedure is sound and makes progress by reducing the search space. This approach is applicable to a large number of constraints involving computable non-linear functions, piecewise polynomial splines, transcendental functions and solutions of polynomial differential equations. In [2] we proved that **ksmt** is a δ-complete decision procedure for bounded problems. In this setting we discuss resent and future research work.

[1] F. Brausse, K. Korovin, M. Korovina, and N. Th. Muller *A CDCL-style calculus for solving non-linear constraints.* **Frontiers of Combining Systems, 12th International Symposium, FroCoS 2019** (London, UK, September 4-6, 2019), Lecture Notes in Artificial Intellegence, vol. 11715, (Andreas Herzig and Andrei Popescu, editors), Springer, 2019, pp. 131–148.

[2] F. Brausse, K. Korovin, M. Korovina, and N. Th. Muller *The ksmt calculus is a delta-complete decision procedure for non-linear constraints*, **The 28th International Conference on Automated Deduction, CADE 2021**, Lecture Notes in Computer Science, (Andrè Platzer and Geoff Sutcliffe, editors), Springer, to appear.

▶ MATTHEW DE BRECHT, *Computable functors on the category of quasi-Polish spaces.*
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Quasi-Polish spaces are a class of well-behaved countably based T_0-spaces which include Polish spaces, ω-continuous domains, and countably based spectral spaces. In this talk, we will introduce some recent work on effectivizing the theory of quasi-Polish spaces, with an emphasis on a characterization in terms of spaces of ideals of a transitive relation on the natural numbers. Based on this characterization, it is straightforward to interpret the category of quasi-Polish spaces as a pair of represented spaces Mor (morphisms) and Obj (objects) along with (trivially computable) functions $s\colon \mathsf{Mor} \to \mathsf{Obj}$ (source), $t\colon \mathsf{Mor} \to \mathsf{Obj}$ (target), $i\colon \mathsf{Obj} \to \mathsf{Mor}$ (identity), and $\circ\colon \mathsf{Mor} \times_{\mathsf{Obj}} \mathsf{Mor} \to \mathsf{Mor}$ (composition). Our approach is compatible with the Type Two Theory of Effectivity, which allows us to investigate the computability of various category-theoretical constructions within the category of quasi-Polish spaces, such as certain

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limits and functors. As an example, we use domain theoretic techniques to verify the computability of various powerspace functors on the category of quasi-Polish spaces.

▶ VASCO BRATTKA, *Duaility in Weihrauch complexity.*
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We present a systematic approach to duality theory within Weihrauch complexity [2], based on the duality operation that was introduced by Greenberg, Kuyper, and Turetsky [4]. This approach requires a variant of Weihrauch reducibility with total reductions that we call *full Weihrauch reducibility.* Full Weihrauch reducibility relates to ordinary Weihrauch reducibility similarly as truth-table reducibility to Turing reducibility and the relation can formally be described by an interior operator that we call *hip operator.* The dual operator, which we call *hop operator*, is vaguely reminiscent of pseudo-jump operators, as they were introduced in computability theory by Jockusch and Shore [5] and together with the hip operator it can be seen as a deconstruction of the completion operator that was previously studied [1]. Of particular interest is the strong version of full Weihrauch reducibility, which induces a distributive lattice structure (in contrast to the lattice structure of ordinary strong Weihrauch reducibility, which was proved to be non-distributive by Dzhafarov [3]). The duality operation is an order reversing involution for so-called *bi-total* problems in this lattice structure. Somewhat surprisingly, the entire ordinary Weihrauch lattice can be embedded in an order-reversing way into total computable problems in this strong full Weihrauch lattice. Motivated by this observation we propose the study of the computational content of *computable* problems in this lattice structure. We demonstrate how the study of the computational content of such simple problems as the identity operations yields a structure that we call *basic triangle.* This structure serves as a *seed* from which a huge portion of problems that have been previously studied in reverse mathematics, computability theory and Weihrauch complexity can be generated just by applications of the duality, hop, jump and parallelization operators.

[1] VASCO BRATTKA, AND GUIDO GHERARDI, *Weihrauch goes Brouwerian*, **The Journal of Symbolic Logic**, electronically published 2020.

[2] VASCO BRATTKA, GUIDO GHERARDI, AND ARNO PAULY, *Weihrauch complexity in computable analysis*, **Handbook of Computability and Complexity in Analysis** (Vasco Brattka and Peter Hertling, editors), Springer, to appear.

[3] DAMIR D. DZHAFAROV, *Joins in the strong Weihrauch degrees*, **Mathematical Research Letters**, vol. 26 (2019), no. 3, pp. 749–767.

[4] NOAM GREENBERG, RUTGER KUYPER, AND DAN TURETSKY, *Cardinal invariants, non-lowness classes, and Weihrauch reducibility*, **Computability**, vol. 8 (2019), no. 3–4, pp. 305–346.

[5] CARL G. JOCKUSCH, JR. AND RICHARD A. SHORE, *Pseudojump operators I: the r.e. case*, **Transactions of the American Mathematical Society**, vol. 275 (1983), no. 2, pp. 599–609.

▶ ANTONIN CALLARD, *Descriptive complexity on represented spaces.*
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In the framework of Type-2 Theory of Effectivity (TTE), represented spaces (topological spaces equipped with a representation) form a general context in which computability has been extended.

Descriptive Set Theory (DST) provides two competing measures of complexity for sets in such spaces. The first one is topological, and stratifies sets according to the number of Boolean operations required to obtain them from open sets. The second one measures the complexity of effectively testing membership in the set. As it measures the complexity of the symbolic representation of the set, we call it the symbolic complexity.

In this talk, we investigate these two measures of complexity. While they coincide on countably-based spaces (as proved in [1]), topological and symbolic complexity may differ on more general spaces. We suggest that this difference is related to the mismatch between topological and sequential aspects of the topology of these spaces.

This talk is based on joint work with Mathieu Hoyrup.

[1] MATTHEW DE BRECHT, *Quasi-Polish spaces*, **Annals of Pure and Applied Logic**, vol. 164 (2013), no. 3, pp. 356–381.

▶ JACK H. LUTZ, NEIL LUTZ, AND ELVIRA MAYORDOMO*, *Extending the reach of the point-to-set principle.*

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The *point-to-set principle* of J. Lutz and N. Lutz (2018) [1] has recently enabled the theory of computing to be used to answer open questions about fractal geometry in Euclidean spaces $\mathbb{R}^n$. These are classical questions, meaning that their statements do not involve computation or related aspects of logic.

In this talk we extend the *reach* of the point-to-set principle from Euclidean spaces to arbitrary separable metric spaces X. We first extend two fractal dimensions—computability-theoretic versions of classical Hausdorff and packing dimensions that assign dimensions $\dim(x)$ and $\mathrm{Dim}(x)$ to *individual points* $x \in X$—to arbitrary separable metric spaces and to arbitrary gauge families. Our first two main results then extend the point-to-set principle to arbitrary separable metric spaces and to a large class of gauge families.

We demonstrate the power of our extended point-to-set principle by using it to prove new theorems about classical fractal dimensions in hyperspaces. (For a concrete computational example, the stages $E_0, E_1, E_2, \ldots$ used to construct a self-similar fractal E in the plane are elements of the hyperspace of the plane, and they converge to E in the hyperspace.) Our third main result, proven via our extended point-to-set principle, states that, under a wide variety of gauge families, the classical packing dimension agrees with the classical upper Minkowski dimension on *all* hyperspaces of compact sets. We use this theorem to give, for all sets E that are analytic, i.e., Σ_1^1, a tight bound on the packing dimension of the hyperspace of E in terms of the packing dimension of E itself.

[1] JACK H. LUTZ AND NEIL LUTZ, *Algorithmic information, plane Kakeya sets, and conditional dimension*, **ACM Transactions on Computation Theory**, vol. 10 (2018), no. 2, pp. 7:1–7:22.

▶ NEIL LUTZ, *Algorithmically optimal outer measures.*
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In this talk, I will describe recent joint work with Jack H. Lutz, in which we investigate the relationship between algorithmic fractal dimensions and the classical local fractal dimensions of outer measures in Euclidean spaces. This work introduces global and local optimality conditions for lower semicomputable outer measures and proves that globally optimal outer measures exist. Our main theorem states that the classical local fractal dimensions of any locally optimal outer measure coincide exactly with the algorithmic fractal dimensions. Our proof of this theorem uses an especially convenient locally optimal outer measure kappa defined in terms of Kolmogorov complexity. I will present these results and discuss implications for point-to-set principles.

▶ MANLIO VALENTI, *The uniform strength of descending sequences.*
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In this work, we explore the computational strength, from the point of view of Weihrauch reducibility, of the following two (equivalent) problems:

- DS: "given an ill-founded countable linear order, produce an infinite descending sequence in it";
- BS: "given a non-well quasi-order, produce an infinite bad sequence in it".

There are a number of multi-valued functions (choice principles, complete problems in the effective Baire hierarchy, etc) whose degree scaffold the Weihrauch lattice, and are often used as benchmarks to calibrate the uniform strength of a given problem.

We show that DS does not belong to this "explored" part of the lattice, as it requires non-hyperarithmetic strength to be solved, but its lower cone misses many arithmetic problems. This is done by characterizing the "first-order part" (a notion recently introduced in [1]) and the "deterministic part" (a notion we isolate for the first time, albeit it has been implicitly used in the literature) of DS.

We also study the problems $\mathbf{\Gamma}$-DS and $\mathbf{\Gamma}$-BS, where the order in input is given only via a $\mathbf{\Gamma}$-code for it, where $\mathbf{\Gamma} \in \{\mathbf{\Sigma}_k^0, \mathbf{\Pi}_k^0, \mathbf{\Delta}_k^0, \mathbf{\Sigma}_1^1, \mathbf{\Pi}_1^1, \mathbf{\Delta}_1^1\}$. We study the induced hierarchy of problems and show that it does not collapse at any finite level. We also exploit a technique based on Π_1^1-inseparable sets (first used in [2]) to show that $\mathbf{\Sigma}_1^1$-DS is strictly weaker than the problem $\mathsf{C}_{\mathbb{N}^\mathbb{N}}$ (which can be thought of as the problem of finding a path in an ill-founded subtree of $\mathbb{N}^{<\mathbb{N}}$). The problems $\mathbf{\Pi}_1^1$-DS and $\mathbf{\Sigma}_1^1$-BS are much stronger: they can be used to compute the leftmost path of an ill-founded tree, and this locates them in the realm of $\mathbf{\Pi}_1^1 - \mathsf{CA}_0$.

This is joint work with Jun Le Goh and Arno Pauly.

[1] DAMIR D. DZHAFAROV, REED SOLOMON, AND KEITA YOKOYAMA, *On the first-order parts of Weihrauch degrees*, in preparation.

[2] PAUL-ELLIOT ANGLÈS D'AURIAC AND TAKAYUKI KIHARA, *A Comparison Of Various Analytic Choice Principles*, `https://arxiv.org/abs/1907.02769v1`

▶ LINDA WESTRICK, *Two results by relativization.*
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I will discuss two results which both have short proofs via relativization of known theorems. The first concerns the structure of the Weihrauch lattice [1]. Answering a question of Pauly, we show that if $1 \leq_W F$ and $F \star F \leq_W F$, then $F^\diamond \leq_W F$, where $\star$ is the compositional product and $\diamond$ allows an arbitrary but finite number of uses of a given principle in sequence. The second is an older result on the degree theory of Scott sets [2]. Answering a question of Kučera and Slaman, we show that if $\mathcal{S}$ is an

ω-model of WWKL and $A_1, \ldots, A_n \in \mathcal{S}$ are non-computable, then there is $X \in \mathcal{S}$ which is Turing incomparable with each A_i.

[1] LINDA WESTRICK, *A note on the diamond operator*, **Computability**, to appear.
[2] ——— *Weakly 2-randoms and 1-generics in Scott sets*, **The Journal of Symbolic Logic**, vol. 83 (2018), no. 1, pp. 392–394.

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**Abstracts of invited talks in the Special Session on
Model Theory**

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▶ PABLO ANDÚJAR GUERRERO, *Types, transversals and definable compactness in o-minimal structures.*
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With the aim of advancing the study of definably compact groups, Peterzil and Pillay [3] studied closed and bounded (i.e. definably compact) affine sets in o-minimal expansions of ordered fields. They did this using previous work on forking in o-minimal theories by Dolich [2], who showed in particular that any non-forking formula in an o-minimal expansion of an ordered field extends to a definable type. In this talk we will delve into the connection between forking, definable types, and the study of a suitable notion of definable compactness, in the setting of definable topologies in o-minimal structures. I will present a new characterization of definable compactness in this setting, that takes the form of a (p, q)-theorem [1].

[1] PABLO ANDÚJAR GUERRERO, *Types, transversals and definable compactness in o-minimal structures*, in preparation.
[2] ALFRED DOLICH, *Forking and independence in o-minimal theories*, **The Journal of Symbolic Logic**, vol. 69 (2004), no. 1, pp. 215–240.
[3] YA'ACOV PETERZIL AND ANAND PILLAY, *Generic sets in definably compact groups*, **Fundamenta Mathematicae**, vol. 193 (2007), no. 2, pp. 153–170.

▶ SYLVY ANSCOMBE, *Turing degrees of existential theories of fields.*
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We prove Turing reductions between various fragments of theories of fields. In particular, we exhibit several existential theories of fields Turing equivalent to the existential theory of $\mathbb{Q}$. This is joint work with Arno Fehm.

▶ ALEXI BLOCK GORMAN*, ERIN CAULFIELD, AND PHILIPP HIERONYMI, *Pathological examples of structures with o-minimal open core.*
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In this talk, we will discuss and answer several open questions about structures with o-minimal open core. First, we will construct an expansion of an o-minimal structure R by a unary predicate such that its open core is a proper o-minimal expansion of R.

We will then consider an example of a structure that has an o-minimal open core and the exchange property, yet defines a function whose graph is dense. Finally, we will end with an example of a structure that has an o-minimal open core and definable Skolem functions, but is not o-minimal.

▶ ZOÉ CHATZIDAKIS, *Groups definable in difference-differential fields.*
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This is joint work (in progress) with Ronald Bustamante-Medina and Samaria Montenegro-Guzman.

In the context of a differentially closed field $\mathcal{U}$ of characteristic 0 with m commuting derivations (DCF_m) Phyllis Cassidy showed in [1] that if H is a simple algebraic group defined over $\mathcal{U}$, then a definable subgroup G of $H(\mathcal{U})$ which is Zariski dense in H, is conjugate to $H(L)$, where L is "a field of constants".

We generalize this result to the context of $\mathrm{DCF}_m\mathrm{mA}$, i.e., one adds a generic automorphism of the differential field. The statement is a little different, since there are other fields around, but similar. We also show that these groups have a definable connected component, and describe definable subgroups of algebraic groups.

[1] PHYLLIS CASSIDY, *The classification of the semisimple differential algebraic groups and the linear semisimple differential algebraic Lie algebras*, **Journal of Algebra**, 121 (1989), pp. 169 – 238.

▶ BRADD HART, *Undecidability in continuous logic.*
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In their recent work, MIP*=RE, Ji et al. use quantum complexity theory to resolve the Connes embedding problem. Together with Isaac Goldbring, we realized that this also showed that the universal theory of certain II_1 factors (particular von Neumann algebras) had undecidable continuous universal theories. There was a certain Gödelian aspect to the proof which I will highlight in this talk. This technique applies to other embedding problems and I will give some examples.

▶ ALEX KRUCKMAN, *Higher dimensional obstructions for star reductions.*
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The Becker graph is a directed graph structure on the set of orbits of the action of a Polish group G on a Polish space X. In the case of the logic action of the infinite symmetric group on the space of countable L-structures, the Becker graph is exactly the embeddability relation between isomorphism classes of L-structures. Building on work of Lupini and Panagiotopoulos [1], we show that a reduction between orbit equivalence relations which is Baire measurable and category-preserving (we call such a reduction a "∗-reduction") induces generically an embedding between their Becker graphs. This allows us to obstruct star reductions using invariants associated to the Becker graph. As an application of one such invariant, a notion of dimension related to higher amalgamation properties, we exhibit an infinite family of orbit equivalence relations which are pairwise incomparable with respect to star reductions. This is all joint work with Aristotelis Panagiotopoulos.

[1] MARTINO LUPINI AND ARISTOTELIS PANAGIOTOPOULOS, *Games orbits play and obstructions to Borel reducibility*, **Groups, Geometry, and Dynamics**, vol. 12 (2018), no. 4, pp. 1461–1483.

▸ KOBI PETERZIL, *Interpretable fields in expansions of valued fields.*
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We propose a method of studying an interpretable field F in an expansion of a valued field K, without a general elimination of imaginaries in K. The method works in various dp-minimal settings and is based on analysis of quotients of K itself by a definable equivalence relation. It is applied to real closed valued fields, p-adically closed fields and some expansions.

This work is joint with Y. Halevi and A. Hasson.

▸ NIGEL PYNN-COATES, *An Ax–Kochen/Ershov theorem for differential-henselian pre-H-fields.*
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URL Address: https://people.math.osu.edu/pynn-coates.1/.

Pre-H-fields are a kind of ordered valued differential field introduced by Aschenbrenner and van den Dries as part of their work on the model theory of transseries and Hardy fields [1]. I will describe a class of pre-H-fields, somewhat different from transseries, that admit an Ax–Kochen/Ershov theorem: the theory of each of these pre-H-fields is determined by the theory of its ordered differential residue field. A motivating example arises by coarsening the valuation of a saturated elementary extension of transseries so that it only distinguishes transexponentially different elements; the residue field of the coarsened valuation is an exponentially bounded model of the theory of transseries. Time permitting, I will mention related results.

[1] M. ASCHENBRENNER AND L. VAN DEN DRIES, *H-fields and their Liouville extensions*, **Mathematische Zeitschrift**, vol. 242 (2002), no. 3, pp. 543–588.

▸ CHIEU-MINH TRAN, *Minimal and nearly minimal measure expansions in locally compact groups.*
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In 1964, Kemperman proved the following continuous nonabelian counterpart of the Cauchy–Davenport theorem: If G is a connected unimodular locally compact group with a left (and hence right) Haar measure μ, $A, B \subseteq G$ are nonempty and compact, and AB is their product set, then

$$\mu(AB) \geq \min\{\mu(A) + \mu(B), \mu(G)\}.$$

I will present the recent joint works with Yifan Jing and Ruixiang Zhang where we determine the conditions for the equality to happen or nearly happen in the above inequality. Our results and methods answer several questions by Griesmer, Henstock, Hrushovski, Kemperman, Macbeath, McCrudden, and Tao.

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**Abstracts of invited talks in the Special Session on
Set Theory**

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▸ JEFFREY BERGFALK, *Combinatorial principles of independent interest arising in recent research on higher derived limits and strong homology.*
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Much of the appeal of the research referenced in this talk's title has been its tendency to frame intriguing, and often higher dimensional, variations on classical combinatorial themes. We will discuss at least three such variations which we believe to be of interest in their own right, including:

- partition relations for highly connected and well-connected subgraphs,
- higher-dimensional Δ-system lemmas, and
- n-cofinal subfamilies of directed partial orders.

The talk will draw on works by the speaker together with Nathaniel Bannister, Michael Hrušák, Chris Lambie-Hanson, Justin Tatch Moore, Saharon Shelah, and Stevo Todorcevic. No knowledge, in our audience, of derived limits or of strong homology will be presumed.

▶ FILIPPO CALDERONI, *Rotation equivalence and cocycle superrigidity for compact actions.*
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In this talk we will discuss some recent results about the Euclidean spheres in higher dimensions and the corresponding orbit equivalence relations induced by the group of rational rotations. We will show that such equivalence relations are not treeable in dimension greater than 2. Also we will discuss their relative complexity within the framework of Borel classification theory.

▶ RUIYUAN CHEN, *Some results in descriptive locale theory.*
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A locale is, informally, a topological space without an underlying set of points, with only an abstract lattice of "open sets". A recurring theme in locale theory is that omission of points removes many of the pathologies of point-set topology; instead, locale theory behaves like a generalization of "nice" topology, i.e., classical descriptive set theory, but without any countability restrictions. This talk will present some known and new results exemplifying this idea, revolving around separation and uniformization theorems as well as Baire category techniques.

▶ NOÉ DE RANCOURT, *A dichotomy for countable unions of smooth Borel equivalence relations.*
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I will present a dichotomy for equivalence relations on Polish spaces that can be expressed as countable unions of smooth Borel equivalence relations. It can be seen as an extension of Kechris–Louveau's dichotomy for hypersmooth Borel equivalence relations. If time permits, a generalization of our dichotomy, for equivalence relations that can be expressed as countable unions of Borel equivalence relations belonging to certain fixed classes, will also be presented. This is a joint work with Benjamin Miller.

[1] N. DE RANCOURT AND B. D. MILLER, *A dichotomy for countable unions of smooth Borel equivalence relations*, preprint.

▶ GABRIEL GOLDBERG, *Predictions of the ultrapower axiom.*
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The program to build canonical models for large cardinal axioms has hit an impasse below the level of supercompact cardinals. The Ultrapower Axiom (UA), a simple combinatorial principle that is expected to hold in all canonical models, enables one to develop a detailed structure theory for supercompact cardinals, apparently providing the first glimpse of the canonical models at this level. Assuming they exist, canonical models with supercompact cardinals are expected to exert a strong influence on the structure of the universe of sets itself, motivating the prediction that certain consequences of UA are actually provable outright in ZFC or from large cardinal axioms. This talk surveys some attempts to confirm this prediction.

Sample results: any two elementary embeddings from the universe of sets to the same inner model agree on the ordinals (a conjecture of Woodin); any regular cardinal above the first strongly compact that carries a uniform indecomposable ultrafilter is measurable (a question of Silver); assuming a proper class of strongly compact cardinals, there is no elementary embedding from the universe into a cardinal correct inner model (a conjecture of Caicedo); if κ is extendible, the ultrapower of the universe by a κ^+-complete ultrafilter admits no non-trivial self-embeddings (a question of van Name); the Mitchell order is wellfounded on elementary embeddings from V_λ to V_λ with critical points bounded strictly below λ (a conjecture of Steel). Applications to countably incomplete ultrafilters, set-theoretic geology, the HOD conjecture, and the theory of large cardinals beyond choice will also be discussed.

▶ YAIR HAYUT, *The strength of filter completion.*
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In [4], Mitchell asked whether in a model of the form $L[\mathcal{U}]$, can be a cardinal κ such that every κ-complete filter can be extended to a κ-complete ultrafilter, hoping that it would be in the realm of $o(\kappa) = \kappa^{++}$. In [1], Gitik showed that at least a Woodin cardinal is required. In this talk, I'm going to show that this property is equivalent to the existence of certain elementary embedding, that can be viewed as witnessing κ being "nearly strongly compact". Those embedding entail the failure of squares and thus provide a hint that the consistency strength of this assertion is in the realm of supercompactness, see [2].

Mitchell's question was generalized by Gitik and others in various direction. For example, which limitations of the filters which we are trying to extend can reduce the consistency strength? I will present a few positive results in this direction, [3], and conclude with some open questions.

[1] MOTI GITIK, *On κ-compact cardinals*, **Israel Journal of Mathematics**, vol. 237 (2020), no. 1, pp. 457–483.

[2] YAIR HAYUT, *Partial strong compactness and squares*, **Fundamenta Mathematicae**, vol. 246 (2019), no. 2, pp. 193–204.

[3] ———, *A note on the normal filters extension property*, **Proceedings of the American Mathematical Society**, vol. 148 (2020), no. 7, pp. 3129–3133.

[4] WILLIAM MITCHELL, *Hypermeasurable cardinals*, **Logic Colloquium '78** (Mons, Belgium), (Maurice Boffa, Dirk Dalen and Kenneth McAloon, editors), North Holland, 1979, pp. 303–316.

▶ DAKOTA THOR IHLI, *What generic automorphisms of the random poset look like.*
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The random poset, the Fraïssé limit of the class of finite posets, admits generic

automorphisms — that is, its automorphism group admits a comeagre conjugacy class. This result, due to D. Kuske and J. Truss, was proven without explicitly describing the automorphisms in question. Here we give a new, concrete description of the generic automorphisms, and we discuss the combinatorics and model theory involved.

▶ SANDRA MÜLLER, *The strength of determinacy when all sets are universally Baire.*
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The large cardinal strength of the Axiom of Determinacy when enhanced with the hypothesis that all sets of reals are universally Baire is known to be much stronger than the Axiom of Determinacy itself. In fact, Sargsyan conjectured it to be as strong as the existence of a cardinal that is both a limit of Woodin cardinals and a limit of strong cardinals. Larson, Sargsyan and Wilson showed that this would be optimal via a generalization of Woodin's derived model construction. We will discuss a new translation procedure for hybrid mice extending work of Steel, Zhu and Sargsyan and use this to prove Sargsyan's conjecture.

▶ ASSAF SHANI, *Actions of Polish wreath product groups.*
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Following Clemens and Coskey [1], we study actions of Polish groups of the form $\Lambda \wr \Gamma = \Gamma \ltimes \Lambda^{\Gamma}$, where Γ, Λ are countable groups. We show that for sufficiently different Γ_1, Γ_2, the Γ_1-jump of E_0 (an action of $\Lambda \wr \Gamma_1$), is not Borel reducible to any action of $\Lambda \wr \Gamma_2$. For example, when there are no non-trivial group homomorphisms from Γ_1 to Γ_2.

[1] John D. Clemens and Samuel Coskey, *New Jump Operators on Borel Equivalence Relations*, `https://arxiv.org/abs/2008.06613`.

▶ SARKA STEJSKALOVA, *Indestructibility of some compactness principles.*
Department of Logic, Charles University, Celetná 20 / Institute of Mathematics, Czech Academy of Sciences, Žitná 25; Prague.
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In the talk we survey some indestructibility results for compactness principles at κ^{++} under κ^+-cc forcings, for a regular cardinal κ. We focus on the tree property, the negation of the (weak) Kurepa hypothesis and stationary reflection.

In the first part, we review the result from [2] that if $\kappa^{<\kappa} = \kappa$ and $\lambda > \kappa$ is a weakly compact cardinal, then in the Mitchell model $V[\mathbb{M}(\kappa, \lambda)]$ the tree property at $\lambda = \kappa^{++V[\mathbb{M}(\kappa,\lambda)]}$ is indestructible under all κ^+-cc forcing notions which live in the intermediate submodel $V[\mathrm{Add}(\kappa, \lambda)]$. This result has direct applications for Prikry-style forcing notions and hence for the tree property at the double successor of a singular strong limit cardinal. We compare this result with the results of Todorcevic [6] for the tree property and the negation of the weak Kurepa hypothesis, and of Jensen and Schlechta [4] for the negation of the Kurepa hypothesis.

In the second part, we discuss an indestructibility result for stationary reflection at κ^{++} under κ^+-cc forcings, which appears in [3]. This indestructibility is stronger because it works over any model, which compares nicely with results for the negation of approachability [1] and the existence of a disjoint stationary sequence [5].

[1] Moti Gitik and John Krueger, *Approachability at the second successor of*

singular cardinal., **The Journal of Symbolic Logic**, vol. 74 (2009), no. 4, pp. 1211–1224.

[2] RADEK HONZIK AND SARKA STEJSKALOVA, *Indestructibility of the tree property*, **Journal of Symbolic Logic**, vol. 85 (2020), no. 1, pp. 467–485.

[3] ———, *Small* $\mathfrak{u}(\kappa)$ *at singular* κ *with compactness at* κ^{++}, **Archive for Mathematical Logic**, to appear.

[4] RONALD JENSEN AND KARL SCHLECHTA, *Result on the generic Kurepa hypothesis*, **Archive for Mathematical Logic**, vol. 55 (1990), no. 2, pp. 13–27.

[5] JOHN KRUEGER, *Some applications of mixed support iterations*, **Annals of Pure and Applied Logic**, vol. 158 (2009), no. 1-2, pp. 40–57.

[6] STEVO TODORCEVIC, *Some consequences of* MA + ¬wKH, **Topology and its Applications**, vol. 12 (1981), no. 2, pp. 187–202.

▶ TREVOR M. WILSON, *Weak Vopěnka cardinals.*
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Weak Vopěnka's principle says there is no sequence of structures $\langle M_\alpha : \alpha \in \mathrm{Ord}\rangle$ in a common signature such that whenever $\alpha \leq \beta$ there is a unique homomorphism $M_\beta \to M_\alpha$ and whenever $\alpha < \beta$ there is no homomorphism $M_\alpha \to M_\beta$. Adámek *et al.* [2] showed that it is both a dual and a consequence of Vopěnka's principle. By analogy with Vopěnka cardinals, we call an infinite cardinal κ *weak Vopěnka* if there is no sequence of structures $\langle M_\alpha : \alpha < \kappa\rangle$, each of cardinality $<\kappa$ in a common signature of cardinality $<\kappa$, such that whenever $\alpha \leq \beta < \kappa$ there is a unique homomorphism $M_\beta \to M_\alpha$ and whenever $\alpha < \beta < \kappa$ there is no homomorphism $M_\alpha \to M_\beta$.

The inaccessible weak Vopěnka cardinals are the Woodin cardinals [3]. In contrast to Vopěnka cardinals, weak Vopěnka cardinals need not be inaccessible, so we may call the weak Vopěnka property the algebraic essence of Woodinness just as Weiß [1] called ITP the combinatorial essence of supercompactness. We show that ITP(κ) implies κ is weak Vopěnka, and that ω_2 is weak Vopěnka after Mitchell forcing to collapse a Woodin cardinal to ω_2. We also discuss consistency strength lower bounds.

[1] C. WEISS, *The combinatorial essence of supercompactness*, **Annals of Pure and Applied Logic**, vol. 163 (2012), no. 11, pp. 1710–1717.

[2] J. ADÁMEK, J. ROSICKÝ, AND V. TRNKOVÁ, *Are all limit-closed subcategories of locally presentable categories reflective?*, **Categorical algebra and its applications**, Lecture Notes in Mathematics, vol. 1348, Springer, Berlin, 1988, pp. 1–18.

[3] T. WILSON, *The large cardinal strength of Weak Vopěnka's Principle*, `https://arxiv.org/abs/1907.00284`.

▶ KONRAD WRÓBEL, *Orbit equivalence of wreath products.*
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We prove various rigidity and antirigidity results around the orbit equivalence of wreath product actions. In particular, we show the groups $C_2 \wr \mathbb{F}_2$ and $C_n \wr \mathbb{F}_2$ are orbit equivalent. In order to accomplish this, we introduce the notion of a cofinitely equivariant map between shift spaces. This is joint work with Robin Tucker-Drob.

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**Abstracts of invited talks in the Special Session on
Topology Meets Philosophy and Logic**

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▶ ADAM BJORNDAHL, *Almost-logic.*

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In standard possible worlds semantics for modal logics, a model consists in a set of worlds W together with some additional structure (e.g., a relation, a topology, a (set of) function(s), etc.). And a formula is defined to be valid in such a model if it is true at each and every world in W. In this talk, we consider the idea of relaxing this definition of validity: instead of requiring truth at *all* worlds in W, what happens if we only ask for truth at "almost all" worlds? Of course, this depends on just what we mean by "almost all". Natural closure conditions on the corresponding notion of "almost-validity" yield some constraints, but of course do not determine a unique definition of "almost all". On the other hand, well-known topological and measure-theoretic notions of "large" sets (and, dually, "negligible" sets) provide appealing candidates for making this notion precise; each determines a corresponding class of "almost-valid" formulas, with some surprising and familiar axiomatizations to explore.

▶ A.J. COTNOIR, *Partial identity & mereotopology*.
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How should we think about the ways in which *identity* and *parthood* interact? One important line of thought comes from the joint influence of Armstrong and Lewis. The underlying idea is that mereological overlap is a kinds of identity: *partial identity*. The aim of this paper is to ask whether there may be principled reasons to doubt that two partially identical objects must share some part. We wish to explore a notion of partial identity that does not require the existence of some separate part of both. We then provide a formal theory of such a relation drawn from mereotopology. We then consider some applications in metaphysics and the philosophy of mathematics.

▶ NINA GIERASIMCZUK, *Learning and modal Logic: there and back again*.
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Among many interpretations of modal logic the one pertaining to knowledge and belief has been especially buoyant in recent years. The framework of epistemic logic offers a platform for a systematic study of knowledge and belief. Dynamic epistemic logic further extends that way of thinking to cover many kinds of transformations knowledge undergoes in communication, and under other informative events. Such iterated changes can be given a long-term horizon of learning, i.e., they can be seen as ways to acquire a desirable kind of epistemic state. Thus, the question arises: Can modal logic contribute to our understanding of learning processes in general?

The link between dynamic epistemic logic and computational learning theory was introduced in [10, 11], where it was shown that exact learning in finite time (also known as finite identification, see [16, 17]) can be modelled in dynamic epistemic logic, and that the elimination process of learning by erasing [15] can be seen as iterated upgrade of dynamic doxastic logic. This bridge opened a way to study truth-tracking properties of doxastic upgrade methods on positive, negative, and erroneous input [2, 4]. Switching from relational to topological semantics for modal logic allowed characterising favourable conditions for learning in the limit in terms of general topology [3]. This line of research recently culminated in proposing a Dynamic Logic for Learning Theory, which extends Subset Space Logics [7] with dynamic observation modalities and a

learning operator [1].

Finite identifiability and its connections with epistemic temporal logic have been further studied in [9]. Learning seen as conclusive epistemic update resulted in designing new types of learners, such as preset learners and fastest learners [14]. Some of those results were later adopted to study learning of action models in dynamic epistemic logic [5, 6], and to investigate properties of finite identification from complete data [8]. For an overview of some above contributions one can also consult [12, 13].

In my lecture, which I also gave at *Advances in Modal Logic* 2020, I will overview the modal logic and topological perspective on learnability as described above.

[1] A. Baltag, N. Gierasimczuk, A. Özgün, A. L. Vargas-Sandoval, and S. Smets, *A dynamic logic for learning theory*, **Journal of Logical and Algebraic Methods in Programming**, vol. 109 (2019), pp. 100485.

[2] A. Baltag, N. Gierasimczuk, and S. Smets, *Belief revision as a truth-tracking process*, **TARK'11: Proceedings of the 13th Conference on Theoretical Aspects of Rationality and Knowledge** (Groningen, The Netherlands), (Krzysztof Apt, editor), ACM, New York, 2011, pp. 187–190.

[3] A. Baltag, N. Gierasimczuk, and S. Smets, *On the solvability of inductive problems: A study in epistemic topology*, **TARK'15: Proceedings of the 15th Conference on Theoretical Aspects of Rationality and Knowledge** (Pittsburgh, USA), (Ram Ramanujam, editor), vol. 215, EPTCS, 2016, pp. 81–98.

[4] A. Baltag, N. Gierasimczuk, and S. Smets, *Truth-tracking by belief revision*, **Studia Logica**, vol. 107 (2019), no. 5, pp. 917–947.

[5] T. Bolander and N. Gierasimczuk, *Learning actions models: Qualitative approach*, **Logic, Rationality, and Interaction - 5th International Workshop, LORI 2015** (Taipei, Taiwan), (W. van der Hoek, W. H. Holliday, and W. Wang, editors), vol. 9394, Lecture Notes in Computer Science, Springer, 2015, pp. 40–52.

[6] T. Bolander and N. Gierasimczuk, *Learning to act: qualitative learning of deterministic action models*, **Journal of Logic and Computation**, vol. 28 (2018), no. 2, pp. 337–365.

[7] A. Dabrowski, L. S. Moss, and R. Parikh, *Topological reasoning and the logic of knowledge*, **Annals of Pure and Applied Logic**, vol. 78 (1996), no. 1, pp. 73–110.

[8] D. de Jongh and A. L. Vargas-Sandoval, *Finite identification with positive and with complete data*, **Language, Logic, and Computation. TbiLLC 2018** (Tbilisi, Georgia), (A. Silva, S. Staton, P. Sutton, and C. Umbach, editors), vol. 11456, Springer Berlin Heidelberg, 2019, pp. 42–63.

[9] C. Dégremont and N. Gierasimczuk, *Finite identification from the viewpoint of epistemic update*, **Information and Computation**, vol. 209 (2011), no. 3, pp. 383–396.

[10] N. Gierasimczuk, *Bridging learning theory and dynamic epistemic logic*, **Synthese**, vol. 169 (2009), no. 2, pp. 371–384.

[11] N. Gierasimczuk, *Learning by erasing in dynamic epistemic logic*, **LATA'09: Proceedings of 3rd International Conference on Language and Automata Theory and Applications** (Tarragona, Spain), (A. H. Dediu, A. M. Ionescu, and C. Martin-Vide, editors), vol. 5457, Lecture Notes in Computer Science, Springer, 2009, pp. 362–373.

[12] N. Gierasimczuk, **Knowing One's Limits. Logical Analysis of Inductive Inference**, PhD thesis, Universiteit van Amsterdam, The Netherlands, 2010.

[13] N. Gierasimczuk, D. de Jongh, and V. F. Hendricks, *Logic and learning*, **Johan van Benthem on Logical and Informational Dynamics** (A. Baltag and S. Smets, editors), Springer, 2014, pp. 267–288.

[14] N. Gierasimczuk and D. Jonghde Jongh, *On the complexity of conclusive*

update, **The Computer Journal**, vol. 56 (2013), no. 3, pp. 365–377.

[15] S. Lange, R. Wiehagen, and T. Zeugmann, *Learning by erasing*, **ALT 1996: Algorithmic Learning Theory** (Sydney, Australia), (S. Arikawa and A. Sharma, editors), vol. 1160, Lecture Notes in Computer Science, Springer, 1996, pp. 228–241.

[16] S. Lange and T. Zeugmann, *Types of monotonic language learning and their characterization*, **COLT'92: Proceedings of the 5th Annual ACM Conference on Computational Learning Theory** (Pittsburgh, USA), ACM, New York, 1992, pp. 377–390.

[17] Y. Mukouchi, *Characterization of finite identification*, **AII'92: Proceedings of the International Workshop on Analogical and Inductive Inference** (Dagstuhl Castle, Germany), (K. Jantke, editor), vol. 642, Lecture Notes in Computer Science, Springer, 1992, pp. 260–267.

▶ GEOFFREY HELLMAN AND STEWART SHAPIRO, *Regions-based topology in geometry.*

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In this presentation, we explore the relationship between geometric and topological regions-based (or point-free) theories of continua, concentrating on the (classical) one-dimensional case (the real line, $\mathbb{R}$). First we review the essentials of our geometric/analytic regions-based account (2018) of what we call the "gunky line", G. Although in our theory, points are not recognized as parts of G, there are multiple ways of explicitly defining points and relevant relations among them in our language of regions, using mereology and some second-order machinery (e.g. second-order logic, a weak set theory, or logic of plurals), so that standard Dedekind-Cantor accounts of the real line are reducible to our theory of G. And the latter is also reducible to the former, so we have full mathematical equivalence. Here we highlight the role of our unrestricted fusions axiom of mereology enabling derivation of Dedekind Completeness, and our geometric primitive of *congruence of intervals* and a Translation axiom that enables derivation of the Archimedean property, so that neither of these need be taken as axioms. Next we examine regions-based topological accounts of the classical continuum (e.g. of Roeper (2006)). These accounts adopt two primitives pertaining to regions, viz. "limited" and "connected": a region is limited iff it is bounded (in effect, lies between two other regions); and two regions are connected iff no region lies between them. Thus, these topological primitives are definable in the language of G; further, the axioms governing them are derivable as theorems in our theory of G. However, the theory of G is not reducible to the topological theory of $\mathbb{R}$ as the latter lacks the means to define *congruence* (essentially a metrical concept). Thus, whatever topology is essential to a categorical regions-based account of $\mathbb{R}$ is already incorporated in our theory of G.

[1] Geoffrey Hellman and Stewart Shapiro, **Varieties of Continua: from Regions to Points and Back**, Oxford University Press, 2018.

[2] Peter T. Johnstone, *The Point of Pointless Topology*, **Bulletin of the American Mathematical Society**, vol. 8 (1983), pp. 41–53.

[3] Peter Roeper, *The Aristotelian Continuum: a Formal Characterization*, **Notre Dame Journal of Formal Logic**, vol. 47 (2006), pp. 211–231.

▶ SOPHIA KNIGHT, *Algebraic structures for distributed knowledge of potentially infinite groups of agents.*

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We will present a method of defining the distributed knowledge of a potentially infinite group of agents, using spatial constraint systems from concurrency theory. Spatial constraint systems are lattice-based semantic structures for reasoning about spatial and epistemic information in concurrent systems. We develop the theory of spatial constraint systems to reason about the distributed knowledge or information of potentially infinite groups. We characterize the notion of distributed information/knowledge of a group of agents as the infimum of the set of join-preserving functions that represent the spaces of the agents in the group. We provide an alternative characterization of this notion as the greatest family of join-preserving functions that satisfy certain basic properties. For completely distributive lattices, we establish that the distributed information of c amongst a group is the greatest lower bound of all possible combinations of information in the spaces of the agents in the group that derive c. We show compositionality results for these characterizations and conditions under which information that can be obtained by an infinite group can also be obtained by a finite group. Finally, we provide an application on mathematical morphology where dilations, one of its fundamental operations, define an scs on a powerset lattice. We show that distributed information represents a particular dilation in such scs.

This talk is based on joint work with Michell Guzmán, Santiago Quintero, Sergio Ramírez, Camilo Rueda, and Frank Valencia.

Abstracts of contributed talks

▶ IRFAN ALAM, *Generalizing de Finetti's theorem using nonstandard methods.*
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In its classical form, de Finetti's theorem provides a representation of any exchangeable sequence of Bernoulli random variables as a mixture sequences of iid random variables. Following the work of Hewitt and Savage, such a representation was known for exchangeable random variables taking values in any Polish space. In a recent work, the author has used nonstandard analysis to show that such a representation holds for a sequence of exchangeable random variables taking values in any Hausdorff space as long as their underlying distribution is Radon (in fact, tightness and outer regularity on compact sets are also sufficient). The arguments have topological measure theoretic and combinatorial flavors, with nonstandard analysis serving as a bridge between these themes. This talk will give an overview of this work.

▶ ALEXANDR BESSONOV, *Gödel's incompleteness theorems from the perspective of a falsifiability predicate.*
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In the proofs of the incompleteness theorems (see, e.g. [1]), Gödel formalizes (un)provability in formal Dedekind–Peano arithmetic (PA) by means of a *provability predicate* (up to notation) $\Pr(x, y)$ which holds iff x is the Gödel number of some formula, and y is the number of a proof of that formula or some of its constructive transformation. At the same time, other Gödel style numeralwise expressible (G-expressible) predicates are

usually not involved. What will happen to the incompleteness theorems if alternative methods for formalizing (un)provability are used?

Instead of Gödel's provability predicate, we consider a *falsifiability predicate* F(x, y), which holds iff x is the Gödel number of some formula $\Phi(z)$ with one free variable, and y is the Gödel number of a proof of $\neg\Phi(x)$, i.e., the number of a proof of the *negation* of a formula obtained from $\Phi(z)$ by substituting the number x for the variable z. The falsifiability predicate F(x, y) is solvable, and hence it is G-expressible in PA via some arithmetic formula $F(x, y)$.

Consider a formula $\exists y F(x, y)$, and assume that its Gödel number is m. If in this formula we substitute numeral **m** for x we obtain a formula of the form

$$\exists y F(\mathbf{m}, y), \tag{1}$$

which G-expresses its own falsifiability. Repeating the Gödelian arguments almost verbatim, we can prove that (1) is unsolvable if PA satisfies conditions similar to the Gödelian. Thus, in our presentation of (un)provability in PA, the first incompleteness theorem remains valid. And what about the second theorem?

Consider a falsifiability predicate Fals(x, y), which holds iff x is the Gödel number of a formula, and y is the Gödel number of a proof of the negation of this formula. The predicate Fals(x, y) is solvable, and hence it is G-expressible in PA via some arithmetic formula $Fals(x, y)$. Take a formula of the form

$$\exists x \exists y Fals(x, y), \tag{2}$$

which reads as follows: there is a formula whose negation is provable in PA. This, under the assumption that PA is consistent, means that the above formula is unprovable. Therefore, (2) G-expresses the existence in PA of an unprovable formula, and thus G-expresses the consistency of PA.

It is easy to see that (2) is elementarily provable in PA [2]. This, however, directly refutes the conclusion of the second incompleteness theorem: "Arithmetic, if it is consistent, cannot prove its own consistency." It follows that the second incompleteness theorem is independent of the first: for one presentation of (un)provability in PA, both theorems are true, and for the other, the first theorem is true, and the second is not. This refutes the generally accepted view that there exists an inextricable connection between Gödel's first and second incompleteness theorems.

We can also conclude that the basis of an almost religious belief in the second incompleteness theorem is a random event. If, in the proof of the first incompleteness theorem, Gödel had chosen a falsifiability predicate instead of a provability one, then the conclusion of the second theorem would not have been formulated at all. Nor would there be any reason to assert that Gödel's second incompleteness theorem dealt a fatal blow to Hilbert's finitistic program.

[1] K. GÖDEL, *On formally undecidable propositions of Principia mathematica and related systems I*, **Kurt Gödel. Collected Works**, vol. 1, (S. Feferman, J. R. Dawson, S. C. Kleene, G. H. Moore, R. M. Solovay, and J. van Heijenoort, editors.), Oxford University Press, 1986, pp. 145–195.

[2] A. BESSONOV, *Peano arithmetic can well prove its own consistency*, **The Bulletin of Symbolic Logic**, vol. 22 (2016), No. 3, pp. 389.

▶ CALEB CAMRUD* AND RANPAL DOSANJH, $[0, \infty]$-*indexed multimodal logics with philosophical applications.*
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Traditional modal logic includes only a discrete accessibility relation between possible worlds. That is, a world either has access to another given world, or it does not, with no "degrees" of accessibility. We examine extensions of the normal multimodal logic constructed from a set of modal operators indexed by $[0, \infty]$ which have frame correspondences that induce a continuum-like degree structure on the set of accessibility relations. These logics follow similar constructions to those found in [1] and [2]. The primary extensions we focus on consist of a pseudometric space modal logic and a metric space modal logic. We further introduce an alternative semantics which defines satisfiability with respect to a pseudometric space, and show that in a restricted class of Kripke frames, this semantics is equivalent to the standard possible world semantics. In this way, the multimodal logics introduced correctly characterize their respective continuous spaces in a systematic and uniform manner, inducing their structure from classical Kripke frames. We also briefly discuss the applications of these logics and their continuous accessibility relation to philosophy in the analysis of counterfactual conditionals based on dimensions of similarity, as an analog to the analysis found in [3].

[1] Frank Wolter and Michael Zakharyaschev, *Reasoning about distances*, **Proceedings of the 18th International Joint Conference on Artificial Intelligence** (IJCAI 2003), (Morgan Kaufmann, editor), 2003, pp. 1275–1280.

[2] ———, *A Logic for Metric and Topology*, **The Journal of Symbolic Logic**, vol. 70 (2005), no. 3, pp. 795–828.

[3] M. Sheremet, D. Tishkovsky, F. Wolter, and M. Zakharyaschev, *A Logic for Concepts and Similarity*, **Journal of Logic and Computation**, vol. 17 (2007), no. 3, pp. 415–452.

► CALEB CAMRUD*, ISSAC GOLDBRING, AND TIMOTHY MCNICHOLL, *Diagram complexity of metric structures in continuous logic.*

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The arithmetical complexity of classical diagrams of computable structures is almost trivial: for every natural number N, the Π_N diagram is definable by a Π_N^0 formula (and likewise for Σ_N). In the continuous logic of [1], however, we show that there is a computably presentable metric structure such that the Π_N closed diagram remains Π_N^0-complete, while the Σ_N closed diagram jumps in complexity to being Π_{N+1}^0-complete, and the Σ_N open diagram remains Σ_N^0-complete, while the Π_N open diagram jumps in complexity to being Σ_{N+1}^0-complete. On the other hand, when considering only metric structures with computably compact computable presentations, the elementary open and closed diagrams of these structures are only Σ_1^0-complete and Π_1^0-complete, respectively. We further examine the hyperarithmetical complexity, see [2], of the open and closed Dedekind cuts of interpretations of computable infinitary formulas of continuous logic in computably presentable metric structures, using the development of infinitary continuous logic found in [3] and [4].

[1] Itaï Ben Yaacov, Alexander Berenstein, C. Ward Henson, and Alexander Usvyatsov, *Model theory for metric structures*, **Model Theory with Applications to Algebra and Analysis, vol. 2**, (Zoé Chatzidakis, Dugald Macpherson, Anand Pillay, and Alex Wilkie, editors) London Math Society Lecture Note Series, vol. 350, London, 2008, pp. 315–427.

[2] C.J. Ash and J. Knight, **Computable Structures and the Hyperarithmetical Hierarchy**, Studies in Logic and the Foundations of Mathematics, vol. 144, North Holland, 2000.

[3] Christopher J. Eagle, *Omitting types for infinitary* $[0, 1]$-*valued logic*, **Annals of Pure and Applied Logic**, vol. 165 (2014), pp. 913–932.

[4] Itaï Ben Yaacov, Michal Doucha, André Nies, and Todor Tsankov, *Metric Scott Analysis*, **Advances in Mathematics**, vol. 318 (2017), pp. 46–87.

▶ LANDON D. C. ELKIND AND RICHARD ZACH, *The genealogy of* ∨.

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The use of the symbol ∨ for inclusive disjunction in formal logic is ubiquitous. We trace the modern use of the symbol to Russell's early investigations into formal logic: he first used it for disjunction in [1]; and in print in [2]. We consider and reject the hypothesis that Russell chose the symbols because it resembles 'v', the inital letter of the Latin *vel*. Rather, Russell started by adopting Peano's '∪' but wanted to distinguish typographically between class union and disjunction of propositions and propositional functions. We also trace the influence of *Principia*'s use of ∨ on the symbols used by subsequent authors and their alternative notations for disjunction, focusing especially on those in the Hilbert school, Carnap, and early Quine.

[1] Bertrand Russell, *Classes*, 1903, manuscript, edited in: **Foundations of logic, 1903–05** (Alasdair Urquhart, editor), The Collected Papers of Bertrand Russell 4, Routledge, London and New York, 1994, pp. 3–37.

[2] Bertrand Russell, *The theory of implication*, **American Journal of Mathematics**, vol. 28 (1906), no. 2, pp. 159–202.

▶ JOSIAH JACOBSEN-GROCOTT, *Classification of classes of enumeration degrees of non-metrizable spaces by topological separation axioms*.

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A point in a represented second-countable T_0-space can be identified with the set of basic open sets containing that point. Using this coding, we can consider the enumeration degrees of the points in a second-countable T_0-space. For example, the ω-product of the Sierpiński space is universal for second-countable T_0-spaces and gives us all enumeration degrees and the Hilbert cube gives us all continuous degrees.

Kihara, Ng, and Pauly have introduced this nottion and studied various classes that arise from different spaces. They show that any enumeration degree is contained in a class arising from some computable, submetrizable T_0-space, and that no T_1-space contains all enumeration degrees. Similarly they separate T_2 classes from T_1 classes and $T_{2.5}$ classes from T_2 classes by showing that no T_2 class contains all the cylinder-cototal

degrees and no $T_{2.5}$ class contains all degrees arising from $(\mathbb{N}_{\mathrm{rp}})^{\omega}$. We answer several questions posed in their article: we show that the cylinder-cototal degrees are T_2-quasi-minimal and the $(\mathbb{N}_{\mathrm{rp}})^{\omega}$ degrees are $T_{2.5}$-quasi-minimal. We then give separations of the $T_{2.5}$ degrees from the submetrizable degrees using the Arens co-d-CEA degrees and the Roy halfgraph above degrees.

▶ RUSSELL MILLER, *Generic algebraic fields.*
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The algebraic field extensions of the field $\mathbb{Q}$ of rational numbers – equivalently, the subfields of the algebraic closure of $\overline{\mathbb{Q}}$ – form a computable topological space in a natural way. The topology is variously known as the étale topology or the Vietoris topology. This space is homeomorphic to Cantor space, and therefore has the property of Baire, allowing us to apply the techniques of Baire category on it. The standard notions of genericity from computability theory hold: the *n-generic* elements are those that meet every dense $\emptyset^{(n)}$-computable subset of the space. We present several results that hold for all 1-generic fields, describing which sets can be either existentially or universally definable in such fields, and also how difficult Hilbert's Tenth Problem can be for such fields. Of course, from the point of view of Baire category, these results therefore hold for "almost all" algebraic fields, as the 1-generic elements form a comeager subset of the space.

This is joint work with Kirsten Eisenträger, Caleb Springer, and Linda Westrick.

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We give exact definitions of these key concepts. We show that equivalence relations may be identified with certain alternative similarities and, more originally, universal equalities. Eventually, we analyze assertions of the form of "all men are equal".

I. Let $P \subseteq M$ be any property, $a, b, c, \ldots \in M$, $P(a)$:iff $a \in P$. We define $a \sim_P b$ by $P(a)$ & $P(b)$. For instance, $1 \sim_{\mathrm{odd}} 5$, $4 \nsim_{\mathrm{odd}} 8$. $\sim_P$ is symmetric and transitive; $\sim_P$ is reflexive iff P is total iff $\sim_P$ is total. $\sim_P$ must not be confused with $\approx$.

For any property system $\mathcal{P} \subseteq \wp(M)$, $a \sim_{\mathcal{P}} b$:iff $a \sim_P b$ for some $P \in \mathcal{P}$. $\sim_{\mathcal{P}}$ is symmetric; $\sim_{\mathcal{P}}$ is reflexive if $\mathcal{P}$ covers M; $\sim_{\mathcal{P}}$ is transitive if $\mathcal{P}$ is separative. If $E \subseteq M^2$ is an equivalence, the quotient set M/E is a partition and $E = \sim_{M/E}$. $a \dot{\sim}_{\mathcal{P}} b$:iff $a \sim_P b$ for all $P \in \mathcal{P}$. If $\mathcal{P}$ is trivial, $\sim_{\mathcal{P}}, \dot{\sim}_{\mathcal{P}}$ are total; if $\dot{\sim}_{\mathcal{P}}$ is total, $\mathcal{P} = \{M\}$.

II. We define $a \equiv_P b$ by $P(a) \Leftrightarrow P(b)$. P-similar implies P-equal, but not vice versa. For example, $4 \equiv_{\mathrm{odd}} 8$. $\equiv_P$ is an equivalence.

Theorem. (i) If P is total, $\equiv_P$ is total.
(ii) If P is not empty and $\equiv_P$ is total, P is total.
Proof. (i) As P is total, so is $\sim_P$, whence so is $\equiv_P$. (ii) By $P(a_0)$ and $a_0 \equiv_P a$, $P(a)$.

We define $a \equiv_{\mathcal{P}} b$:iff $a \equiv_P b$ for all $P \in \mathcal{P}$. Following Leibniz, equality with respect to all properties coincides with identity, viz. $a \equiv_{\mathcal{P}*} b$ iff $a = b$. All $\equiv_{\mathcal{P}}$ are equivalences.

Buchholz's Theorem. If $\mathcal{P}$ disjointly covers M, $a \equiv_{\mathcal{P}} b$ iff $a \sim_{\mathcal{P}} b$.
Proof. ($\Rightarrow$) Since $a \in \cup\mathcal{P}$, $P(a)$ for some $P \in \mathcal{P}$, whence, by $a \equiv_P b$, $P(b)$, whereby $a \sim_P b$. ($\Leftarrow$) By assumption, $a \sim_Q b$ for some $Q \in \mathcal{P}$, whence $a \equiv_P b$ for $P = Q$. If $P \in \mathcal{P}$ with $P \neq Q$, $P \cap Q = \emptyset$, whence $P(a), P(b)$ are not the case, whereby $a \equiv_P b$.

Corollary. If E is any equivalence, $E = \equiv_{M/E}$.

III. Propositions of the form "all M are P-equal" may be specified by $a \equiv_P b$ for all $a, b \in M$, i. e. $\equiv_P$ is total. Thus there is one and only one (non-vacuous) property with respect to which all M are equal, namely—and trivially—M itself, viz. all M are M-equal (Satz von Peana Pesen) and all M are P-equal implies $P = M$ if P is not empty. Consequently, the trivial property system is the unique stuffed $\mathcal{P}$ such that all M are $\mathcal{P}$-equal; and, likewise, the one and only $\mathcal{P}$ such that all M are universally $\mathcal{P}$-similar.

▸ WIM RUITENBURG, *Kolmogorov translations into basic logic.*
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Kolmogorov established the principle of the double negation translation by which to embed Classical Predicate Logic into Intuitionistic Predicate Logic. We generalize this to an embedding into Basic Predicate Logic. Basic Predicate Logic is a sublogic of Intuitionistic Predicate Logic with a weakened rule of modus ponens, and is proposed to be *the* logic of constructive mathematics. The extended Kolmogorov embedding demonstrates that Basic Predicate Logic has great logical strength.

Abstracts of talks presented by title

▸ B.SH. KULPESHOV, T.S. MUSTAFIN, *Binarity of almost ω-categorical weakly o-minimal theories of convexity rank 1.*
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This lecture concerns the notion of *weak o-minimality* which was initially deeply studied by D. Macpherson, D. Marker and C. Steinhorn in [1]. A *weakly o-minimal structure* is a linearly ordered structure $M = \langle M, =, <, \ldots \rangle$ such that any definable (with parameters) subset of M is a union of finitely many convex sets in M. The rank of convexity of a formula with one free variable was introduced in [2].

The following notion was introduced in [3] and investigated in [4]. Let T be a complete theory, and $p_1(x_1), \ldots, p_n(x_n) \in S_1(\emptyset)$. A type $q(x_1, \ldots, x_n) \in S_n(\emptyset)$ is said to be a $(p_1, \ldots, p_n)$-*type* if $q(x_1, \ldots, x_n) \supseteq \bigcup_{i=1}^{n} p_i(x_i)$. The set of all $(p_1, \ldots, p_n)$-types of the theory T is denoted by $S_{p_1, \ldots, p_n}(T)$. A countable theory T is said to be *almost ω-categorical* if for any types $p_1(x_1), \ldots, p_n(x_n) \in S_1(\emptyset)$ there are only finitely many types $q(x_1, \ldots, x_n) \in S_{p_1, \ldots, p_n}(T)$.

THEOREM 1. *Any almost ω–categorical weakly o-minimal theory of convexity rank 1 is binary.*

[1] H.D. MACPHERSON, D. MARKER, AND C. STEINHORN, *Weakly o-minimal structures and real closed fields*, **Transactions of The American Mathematical Society**, vol. 352 (2000), pp. 5435–5483.

[2] B.SH. KULPESHOV, *Weakly o-minimal structures and some of their properties*, **The Journal of Symbolic Logic**, vol. 63 (1998), pp. 1511–1528.

[3] K. IKEDA, A. PILLAY, A. TSUBOI, *On theories having three countable models*, **Mathematical Logic Quarterly**, vol. 44, issue 2 (1998), pp. 161–166.

[4] S.V. Sudoplatov, *Classification of countable models of complete theories I*, Novosibirsk State Technical University Publishing House, 2018.