THE BULLETIN OF SYMBOLIC LOGIC
Volume 10, Number 1, March 2004

2003 ANNUAL MEETING OF THE ASSOCIATION FOR SYMBOLIC LOGIC

University of Illinois at Chicago, Chicago, IL, June 1–4, 2003

The Annual Meeting of the Association was held on the campus of the University of Illinois at Chicago, June 1–4, 2003. The program included the Fourteenth Annual Gödel Lecture, a tutorial, the awarding of the Karp Prize and a lecture on the winners' work, 12 additional invited talks, three special sessions, 19 contributed talks, and three abstracts presented by title. The members of the Program Committee were John Baldwin, Andreas Blass (Chair), Timothy Carlson, W. D. Hart, Denis Hirschfeldt, David MacQueen, and Donald Monk. The members of the Local Organizing Committee were Willem Blok, W. D. Hart (Chair), William Howard, and David Marker. There were 132 registered participants at the meeting, including 42 graduate students. Generous financial support was provided by the University of Illinois at Chicago. The ASL hosted a welcoming reception.

The Sixth Carol Karp Prize was awarded to Alexander Kechris (Caltech) and Gregory Hjorth (U.C.L.A.) for their work on Borel equivalence relations. Simon Thomas (Rutgers University) presented a lecture on this work.

The Fourteenth Annual Gödel Lecture, *Categoricity*, was presented by Boris Zilber (Oxford University). Jack Lutz (Iowa State University) gave a tutorial of three lectures on Kolmogorov complexity. The other hour-long invited addresses were:

Gregory Cherlin (Rutgers University), *Simple groups of finite Morley rank: The Borovik program*.

Alan Dow (University of North Carolina, Charlotte), *MAD families and topological spaces*.

Yuri Gurevich (Microsoft Research), *Kolmogorov machines and related issues*.

Leo Harrington (University of California, Berkeley), *Anaximander's saying*.

Ulrich Kohlenbach (BRICS, University of Aarhus), *Proof theoretic applications to functional analysis*.

Phokion Kolaitis (University of California, Santa Cruz), *Constraint satisfaction, finite-variable logics, and treewidth*.

Leonid Levin (Boston University), *Forbidden information*.

Michael Makkai (McGill University), *A new set theory*.

Ralph McKenzie (Vanderbilt University), *The interplay between structural insight and algorithmic problems in general algebra*.

Don Pigozzi (Iowa State University), *Abstract algebraic logic and the algebraic hierarchy*.

Andrzej Rosłanowski (University of Nebraska, Omaha), *How much sweetness is there in the universe?*

Sergei Starchenko (Notre Dame University), *On isomorphisms of elliptic curves definable in o-minimal structures*.

There were also special sessions (with organizers given in parentheses) on Algebraic Logic and Universal Algebra (Joel Berman and Willem Blok), Computability Theory and Effective Mathematics (Denis Hirschfeldt and Robert Soare), and Model Theory (John Baldwin and David Marker). These had a total of 31 speakers.

1079-8986/04/1001-0008/$3.60

Abstracts of talks given in person or by title by members of the Association for Symbolic Logic follow.

For the Program Committee
ANDREAS BLASS

Abstract of the 14th Annual Gödel Lecture

► BORIS ZILBER, *Categoricity*.
Mathematical Institute, University of Oxford, 24–29 St. Giles, Oxford, OX1 3LB United Kingdom.
E-mail: zilber@maths.ox.ac.uk.
http://www.maths.ox.ac.uk/~zilber.

I am going to discuss Categoricity both as one of the basic principles of mathematics usually called Uniqueness and its logical form, the concept of categoricity of a formal theory, the ultimate form of completeness, as studied in model theory.

I will present a brief survey of model theoretical results on categoricity and stability, both in first order and non-elementary languages, with applications in mathematics, and argue that the categoricity theory developed by logicians is a universal and powerful heuristic principle.

Abstracts of invited plenary talks

► GREGORY CHERLIN, *Simple groups of finite Morley rank: The Borovik Program*.
Department of Mathematics, Rutgers University, Hill Center Busch Campus, 110 Frelinghuysen Road, Piscataway, NJ 08854, USA.
E-mail: cherlin@math.rutgers.edu.
http://www.rci.rutgers.edu/~cherlin/FMR.

Groups interpretable in uncountably categorical structures inherit a notion of dimension known as Morley rank, and the rank is finite in this context. From a group theoretical point of view it is natural to ask for an explicit classification of the simple (nonabelian) ones. All known simple groups of finite Morley rank are definable over algebraically closed fields (in short, are “algebraic”), and it has been conjectured that there are no others. As the classification of the simple algebraic groups is known explicitly (generally expressed in terms of “Dynkin diagrams”), the conjecture has very explicit content. Borovik suggested that some aspects of the problem might be analysed using methods which were used successfully in the classification of the finite simple groups. This program has been pursued with some substantial success. I intend to present the Borovik program, and describe some of its successes and some of its limitations. While the work has been going on for more than a decade, some recent work involving Altinel, Berkman, Borovik, Frécon, Jaligot, Nesin, Poizat, and Wagner has broadened and simplified the picture. (Some of this work is in progress, and its final status may not be clear at the time of this report.)

In this work methods of finite group theory are combined with ideas coming from the theory of algebraic groups, with occasional injections of pure model theory, the latter most powerfully represented in recent times by work of Wagner.

► ALAN DOW, *MAD families and topological spaces*.
University of North Carolina at Charlotte, Department of Mathematics, 9201 University City Boulevard, Charlotte, NC 28223, USA.
E-mail: adow@uncc.edu.

Is there a compact sequential space which is not Frechet? Yes, because the natural psi-space extension of the integers N associated with an almost disjoint (mad) family is locally compact and its one-point compactification is sequential but not Frechet. Are there two compact Frechet spaces whose product is not Frechet? Yes [P. Simon], construct a special mad family which can be written as the union of two nowhere maximal almost disjoint families. We will investigate examples of questions about separable compact spaces that seem closely related to mad families and raise questions about mad families that result.

► YURI GUREVICH, *Kolmogorov machines and related issues*.
Microsoft Research, One Microsoft Way, Redmond, WA 98052, USA.
E-mail: `gurevich@microsoft.com`.

Turing arrived at his computation model by analyzing computations performed by human computers. Kolmogorov arrived to his computation model by analyzing computation as a physical process. As far as computable functions are concerned, the Kolmogorov model is equivalent to the Turing model. But as far as computational complexity is concerned, the more flexible Kolmogorov model offered substantial advantages. Levin utilized the advantages to construct an algorithm for any given NP problem that is optimal up to a constant factor. One important question is how well the Kolmogorov machine model reflects the intuitive notion of algorithm.

► LEO HARRINGTON, *Anaximander's Saying*.
Department of Mathematics, University of California, Berkeley, CA 94720-3840, USA.
E-mail: `leo@math.berkeley.edu`.

This talk will present a reading of fragment B1 of the PreSocratic philosopher Anaximander. This fragment has been called "the incipient saying of being". The reading will be entirely mathematical. This is not intended to suggest that the saying itself is mathematical, but only to suggest that such a mathematical reading might help one better hear what the saying may be trying to say.

The reading is based on a key word 'apeiron' from another Anaximander fragment (A9) plus the PreSocratic philosopher Parmenides' description of 'peiras' (in fragment B8.42–44) as 'like the bulk of a well-rounded sphere everywhere from the center equally matched' which this reading will take (in the context of group actions) as 'like an orbit under a stabilizer subaction'.

In mathematical logic, group actions provide an abstract way of looking at what model theory deals with more concretely; group actions (or rather stabilizer subactions) have the advantage, for the purposes of this reading, of not being incipiently tied to a definite interpretation of a definite language. A main feature of the reading proposed in this talk is a rather familiar maneuver from model theory and group actions (and elsewhere) involving the reversal of a thing (in orbit) with its base (a stabilizer), allowing the identification as 'the same' of apparently disparate types of things, while leaving the dependency of 'not the same' on the definiteness of the choice of interpretation of the choice of language.

► ULRICH KOHLENBACH, *Proof theoretic applications to functional analysis*.
BRICS, Department of Computer Science, University of Aarhus, Ny Munkegade, DK-8000 Aarhus C, Denmark.
E-mail: `kohlenb@brics.dk`.
`http://www.brics.dk/~kohlenb`.

We give a survey of recent progress in the area of proof mining. 'Proof mining' is concerned with the extraction of new information from proofs by means of proof theoretic techniques (so-called proof interpretations) such as Gödel's functional interpretation and specially designed variants thereof. This approach has recently had substantial applications in L1-approximation [4] and metric fixed point theory [1, 2, 3]. The applications in fixed point theory systematically yielded not only new effective bounds but even new qualitative results on the uniformity of asymptotic regularity of nonexpansive functions which only partly had been known before. In studying the logical structure of these applications we recently succeeded in proving rather general meta-theorems which guarantee the existence (as well as the extractability of effective versions) of such uniformity results under very broad and easy to check logical conditions. Our meta-theorems deal with general classes of spaces like metric spaces, hyperbolic spaces, normed linear spaces and uniformly convex spaces and classes of functions between such spaces like nonexpansive or directionally nonexpansive functions.

[1] U. KOHLENBACH, *A quantitative version of a theorem due to Borwein-Reich-Shafrir*, ***Numerical Functional Analysis and Optimization***, vol. 22 (2001) pp. 641–656.

[2] U. KOHLENBACH, *Uniform asymptotic regularity for Mann iterates*, ***Journal of Mathematical Analysis and Applications***, vol. 279, pp. 531–544 (2003).

[3] U. KOHLENBACH, L. LEUŞTEAN, *Mann iterates of directionally nonexpansive mappings in hyperbolic spaces*, ***Abstract and Applied Analysis***, vol. 2003, no. 8, pp. 449–477 (2003).

[4] U. KOHLENBACH, P. OLIVA, *Effective bounds on strong unicity in L_1-approximation*, ***Annals of Pure and Applied Logic***, vol. 121 (2003), pp. 1–38.

[5] U. KOHLENBACH, P. OLIVA, *Proof mining: a systematic way of analysing proofs in analysis*, to appear in ***Proceedings of the Steklov Institute of Mathematics***.

► PHOKION G. KOLAITIS, *Constraint satisfaction, finite-variable logics, and treewidth*.
Computer Science Department, University of California, Santa Cruz, CA 95064, USA.
E-mail: `kolaitis@cs.ucsc.edu`.

Constraint satisfaction problems constitute a broad class of algorithmic problems that are ubiquitous in several different areas of computer science. In their full generality, constraint satisfaction problems are NP-complete and, thus, presumed to be algorithmically intractable. For this reason, extensive research efforts have been devoted to the pursuit of "islands of tractability" of constraint satisfaction, that is, special cases of constraint satisfaction problems for which polynomial-time algorithms exist.

The aim of this talk is to present an overview of recent advances in the investigation of the computational complexity of constraint satisfaction with emphasis on the connections between "islands of tractability" of constraint satisfaction, definability in finite-variable logics, and structures of bounded treewidth.

► LEONID A. LEVIN, *Forbidden information*.
Department of Computer Science, Boston University, 111 Cummington Street, Boston, MA 02215, USA.
E-mail: `Lnd@bu.edu`.

Gödel Incompleteness Theorem falls short of implications usually attributed to it. Closing this loophole involves quite technical use of Kolmogorov Complexity (unrelated to, well studied before, complexity quantifications of the usual Gödel effects). Similar problems and answers apply to other unsolvability results for tasks with non-unique solutions, such as, e.g., non-recursive tilings.

D. Hilbert asked if the formal arithmetic can be consistently extended to a complete theory. The question was somewhat vague since an obvious answer was 'yes': just add to the axioms of Peano Arithmetic (PA) a maximal consistent set, clearly existing albeit hard to find. K. Gödel formalized this question as existence among such extensions of recursively enumerable ones and gave it a negative answer (apparently, never accepted by Hilbert). Its mathematical essence is the lack of total recursive extensions of universal partial recursive predicate.

As is well known, the absence of algorithmic solutions is no obstacle when the requirements do not make a solution unique. A notable example is generating strings of linear Kolmogorov complexity, e.g., those that cannot be compressed to half their length. Algorithms fail, but a set of dice does a perfect job!

Thus, while r.e. sets of axioms cannot complete PA, the possibility of completion by other simple means remained open. In fact, it is easy to construct an r.e. theory R that, like PA, allows no consistent completion with r.e. axiom sets. Yet, it allows a recursive set of PAIRS of axioms such that random choice of one in each pair assures such completion with probability .99.

The reference to randomized algorithms seems rather special. However, the impossibility of a task can be formulated more generically. In 1965 Kolmogorov defined a concept of Mutual Information in two finite strings. It can be refined and extended to infinite sequences, so that it satisfies conservation laws: cannot be increased by deterministic algorithms or in random processes or with any combinations of both. In fact, it seems reasonable to assume that no physically realizable process can increase information about a specific sequence.

In this framework one can ask if the Hilbert-Gödel task of a consistent completion of a formal system is really possible for PA, as it is for an artificial system R just mentioned. A negative answer follows from the existence of a specific sequence that has infinite mutual information with ALL total extensions of a universal partial recursive predicate. It plays a role of a password: no substantial information about it can be guessed, no matter what methods are allowed. This "robust" version of Incompleteness Theorem is, however, trickier to prove than the old one.

► MICHAEL MAKKAI, *A new set theory*.
Department of Mathematics and Statistics, McGill University, 805 Sherbrooke Street West, Montreal, Quebec, Canada H3A 2K6.
E-mail: makkai@math.mcgill.ca.

In my talk "Towards a Categorical Foundation of Mathematics" at the Logic Colloquium '95 (see the paper in Springer Lecture Notes in Logic 11, 1998, and the references therein), I gave a statement, which remained incomplete in several ways, of the "Structuralist Foundation of Abstract Mathematics" (SFAM). The main part of the talk is a report on the progress made in the meantime in the program of the SFAM; a general introduction to the main starting ideas is also to be given.

It is the "underlying" language of the SFAM, called First Order Logic with Dependent Sorts (FOLDS), without the specific axioms, that was described fully in *loc. cit.* and in accompanying references; on the universe, only a start was made. As a result of successive developments, starting with suggestions made by John Baez and James Dolan, the definition (in ordinary set-theoretic terms) of (the main part of) the universe is given in the concept named in the title of the paper "The multitopic omega-category of all [small] multitopic omega-categories" (September, 1999; at: www.math.mcgill.ca/makkai/).

SFAM is closely related to (although *not* dependent on) the subject of "Higher Dimensional Categories" (HDC's), pursued by many researchers interested in applications in topology, physics, quantum groups, etc. There are various (partial) definitions of "HDC", some, but not all, of which are possible (partial) alternatives for the universe of SFAM. The subject of comparing alternative (partial) definitions of the universe of SFAM is an important one; I approach it by a use of the framework of FOLDS.

► RALPH MCKENZIE, *The interplay between structural insight and algorithmic problems in general algebra*.
Department of Mathematics, 1326 Stevenson Center, Vanderbilt University, Nashville, TN 37240-0001, USA.
E-mail: mckenzie@math.vanderbilt.edu.

In 1992, B. Hart, S. Starchenko and M. Valeriote proved Vaught's conjecture for varieties. Every variety (equationally defined class of algebras) of countable signature has either a continuum, or at most countably many, non-isomorphic denumerable models. They proved that every such variety with few models admits a decomposition into a product of a combinatorial variety and an affine variety (equivalent to a variety of all modules over some ring).

In 1986, R. McKenzie and M. Valeriote proved that every locally finite variety with decidable first order theory admits a decomposition into a product of a combinatorial variety, an affine variety, and a discriminator variety. The proof afforded an algorithm which inputs a finite algebra **F**, and outputs a finite ring **R** with unit, so that the variety $\mathcal{W}$ generated by **F** is decidable iff the theory of unital modules over **R** is decidable.

In 1993, R. McKenzie proved that there is no algorithm to determine, for a finite algebra **F**, whether the variety $\mathcal{W}$ generated by **F** is residually finite. Likewise there is no algorithm to determine if $\mathcal{W}$ is finitely axiomatizable.

All these results are related by dependence on the techniques (or at least the insights) flowing from the structure theory for finite algebraic systems called "tame congruence theory". In this talk, I will attempt to convey the substance of this theory, and its contribution to these results.

► DON PIGOZZI, *Abstract algebraic logic and the algebraic hierarchy*.
Department of Mathematics, Iowa State University, Ames, IA 50011, USA.
E-mail: dpigozzi@iastate.edu.

All logics have both an *assertional* and an *equivalential* aspect that are represented respectively by the relations of consequence and logical equivalence. The connection between them is very close in the case of the familiar logics: each is simulated by the other in a straightforward manner. The replacement property guarantees that logical equivalence relative to any given set of equivalences (which can be viewed as equations) is a congruence relation on the formula algebra. Taking the quotients of the formula algebra by these congruences we obtain a class of algebras whose equational logic provides a complete algebraic representation of the original logic. This is the classical *Lindenbaum-Tarski process*, and it is used to generate the algebras traditionally associated with a number of different logics: the classical propositional calculus (Boolean algebras), the intuitionistic propositional calculus (Heyting algebras), modal logic (modal algebras), predicate logic (cylindric algebras), etc.

Traditional algebraic logic is mainly concerned with the algebraic theory of the various classes of algebras that arise in this way. *Abstract Algebraic Logic* on the other hand focuses on the process of algebraization itself and the questions that naturally arise from it. How does one abstract the Lindenbaum-Tarski process to logics without a biconditional or even a conditional? What are the limits of the algebraization process—more specifically, can the class of algebraizable logics be precisely characterized? As might be expected, several different answers to this question have been proposed, and this has led to a hierarchy of logics based on how tightly bound they are to the algebras that arise from them by the abstract Lindenbaum-Tarski process. The hierarchy has been intensively studied over the last several years and the results of these investigations will be surveyed in this talk.

► ANDRZEJ ROSŁANOWSKI, *How much sweetness is there in the Universe?*
Department of Mathematics, University of Nebraska at Omaha, Omaha, NE 68182-0243, USA.
E-mail: roslanow@member.ams.org.

Since the very beginning of modern Set Theory there has been an interest in the *countable chain condition* (ccc) of Boolean algebras, topologies, forcing notions etc. The natural question of preserving ccc under various operations, most notably products, led to several *strong ccc* properties.

Amalgamation of forcing notions can be thought of as a generalization of a product, and this could be a good reason to ask for strong variants of ccc (for forcing notions) preserved under amalgamation. But the real interest in amalgamation comes from its use in building homogeneous forcing notions and consistency results concerning regularity of definable sets of reals.

In 1970, Robert M. Solovay proved that the existence of an inaccessible cardinal implies the consistency of "all projective sets of reals have Baire property and are Lebesgue measurable". Then Saharon Shelah showed that to get Lebesgue measurability one really needs inaccessibles, while the suitable forcing notion for the property of Baire can be constructed in ZFC. The proofs were built upon an analysis what happens if one tries to amalgamate forcing notions over random or Cohen forcing notion, respectively. The reason why we do need an inaccessible cardinal for Lebesgue measurability is that the amalgamation of the Amoeba for Measure forcing notion over a random real may fail ccc (and even may collapse $\aleph_1$). What allows us to amalgamate forcing notions without collapsing cardinals are strong ccc properties like *sweetness*.

We will discuss various friends and relatives of sweetness, how many sweet forcing notions are there and what we can use them for. We will also look at the opposite end of the spectrum: *sour forcing notions*.

Abstracts of invited talks in the Special Session on Algebraic Logic and Universal Algebra

► K. V. ADARICHEVA AND J. B. NATION, *Largest extension of a finite convex geometry*.
Institute of Mathematics SB RAS, Acad. Koptyug Prosp., 4, 630090, Novosibirsk, Russia.
E-mail: `ki13ra@yahoo.com`.
Department of Mathematics, University of Hawaii, Honolulu, HI 96822, USA.
E-mail: `jb@math.hawaii.edu`.

A convex geometry is a closure system with the anti-exchange property. An extension of a convex geometry (X, φ) is another convex geometry (X, ψ), on the same base set X, with the property that the lattice of closed sets of (X, φ) is a sublattice of the lattice of closed sets of (X, ψ). All extensions of a given *finite* convex geometry can be naturally ordered and they form a lattice with respect to this order. The latter fact was formulated implicitly in [1]: when a convex geometry is finite it always has a largest extension. Still, the exact formula for this largest extension was not presented in [1] leaving the question open.

We provide a new proof of the result in [1] that any finite join-semidistributive lattice can be embedded into an atomistic finite join-semidistributive lattice, with the same number of join-irreducible elements. The new construction of such an embedding turns out to be the largest extension, when applied to a finite convex geometry.

[1] K. V. Adaricheva, V. A. Gorbunov, and V. I. Tumanov, *Join-semidistributive lattices and convex geometries*, ***Advances in Mathematics***, vol. 173 (2003), pp. 1–49.

► CLIFFORD BERGMAN, *Boolean semilattices*.
Iowa State University, Ames Iowa 50011, USA.
E-mail: `cbergman@iastate.edu`.

Let $\mathbf{S} = \langle S, \cdot \rangle$ be a semilattice. The *complex algebra of* $\mathbf{S}$ is the algebra $\mathbf{S}^+ = \langle P(S), \cap, \cup, ', S, \cdot \rangle$ which is the Boolean algebra of all subsets of S augmented with the complex operation given by $X \cdot Y = \{x \cdot y : x \in X, y \in Y\}$. The variety of *Boolean semilattices* is generated by all such complex algebras.

The variety of Boolean semilattices is a very rich one, with an interesting arithmetic, many subvarieties and, of course, many open problems. In particular, it is unknown whether the variety is finitely based. In this talk I will survey what little we know about this variety and discuss some of the open problems.

► NIKOLAOS GALATOS, *Varieties of residuated lattices generated by positive universal classes*.
Department of Mathematics, Vanderbilt University, Nashville, TN 37240, USA.
E-mail: ngalatos@math.vanderbilt.edu.

A *residuated lattice* is an algebra $\boldsymbol{L} = \langle L, \wedge, \vee, \cdot, \backslash, /, e\rangle$, such that $\langle L, \wedge, \vee\rangle$ is a lattice, $\langle L, \cdot, e\rangle$ is a monoid, and for all elements $a, b, c \in L$,

$$ab \leq c \Leftrightarrow a \leq c/b \Leftrightarrow b \leq a\backslash c.$$

It is easy to see that residuated lattices form a finitely based variety.

For every positive universal formula in the language of residuated lattices, we construct a variety of residuated lattices, such that a subdirectly irreducible residuated lattice is in the variety iff it satisfies the positive universal formula.

As an application of this correspondence, we prove that the join of two finitely based commutative varieties of residuated lattices is also finitely based.

► PETER JIPSEN, *An online database of classes of algebraic structures*.
Department of Mathematics, Computer Science, Physics, Chapman University, Orange, CA 92866, USA.
E-mail: jipsen@chapman.edu.

Over the course of the previous century, many different types of algebraic structures have been investigated. While much effort has concentrated on the so-called classical structures (groups, rings, fields, vector spaces, modules, lattices, etc.) there has also been a proliferation of other algebraic structures that have been defined and analyzed. Some of them are generalizations or specializations of classical structures, while others are motivated by algebraic versions of logics, or by topology, combinatorics, and computer science. With so many different algebraic structures, it is not a simple task to determine how they are related, and what is currently known about them. General theories like Universal Algebra and Category Theory have done much to provide a useful framework for these investigations.

This talk presents a preliminary version of a database that aims to collect basic facts about classes of algebraic structures and their relationships. While there are several handbooks of algebra and online encyclopedia of mathematics, the aim of this database is to provide an overview of the structures that have appeared in the literature together with links to computational tools that can be used to investigate the structures further. Each database entry for a class of structures has, at minimum, a name, (several equivalent) definition(s), some standard examples, a list of basic properties that hold for all members, and a list of its "nearest" sub- and superclasses. If there are feasible algorithms for deciding syntactic properties of the structures, implementations of such algorithms may be linked to the database, as well as enumerations of some finite members (if any). Most classes are categories in a natural way, and concepts from category theory are used to express structure preserving relationships between different classes. Currently the database contains over a hundred classes from *abelian groups* to *weakly representable relation algebras*.

Recent advances in electronic publishing (MathML, XML style sheet transformation, scalable vector graphics) provide the tools for this project, and will also be discussed briefly. Much work still remains to be done, and if it is successful, this effort will not conclude at some future date, but rather continue to evolve in a collaborative style to ensure that the information is useful and up-to-date.

► ÁGNES SZENDREI, *Clones closed under conjugation*.
Bolyai Institute, University of Szeged, Aradi vertanuk tere 1, H-6720 Szeged, Hungary.
E-mail: a.szendrei@math.u-szeged.hu.

Let G be a permutation group acting on a set A. A clone $\mathcal{C}$ of operations on A is called G*-closed* if for every operation $f(x_1, \ldots, x_n)$ in $\mathcal{C}$, all conjugates $f^g(x_1, \ldots, x_n) = gf(g^{-1}(x_1), \ldots, g^{-1}(x_n))$ of f by permutations $g \in G$ also belong to $\mathcal{C}$. Examples of G-closed clones include the clone of all operations, Słupecki's and Burle's clones as well as all clones of homogeneous operations. In the talk we will discuss the following question: for which groups G on a finite set A is the lattice of G-closed clones finite?

The talk will present results of joint work with Keith A. Kearnes.

► CONSTANTINE TSINAKIS, *Semi-direct products of residuated lattices*.
Department of Mathematics, Vanderbilt University, Nashville, TN 37240, USA.
E-mail: constantine.tsinakis@vanderbilt.edu.

A *residuated lattice* is an algebra $\boldsymbol{L} = \langle L, \wedge, \vee, \cdot, \backslash, /, e\rangle$ such that $\langle L, \wedge, \vee\rangle$ is a lattice; $\langle L, \cdot, e\rangle$ is a monoid; and the binary operations $\backslash, /$ are the residuals of the monoid multiplication relative to the lattice structure; that is, the following equivalences hold for all $x, y, z \in L$:

$$x \cdot y \leq z \Leftrightarrow x \leq z/y \Leftrightarrow y \leq x\backslash z.$$

The class $\mathcal{RL}$ of all residuated lattices is easily seen to be a finitely based arithmetical variety. It includes algebras that are term equivalent to many well studied and diverse structures, such as generalized Boolean algebras, Brouwerian algebras, relative Stone algebras and lattice-ordered groups. Thus, residuated lattices allow the study of all these algebras under a common language.

The purpose of this talk is to illustrate the importance of semi-direct products in the study of residuated lattices. En route, we use these products to provide simple equational bases for a number of important subvarieties of $\mathcal{RL}$.

This talk will report on joint research with Bjarni Jónsson.

[This abstract is presented by title.]

► MATT VALERIOTE, *Definable principal congruences and solvability*.
Department of Mathematics and Statistics, Burke Sciences Building 133, McMaster University, Hamilton, Ontario Canada.
E-mail: matt@math.mcmaster.ca.

An equationally defined class of algebraic structures $\mathcal{V}$ is said to have Definable Principal Congruences (DPC) if there is a first order formula defining the principal congruences of the algebras in $\mathcal{V}$. In this talk I will present joint work with Pawel Idziak, Keith Kearnes, and Emil Kiss that considers solvable congruences and algebras in a DPC equational class. We find that DPC imposes stronger centrality conditions like nilpotence, or strong abelianness.

► GEORGE VOUTSADAKIS, *A result and some questions in CAAL*.
School of Mathematics and Computer Science, Lake Superior State University, 650 W. Easterday Avenue, Sault Sainte Marie, MI 49783, USA.
E-mail: gvoutsad@lssu.edu.

Categorical Abstract Algebraic Logic (CAAL) has been proposed in [8], [9], [10] as a generalization of Abstract Algebraic Logic (AAL) [1], [2], [3], [4] and [5], [6], [7] that is appropriate for handling multisignature deductive systems with quantifiers such as equational and first-order logic. The categorical structure of a π-institution plays, in this more abstract framework, the role played by deductive systems in AAL. Also categorical algebra is used in place of universal algebra to handle the possibility of working in categories other than the category of small sets. A recent result [11] on the characterization of algebraizability of π-institutions is presented. This sharpens a result of [8], [9] and provides a perfect analog of a corresponding characterization for the algebraizability of deductive systems in [2]. A few open questions that may lead future research in this area are also proposed.

[1] W. J. BLOK AND D. PIGOZZI, *Protoalgebraic logics*, ***Studia Logica***, vol. 45 (1986), pp. 337–369.

[2] ———, *Algebraizable logics*, ***Memoirs of the American Mathematical Society***, vol. 77, no. 396 (1989).

[3] J. CZELAKOWSKI, *Equivalential logics I, II*, ***Studia Logica***, vol. 40 (1981), pp. 227–236, 355–372.

[4] J. M. FONT AND R. JANSANA, *A general algebraic semantics for sentential logics*, ***Lecture Notes in Logic***, vol. 7 (1996), Springer-Verlag, Berlin Heidelberg 1996.

[5] B. HERRMANN, *Equivalential logics and definability of truth*, ***Dissertation***, Freie Universitat Berlin, Berlin 1993.

[6] ———, *Equivalential and algebraizable logics*, ***Studia Logica***, vol. 57 (1996), pp. 419–436.

[7] ———, *Characterizing equivalential and algebraizable logics by the Leibniz operator*, ***Studia Logica***, vol. 58 (1997), pp. 305–323.

[8] G. VOUTSADAKIS, *Categorical abstract algebraic logic*, ***Doctoral Dissertation***, Iowa State University, Ames, Iowa, August 1998.

[9] ———, *Categorical abstract algebraic logic: equivalent institutions*, To appear in ***Studia Logica***.

[10] ———, *Categorical abstract algebraic logic: algebraizable institutions*, ***Applied Categorical Structures***, vol. 10 (2002), pp. 531–568.

[11] ———, *Categorical abstract algebraic logic: the criterion for deductive equivalence*, To appear in ***Mathematical Logic Quarterly***.

Abstracts of invited talks in the Special Session on Computability Theory and Effective Mathematics

► PETER A. CHOLAK, MARIAGNESE GIUSTO, JEFFRY L. HIRST AND CARL G. JOCKUSCH, JR., *The logical strength and effective content of the thin set theorem and the free set theorem.*

Dept. of Mathematics, 255 Hurley, University of Notre Dame, Notre Dame, IN 46556-5683, USA.
E-mail: peter.cholak.1@nd.edu.
Via Loreto Vecchia 9/10/A, 17100 Savona, Italy.
E-mail: mariagnese@savanaonline.it.
Dept. of Mathematical Sciences, Appalachian State University, Boone, NC 28608, USA.
E-mail: jlh@math.appstate.edu.
Dept. of Mathematics, University of Illinois, 1409 W. Green Street, Urbana, IL 61801, USA.
E-mail: jockusch@math.uiuc.edu.

Let $[A]^k$ denote the set of all k-element subsets of the set A. The *thin set theorem*, due to Harvey Friedman, (see [2] or [1]), asserts that for every $k \in \omega$ and every function $f : [\omega]^k \to \omega$ there is an infinite set $A \subseteq \omega$ such that $f([A]^k) \neq \omega$. The *free set theorem*, also due to Harvey Friedman (see [2] or [1]), asserts that for every k and every function $f : [\omega]^k \to \omega$ there is an infinite set $A \subseteq \omega$ such that, for all $D \in [A]^k$, if $f(D) \in A$, then $f(D) \in D$. We partially analyze the strength of these two results (and especially their restrictions to fixed k) in the sense of reverse mathematics. We also study the effective content of these results for fixed k, and compare them with corresponding results for Ramsey's Theorem [3].

[1] PETER A. CHOLAK, MARIAGNESE GIUSTO, JEFFRY L. HIRST, and CARL G. JOCKUSCH, JR., *Free sets and reverse mathematics*, submitted for publication (available online at www.math.uiuc.edu/~jockusch/ under "Online Articles").

[2] HARVEY FRIEDMAN and STEPHEN G. SIMPSON, *Issues and problems in reverse mathematics*, ***Computability theory and its applications* (*Boulder, CO, 1999*)**, American Mathematical Society, Providence, RI, 2000, pp. 127–144.

[3] CARL G. JOCKUSCH, JR., *Ramsey's Theorem and recursion theory*, ***The Journal of Symbolic Logic***, vol. 37 (1972), pp. 268–280.

► PETER CHOLAK AND LEO HARRINGTON, *On the complexity of orbits in $\mathcal{E}^*$*.
Department of Mathematics, 255 Hurley, Notre Dame, Indiana 46556-5683, USA.
E-mail: `Peter.Cholak.1@nd.edu`.
Department of Mathematics, University of California, Berkeley, CA 94720-3840, USA.
E-mail: `leo@math.berkeley.edu`.

Using coding and other methods we will explore the orbits of certain definable sets. For example, we will show that a pair of hhsimple sets are automorphic iff they are Δ^0_3-automorphic, a pair of simple sets are automorphic iff they are Δ^0_6-automorphic, and, perhaps if there is time, a pair of promptly simple sets are automorphic iff they are Δ^0_3-automorphic. We will reflect on what these results tell us about our goal to construct an c.e. A where membership in A's orbit is Σ^1_1-complete.

► MALGORZATA DABKOWSKA, MIECZYSLAW DABKOWSKI AND VALENTINA S. HARIZANOV, *Degrees of the isomorphism types of countable structures*.
Dept. of Mathematics, The George Washington University, Washington, D.C., 20052, USA.
E-mail: `gdab@gwu.edu`.
E-mail: `mdab@gwu.edu`.
E-mail: `harizanv@gwu.edu`.

We consider only countable models of theories in finite languages. The Turing degree of a structure $\mathcal{B}$ with domain ω, $\deg(\mathcal{B})$, is the Turing degree of its atomic diagram. The *Turing degree spectrum* of a structure $\mathcal{A}$ is $DgSp(\mathcal{A}) = \{\deg(\mathcal{B})\colon \mathcal{B} \simeq \mathcal{A}\}$. A structure $\mathcal{A}$ is automorphically trivial if there is a finite subset S of its domain such that every permutation of the domain, whose restriction on S is the identity, is an automorphism of $\mathcal{A}$. Knight proved that for an automorphically nontrivial structure $\mathcal{A}$, $DgSp(\mathcal{A})$ is closed upwards. Hirschfeldt, Khoussainov, Shore and Slinko established that for every automorphically nontrivial structure $\mathcal{G}$, there is a symmetric irreflexive graph, a partial order, a lattice, a ring, an integral domain of arbitrary characteristic, a commutative semigroup, and a 2-step nilpotent group, $\mathcal{A}$, such that $DgSp(\mathcal{A}) = DgSp(\mathcal{G})$.

Jockusch defined the *Turing degree of the isomorphism type* of a structure $\mathcal{A}$, if it exists, to be the least Turing degree in $DgSp(\mathcal{A})$. Richter systematically studied degrees of the isomorphism types. She established that the Turing degree of the isomorphism type of a structure without a computable copy, which satisfies a certain condition on effective extendability of embeddings, does not exist. Such structures include linear orders and trees. A. N. Khisamiev has recently proved that they also include abelian p-groups. Richter introduced for a theory T a general combination method for constructing a model of T whose isomorphism type has an arbitrary Turing degree. For example, there is such an abelian group. On the other hand, there is an abelian non-p-group whose isomorphism type does not have a degree. We extend Richter's method and apply it to investigate the isomorphism types of nonabelian *orderable groups*.

► NOAM GREENBERG, ANTONIO MONTALBAN AND RICHARD A. SHORE, *Generalized high degrees have the complementation property*.
Department of Mathematics, Malott Hall, Cornell University, Ithaca, NY 14853, USA.
E-mail: `erlkonig@math.cornell.edu`.
E-mail: `antonio@math.cornell.edu`.
E-mail: `shore@math.cornell.edu`.

We show that if $\boldsymbol{d}$ is generalized high, then every degree below $\boldsymbol{d}$ has a complement in $D(\leq \boldsymbol{d})$. This answers a question raised by D. Posner in 1981.

► DENIS R. HIRSCHFELDT AND RICHARD A. SHORE, *Some combinatorial principles about linear orderings weaker than Ramsey's Theorem*.
Department of Mathematics, University of Chicago, Chicago IL 60637, USA.
E-mail: drh@math.uchicago.edu.
Department of Mathematics, Cornell University, Ithaca NY 14853, USA.
E-mail: shore@math.cornell.edu.

We analyze the status in terms of reverse mathematics of some combinatorial principles about linear orderings such as (ASDS): Every linear ordering has an infinite ascending sequence or an infinite descending one. All of the principles follow from Ramsey's theorem for pairs but none from WKL_0 (over RCA_0). In particular, we consider two, ASDS^* and $\mathrm{ASDS}^\#$ (analogous to SRT^2_2 and COH, respectively) which are incomparable over RCA_0 but which join up to ASDS in the sense that $\mathrm{RCA}_0 \vdash \mathrm{ASDS} \leftrightarrow (\mathrm{ASDS}^* \;\;\&\;\; \mathrm{ASDS}^\#)$ while $(\mathrm{RCA}_0 \;\;\&\;\; \mathrm{ASDS}^*) \nvdash \mathrm{ASDS}^\#$ and $(\mathrm{RCA}_0 \;\;\&\;\; \mathrm{ASDS}^\#) \nvdash \mathrm{ASDS}^*$. Most of our reverse mathematical conclusions follow from degree theoretic analyses.

► GEOFF LAFORTE, *Notions of randomness for reals*.
Department of Computer Science, University of West Florida, Pensacola, FL 32514, USA.
E-mail: glaforte@uwf.edu.

Call a c.e. sequence of open sets $\langle U_n : n \in \omega \rangle$ a c.e. *test sequence* if for every n, $\mu(U_n) \leq 2^n$. A real number is Martin-Löf random if it avoids (the intersection of) every c.e. test sequence. By Slaman and Kucera [3], a Martin-Löf c.e. random real must have complete Turing degree. Although Martin-Löf randomness is a natural notion, it has some drawbacks that led Schnorr [4] to introduce a less restrictive notion of randomness. Call a c.e. test sequence a Schnorr sequence if for all n, $\mu(U_n) = 2^n$. This stricter requirement on the test sequence leads to a weaker notion of randomness for reals. A c.e. real is Schnorr random if and only it has high Turing degree. Schnorr randomness also has interesting characterizations in terms of martingales and universal Turing machines. A similar, intermediate notion of randomness is computable randomness, which has a natural definition in terms of computable martingales, and alternate characterizations in terms of test sets and universal Turing machines.

Joint work with Rod Downey and Evan Griffiths.

[1] R. Downey and E. Griffiths, *On Schnorr randomness*, extended abstract in ***Computability and Complexity in Analysis***, Malaga, (Electronic notes in Theoretical Computer Science, and proceedings, (Brattka, Schröder, Weihrauch, editors), Fern Universität 294-6/2002, 25-36), July 2002.

[2] R. Downey, E. Griffiths, G. LaForte, *On Schnorr and computable randomness*, in preparation.

[3] A. Kucera, T. Slaman, *Randomness and recursive enumerability*, to appear in ***SIAM Journal of Computing***.

[4] C. Schnorr, *Zufälligkeit und Warscheinlichkeit*, Lecture Notes in Mathematics, vol. 218, Springer-Verlag.

► TIMOTHY H. MCNICHOLL, *Automorphisms of the c.e. weak truth-table degrees*.
Department of Mathematics, University of Dallas, Irving, Texas 75062, USA.
E-mail: tmcnicho@acad.udallas.edu.

We discuss work on constructing a non-trivial automorphism of the c.e. weak truth-table degrees.

► RUSSELL MILLER, *Spectra of structures and relations*.
Department of Mathematics, Cornell University, Ithaca, NY 14853, USA.
E-mail: russell@math.cornell.edu.

The *spectrum of a structure* $\mathcal{A}$ is the set of all Turing degrees of presentations of $\mathcal{A}$, i.e., $\{\deg(\mathcal{B}) \mid \mathcal{B} \simeq \mathcal{A}\}$. The *degree spectrum of a relation* R on a computable structure $\mathcal{C}$ is the set of Turing degrees of images of R under isomorphisms from $\mathcal{C}$ onto other computable structures. These notions are related conceptually, but we provide a concrete link by proving that for every linear order $\mathcal{L}$, there is a unary relation R on a fixed computable presentation $\mathbb{Q}$ of the rational numbers (as a linear order) such that the spectrum of $\mathcal{L}$ is precisely the degree spectrum of R on $\mathbb{Q}$.

The converse to this question remains open: given the degree spectrum of a unary relation R on $\mathbb{Q}$, is there a linear order $\mathcal{L}$ with that same spectrum? We offer some progress on this question by discussing when the degree spectrum of R on $\mathbb{Q}$ must be upwards-closed under Turing reducibility. (All spectra of infinite linear orders are upwards-closed, by a result of Knight.) We also note that in the related case of Boolean algebras, with the countable atomless Boolean algebra $\mathcal{B}$ in place of $\mathbb{Q}$, the converse fails: there exists a unary relation on $\mathcal{B}$ whose degree spectrum contains a low degree but does not contain 0, so that (by results of Downey and Jockusch) no Boolean algebra could have that spectrum.

We present joint work by Valentina Harizanov and the speaker.

► ANTONIO MONTALBÁN, *Embedding jump upper semilattices into the Turing degrees*.
Department of Mathematics, Cornell University, Ithaca, NY 14853, USA.
E-mail: antonio@math.cornell.edu.

We prove that every countable jump upper semilattice can be embedded in $\mathcal{D}$. A jump upper semilattice (jusl) is an upper semilattice endowed with a strictly increasing and monotone unary operator that we call jump, and $\mathcal{D}$ is the jusl of Turing degrees. As a corollary we get that the existential theory of $\mathcal{D}(\leq, \vee, ')$ is decidable. We also prove that this result is not true about jusls with 0, by proving that not every quantifier free 1-type of jusl with 0 is realized in $\mathcal{D}$. On the other hand, we show that every quantifier free 1-type of jump partial ordering (jpo) with 0 is realized in $\mathcal{D}$. Moreover, we show that if every quantifier free type, $p(x_1, \dots, x_n)$, of jpo with 0, which contains the formula $x_1 \leq 0^{(m)}\ \&\ \cdots\ \&\ x_n \leq 0^{(m)}$ for some m, is realized in $\mathcal{D}$, then every every quantifier free type of jpo with 0 is realized in $\mathcal{D}$.

► ANDRÉ NIES, *Randomness and lowness*.
Dept. of Computer Science, University of Auckland, Private Bag 92019, Auckland, NZ.
E-mail: andre@cs.auckland.ac.nz.

We relate randomness properties of reals and lowness properties, which say the real is computationally weak (a real is a subset of the natural numbers). First we consider r.e. randomness, also called Martin-Löf randomness. We show that a real A is far from random in the sense of having low initial segment complexity iff it is low for random, namely each random set is already random relative to A. This implies that the low for random reals are Turing below the halting problem, which had been asked by Terwijn, Kucera and others. Next we consider computable randomness, a notion weaker than Martin-Löf-random which was introduced by Schnorr (1975). We answer a question of Ambos-Spies and Kucera by showing that the only low for computably random reals are the computable reals.

► REED SOLOMON, *On the filter of computably enumerable supersets of an r-maximal set*.
Department of Mathematics, University of Notre Dame, 255 Hurley Building, Notre Dame, IN 46556, USA.
E-mail: dsolomon@nd.edu.

One method for studying the algebraic structure of the computably enumerable sets under inclusion is to examine the principal filters. In this talk, we look at the principal filter generated by an atomless r-maximal set A. In particular, we consider the complexity of the index set of computable enumerable sets whose union with A is cofinite. We show that there is an atomless r-maximal set for which this index set is Σ^0_3 complete. The material presented in this talk is joint work with Steffen Lempp and Andre Nies.

Abstracts of invited talks in the Special Session on Model Theory

► ITAY BEN-YAACOV, *Model theory of probability spaces*.
University of Paris VII and University of Illinois at Urbana-Champaign, Department of Mathematics, 1409 W. Green Street, Urbana, IL 61801, USA.
E-mail: pezz@math.uiuc.edu.

Probability spaces, classically defined as sets equipped with a σ-algebra of subsets and a σ-additive positive measure, do not seem to admit a direct model theoretic treatment. Instead, we point out that for (almost) all practical purposes, probability spaces are equivalent to boolean algebras equipped with an additive positive measure, and show that a good model theoretic treatment exists for the category of these objects.

The framework in which this is done is that of cats (compact abstract theories), which are the analogues of elementary classes in a compact logic without negation. Many notions and tools, such as categoricity, stability and simplicity, generalise naturally from first order model theory to this non-first-order context.

We prove that the category of complete atomless measured boolean algebras is a cat, and is ω-categoric and ω-stable as such. Non-dividing coincides of course with probabilistic independence. This allows us to translate probabilistic problems to model-theoretic terms, and attack them using ordinary stability theory.

► ALEXANDER J. BERENSTEIN, *Non-dividing in the Banach lattices $L^p(X, V, \mu)$*.
Department of Mathematics, University of Illinois at Urbana-Champaign, 1409 W. Green Street, Urbana, Illinois 61801-2975, USA.
E-mail: aberenst@math.uiuc.edu.

We characterize non-dividing inside a saturated normed space structure (see [1]) $(L^p(X, V, \mu), +, \wedge, \vee, \|\|_p)$, where X is a measure space, V is a σ-algebra on X, μ is an atomless measure defined on V, $\|\|_p$ is the L^p norm and $\wedge$, $\vee$ are the lattice operations (pointwise minimum and maximum). We include a second sort for the real field and the natural action from the real numbers on the space $L^p(X, V, \mu)$. We analyze this structure using positive bounded formulas (see [1]) and types formed by these formulas. We also discuss canonical bases in this setting.

This is a joint work with Itay Ben-Yaacov and C. Ward Henson.

[1] C. Ward Henson and José Iovino, *Ultraproducts in analysis*, ***Analysis and Logic***, London Mathematical Society Lecture Notes Series 262, Cambridge University Press, 2002, pp. 1–113.

► ALFRED DOLICH, *On properties guaranteeing the existence of universal models in an elementary class*.
Department of Mathematics, University of Wisconsin, 480 Lincoln Dr., Madsion, WI 53706, USA.
E-mail: dolich@math.wisc.edu.

In [1] Džamonja and Shelah give a criterion sufficient to guarantee that an abstract elementary class has universal elements under appropriate set theoretic conditions. Shelah in [2] and [3] has shown that the elementary class of any simple theory as well as several non-simple examples meet this criterion. In this talk we present a general framework which when present is sufficient to guarantee that an elementary class meets the criterion for the existence of universal models. This framework relies on the existence of independence notions for the theory satisfying axioms like those, though considerably weaker, satisfied by dividing in a simple theory. We present several examples of theories fitting into this framework.

[1] M. Džamonja and S. Shelah, *On the existence of universal models*, Preprint.

[2] S. Shelah, *Toward classifying unstable theories*, ***Annals of Pure and Applied Logic***, vol. 80 (1996), pp. 229–255.

[3] S. Shelah, *The universality spectrum: consistency for more classes*, ***Combinatorics, Paul Erdös is Eighty***, vol. 1 (1993), pp. 403–420.

► CHRIS MILLER, *Proper analytic subrings of the reals have Hausdorff dimension zero*.
Department of Mathematics, The Ohio State University, 231 West 18th Avenue, Columbus, OH 43210, USA.
E-mail: miller@math.ohio-state.edu.

Every proper subring of the ring of real numbers that is analytic (in the sense of descriptive set theory) has Hausdorff dimension zero. Extensions of the method of proof yield that every proper analytic subring of the complex numbers either has Hausdorff dimension zero or is equal to the real numbers, and every proper analytic subring of p-adic numbers either has Hausdorff dimension zero or is equal to the p-adic integers.

This is joint work with G. A. Edgar.

► ZIV SHAMI, *On Kueker simple theories and small unidimensional simple theories*.
McMaster University, The Fields Institute and Department of Mathematics, 273 Altgeld Hall, MC-382, 1409 W. Green Street, University of Illinois at Urbana-Champaign, Urbana, IL 61801, USA.
E-mail: zshami@math.uiuc.edu.

A countable theory T is said to be Kueker if it is not $\aleph_0$-categorical and every uncountable model of T is $\aleph_0$-saturated. Kueker's conjecture states that every Kueker theory is $\aleph_1$-categorical. This conjecture has been proved by Buechler for superstable theories and by Hrushovski for stable theories. Here we show a partial 'simple' analog of the gap between Buechler's and Hrushovski's results. More precisely, we show that a Kueker simple theory eliminates $\exists^\infty$ and densely interpret weakly minimal formulas (i.e., every non-algebraic formula is implied by a weakly minimal one). As part of the proof, we generalize Hrushovski's dichotomy for almost complete formulas to simple theories. We also conclude that a small unidimensional simple theory is supersimple of finite SU-rank.

► PATRICK SPEISSEGGER, *A geometric proof of the definability of Hausdorff limits*.
University of Wisconsin, Department of Mathematics, 480 Lincoln Drive, Madison WI 53706, USA.
E-mail: speisseg@math.wisc.edu.

We give a geometric proof of the following well-established theorem for o-minimal expansions of the real field: the Hausdorff limits of a compact, definable family of sets are definable. While previous proofs of this fact relied on the model-theoretic compactness theorem, our proof explicitely describes the family of all Hausdorff limits in terms of the original family.

Joint work with Jean-Marie Lion.

► MONICA VANDIEREN, *Stability in Tame AECs*.
Department of Mathematics, Stanford University, Stanford CA 94305-2125, USA.
E-mail: monica@math.stanford.edu.

We introduce the most general framework (to date) of Abstract Elementary Classes (AECs) for which a decent stability theory has been developed, namely tame AECs. Tame classes include (but are not limited to) homogeneous classes, excellent classes, categorical

AECs with amalgamation and good frames. In this talk we summarize known stability results for tame classes and discuss open problems in this virgin territory.

This is joint work with Rami Grossberg.

► EVGUENI VASSILIEV, *Lovely pairs of simple structures*.
Department of Mathematics, University of Illinois at Urbana-Champaign, 1409 W. Green Street, Urbana, IL 61801, USA.
E-mail: evas@math.uiuc.edu.

We will survey some recent results on elementary pairs of models of simple theories. In a joint work with Itay Ben-Yaacov and Anand Pillay [1] we introduce the notion of a *lovely pair* of models of a simple theory, which generalizes the "beautiful pairs" of stable structures introduced by Poizat in [3], and the "generic pairs" of SU-rank 1 structures ([4]). A pair (M, P) of models of a simple theory T (where $P(M) \preceq M$) is said to be *lovely*, if for any type $p \in S_T(A)$ over a small subset of A of M, p has a non-forking extension over $P(M) \cup A$ realized in M (extension property), and whenever p does not fork over $A \cap P(M)$, p is also realized in $P(M)$ (coheir property). For any simple theory T, lovely pairs of models of T exist, are elementarily equivalent, and in the stable case essentially coincide with the beautiful pairs. Assuming T satisfies certain "simple analogue" of the non-fcp property, T_P is again simple, forking in T_P has a natural description in terms of forking in T, and certain properties of T can be characterized in terms of T_P. For example, in the case when T is ω-categorical, T_P is ω-categorical if and only if T is one-based. In [2] we show that for a stable $T = T^{eq}$ without fcp, T_P has elimination of imaginaries if and only if there is no infinite group definable in T. We will also mention some applications of lovely (generic) pairs in the study of the geometry of SU-rank 1 structures.

[1] ITAY BEN-YAACOV, ANAND PILLAY, EVGUENI VASSILIEV, *Lovely pairs of models*, to appear in ***Annals of Pure and Applied Logic***.

[2] ANAND PILLAY, EVGUENI VASSILIEV, *Imaginaries in beautiful pairs*, submitted, 2003.

[3] BRUNO POIZAT, *Paires de structures stables*, ***The Journal of Symbolic Logic***, vol. 48 (1983), no. 2, pp.239–249.

[4] EVGUENI VASSILIEV, *Generic pairs of SU-rank 1 structures*, ***Annals of Pure and Applied Logic***, vol. 120 (2003), no. 1–3, pp. 103–149.

Abstracts of contributed talks

► RICHARD B. ANGELL AND FRED MICHAEL, *The reconciliation of intuitionist and classical logic by T-operator*.
Professor Emeritus, Department of Philosophy, Wayne State University, Detroit MI, 48202, USA.
E-mail: rbangell@bellatlantic.net.
Department of Philosophy, Brooklyn College, CUNY, Brooklyn, NY 11210, USA.
E-mail: fmichael@brooklyn.cuny.edu.

Heyting's Intuitionist Logic and classical two-valued logic differ on Double Negation and the Law of Excluded Middle. Classically not-not-P is logically equivalent to P. Heyting's Intuitionist Logic holds that P implies not-not-P, but not the converse. In classical logic every proposition is either true or false. In Heyting's logic some propositions about infinite sets are neither provably true nor provably false. Can these views co-exist in one logic?

A truth-operator 'T' is introduced for "It is true that ... ". Trivalent truth-tables are established with '0' for "it is neither true nor false that". Disclaiming Tarski's convention T, P is not equivalent to T P. For if P is 0, T P is F. F P ("It is false that P") is defined as 'T ∼ P'. This is not equivalent to '∼ T P' for 'P is not true'. Classical connectives have the "strong sense" of Kleene's trivalent "strong tables". 'A tautology' is defined as any formula with T's but no F's in the final column of its truth-table. The following variants of classical Double Negation and Excluded Middle are all tautologies: $(\sim\sim \mathrm{P} \equiv \mathrm{P})$, $(\mathrm{T} \sim\sim \mathrm{P} \equiv \mathrm{T\,P})$, $(\sim \mathrm{T} \sim \mathrm{T\,P} \equiv \mathrm{T\,P})$, and $(\sim \mathrm{P} \vee \mathrm{P})$, $(\mathrm{T\,P} \vee\sim \mathrm{T\,P})$, $(\sim \mathrm{F\,P} \vee \mathrm{F\,P})$. Heyting's restrictions on DN and LEM hold by the fact that $(\mathrm{F\,F\,P} \equiv \mathrm{T\,P})$ and $(\mathrm{T\,P} \vee \mathrm{F\,P})$ are both contingent. Both are F when P is 0. However, Non-Contradiction still holds. For $\sim(\mathrm{T\,P}\ \&\ \mathrm{F\,P})$ is a tautology, as is $\sim(\mathrm{P}\ \&\ \sim \mathrm{P})$ and its substitution instances $\sim(\mathrm{T\,P}\ \&\ \sim \mathrm{T\,P})$ and $\sim(\mathrm{F\,P}\ \&\ \sim \mathrm{F\,P})$.

It is shown how these results are all provable from the axioms of Analytic Truth-logic, an extension with 'T' of A-logic [1].

[1] RICHARD BRADSHAW ANGELL, ***A-LOGIC***, University Press of America, Lanham, MD, USA, 2002.

► KATALIN BIMBÓ, *A set theoretical semantics for full propositional linear logic*.
Automated Reasoning Group, Institute of Advanced Studies, Australian National University, Bld. #115, Canberra, ACT 0200, Australia.
E-mail: bimbo@csl.anu.edu.au.

We define a set theoretical semantics for full linear logic (i.e., classical linear logic including the exponentials). The *intensional connectives* $(\circ, \rightarrow)$ and the *modal operator* $(\lozenge)$ are modelled using operations (in a style similar to Urquhart's semantics for relevance logics, [3]). The *extensional connectives* $(\wedge, \vee)$ are represented via a Galois connection that is defined almost exactly as in [1]. *Negation* $(\sim)$ is modelled using a binary relation $\perp$, however, we define the set theoretical operation and the canonical $\perp$ relation differently than Dunn does in [2]. *Soundness* and *completeness* is proven. We also consider a few possible modifications of this semantics for linear logic, as well as for related substructural logics.

[1] K. BIMBÓ, *Semantics for structurally free logic LC+*, ***Logic Journal of the IGPL***, vol. 9 (2001), pp. 557–571.

[2] J. M. DUNN, *Generalized ortho negation*, ***Negation: a Notion in Focus***, (H. Wansing, editor), W. de Gruyter, New York, 1996, pp. 3–26.

[3] A. URQUHART, *Semantics for relevant logics*, ***The Journal of Symbolic Logic***, vol. 37 (1972), pp. 159–169.

► JEFFREY BURDGES, *A signalizer functor theorem for groups of finite Morley rank*.
Department of Mathematics, Rutgers University, Hill Center, Piscataway, New Jersey 08854, USA.
E-mail: burdges@math.rutgers.edu.

There is a longstanding conjecture, due to Gregory Cherlin and Boris Zilber, that all simple groups of finite Morley rank are simple algebraic groups. One of the major theorems in the area is Borovik's trichotomy theorem. The "trichotomy" here is a case division of the minimal counterexamples within odd type, i.e., groups whose Sylow 2-subgroup is divisible-by-finite. We introduce a charateristic zero notion of unipotence which can be used to obtain a connected nilpotent signalizer functor from any sufficiently non-trivial solvable signalizer functor. This result plugs seamlessly into Borovik's work to eliminate the assumption of tameness from his trichotomy theorem for odd type groups. This work also provides us with a form of Borovik's theorem for degenerate type groups.

► DENNIS F. CUDIA, *General inductive logic*.
5343 Cunningham Road, Rockford, Illinois 61102, USA.

Denote the *gold standard effect for the cause* q by $g(q)$ and define $g(q)$ so that q is present if and only if the effect $g(q)$ is present. $g(q)$ is abbreviated by g and the absence of the effect $g(q)$ is denoted by $\sim g$. Let H be a fixed finite non-empty set of instances each of the form (p, g) or $(p, \sim g)$ or $(\sim p, g)$ or $(\sim p, \sim g)$ where p or $\sim p$ denotes the presence or absence, respectively, of the effect p. Let $n_{11}, n_{12}, n_{21}, n_{22}$, respectively, be the number of instances of the form (p, g), $(p, \sim g)$, $(\sim p, g)$, $(\sim p, \sim g)$, respectively. Assume a and b, respectively, are positive rational numbers given by $n_{11}/(n_{11}+n_{21})$ and $n_{22}/(n_{12}+n_{22})$, respectively. Denote the *likelihood table of H* by $\mathrm{LT}(H)$ and define $\mathrm{LT}(1,1) = a$, $\mathrm{LT}(1,2) = 1-b$, $\mathrm{LT}(2,1) = 1-a$, $\mathrm{LT}(2,2) = b$. Denote a diagonal matrix by $\mathrm{diag}(u, v)$, let $C = \mathrm{diag}(c, 1-c)$, let $d = ac + (1-b)(1-c)$, let $D = \mathrm{diag}(d, 1-d)$ and denote the *predictive value table of H* by PV and define PV so that $D \cdot \mathrm{PV} = \mathrm{LT} \cdot C$ where all inverses and multiplications are matrix operations. If $a + b > 1$ then the graphs of $\mathrm{PV}(1,1)$ and $\mathrm{PV}(2,2)$, respectively, are concave functions of c passing through $(0,0), (1,1)$ and $(0,1), (1,0)$, respectively. Expressions are obtained for $\mathrm{PV}(1,1) - c$ and $\mathrm{PV}(2,2) - (1-c)$. An example from cardiology is discussed (see [1]) in which q is coronary heart disease and g is coronary arteriography and left ventriculography.

[1] R. G. Murray, et al., *Bayesian analysis of stress thallium-201 scintigraphy*, ***European Journal of Nuclear Medicine***, vol. 6 (1981), pp. 201–204.

► NATASHA DOBRINEN, *A very weak distributive law and a related game in Boolean algebras*.
Penn State University, 218 McAllister Building, University Park, PA 16802, USA.
E-mail: `dobrinen@math.psu.edu`.

Infinitary distributive laws in Boolean algebras are of interest in their own right and also for their equivalences to some useful forcing properties. Jech pioneered the connections between distributive laws involving countable families of maximal incompatible subsets and related infinitary games between two players. Foreman, Kamburelis, and others have added to this body of knowledge.

We will review some results of Jech, Foreman, and Kamburelis along with some of our own regarding generalized distributive laws and related games. We will then present a generalized notion of weak distributivity due to Prikry, namely the hyper-weak (κ, λ)-distributive law, give a forcing equivalence, define a related game, and show that for certain pairs of cardinal numbers, the hyper-weak (κ, λ)-distributive law is equivalent to the non-existence of a winning strategy for the first player in the game. Under GCH, this equivalence holds for all pairs $\kappa > \lambda$. It is consistent with ZFC that, for all $\kappa \geq \lambda$, this game is undetermined, via κ^+-Suslin trees.

► ALFIO GIARLOTTA, *The representability number of a chain*.
Department of Mathematics, University of Illinois, Urbana IL 61801, USA.
E-mail: `giarlott@math.uiuc.edu`.
Department of Economics and Quantitative Methods, University of Catania, Catania 95129, Italy.

For any pair of linear orderings (L, M), define the *M-representability* number of L, denoted by $\mathrm{repr}_M(L)$, as the least ordinal α such that L can be embedded into the lexicographic power M^{α}_{lex}. We compute $\mathrm{repr}_M(L)$ for some pairs of linear orderings (L, M), paying particular attention to the case $M = \mathbb{R}$.

A chain L is *M-large* if $\mathrm{repr}_2(L) = \mathrm{repr}_M(L)$; a pair of chains (L, M) is *lexicographically independent* if L is M-large and M is L-large. We give some examples of pairs of chains which are lexicographically independent.

► JEFFRY L. HIRST, *Milliken's Theorem, ultrafilters, and reverse mathematics (Preliminary Report)*.
Department of Mathematical Sciences, Appalachian State University, Boone, NC 28608, USA.
E-mail: `jlh@math.appstate.edu`.

Milliken's Theorem [2] is a theorem of infinite combinatorics combining aspects of Ramsey's Theorem and Hindman's Theorem [1]. This talk will explore the connections between Milliken's theorem and the existence of certain ultrafilters on countable Boolean algebras.

[1] NEIL HINDMAN, *Finite sums from sequences within cells of a partition of N*, ***Journal of Combinatorial Theory Series A***, vol. 17 (1974), pp. 1–11.

[2] KEITH R. MILLIKEN, *Ramsey's theorem with sums or unions*, ***Journal of Combinatorial Theory Series A***, vol. 18 (1975), pp. 276–290.

► TETSUYA ISHIU, *Club guessing sequences and their applications*.
Department of Mathematics, 103 Multipurpose Science and Technology Building, University of California, Irvine, Irvine, CA 92697-3875, USA.
E-mail: tishiu@math.uci.edu.

A club guessing sequence was defined by Shelah. Its definition is similar to the ones of $\diamondsuit$ and $\clubsuit$. But unlike these principles, there always exists a club guessing sequence on every regular cardinal above $\aleph_1$. It was very effectively used in various arguments. For example, it played an important role in pcf theory. It also has an application to general topology, which was found by a joint work with Fernando Hernández-Hernández. I will talk about my recent research on this interesting mathematical object.

► JUI-LIN LEE, *On Gödel's completeness theorem*.
National Chung-Cheng University, Philosophy Department, Chia-Yi, Taiwan 621.
E-mail: jllee@phil.ccu.edu.tw.

In the first part "Skolemizing Gödel's completeness theorem" I give a simple proof of completeness theorem. It suffices to consider the prenex normal form case. Then the simple cases Π_1 and Σ_1 can be easily proved: use canonical model and Lindenbaum's trick on diagram for Π_1 case (the universal quantifier then may stand for "for all (equivalence classes of) variable free terms") and introduce new constant symbols for Σ_1 case (the key in Henkin's proof). Completeness theorem then seems trivial for one may introduce Skolem functions to convert any $\forall x\exists y\varphi(x, y)$ into $\forall x\varphi(x, f(x))$ and then it can always be reduced to the Π_1 case. It is not so simple. To preserve the consistency for introducing Skolem functions one needs a careful proof-theoretic analysis to prove Herbrand's theorem and then the "Theorem on Functional Extensions" [3] (pp. 55–56). I will avoid proving "Theorem on Functional Extensions" and modify Henkin's method instead: The proof of completeness theorem can be done by using Skolem functions to index new constant symbols and introducing new constant symbols in a different type of well-ordering.

In the second part "Can a finitist understand the proof of completeness theorem for monadic logic?" I will discuss the proof of completeness theorem for monadic logic without AC (or Maximal Ideal Theorem).

[1] W. HODGES, *Model theory*, Cambridge University Press, 1993.

[2] S. SHAPIRO, *Classical logic II: higher-order logic*, ***The Blackwell Guide to Philosophical Logic***, L. Goble (editor), Blackwell Publishers Ltd., 2001, pp. 33–54.

[3] J. R. SHOENFIELD, ***Mathematical Logic***, Addison-Wesley Press, 1967.

► DANIEL LEIVANT, *The constructive arithmetical hierarchy*.
Computer Science Department, Indiana University, Bloomington, IN 47405, USA.
E-mail: leivant@cs.indiana.edu.

Classically, the same algorithms are provably-convergent using Σ^0_k-induction as Π^0_k-induction, yielding a neat correspondence between function provability using induction for k quantifier-alternations, and definability by rank-k primitive-recursion. This simple picture collapses when the logic is constructive; in particular, Π^0_1-induction is much weaker than Σ^0_1-induction, and induction for arbitrary prenex formulas is no stronger than Π^0_2-induction [3].

We account for these phenomena, and related ones, by developing a constructive analog to the arithmetical hierarchy, focusing on the computational power of restricted induction, rather than on descriptive power (as in [1]). Using the intrinsic-reasoning framework of [2], with N as a primitive predicate (as did Peano in 1889!), we define a formula-as-type homomorphism that maps formulas to simple types over N (no dependent types), and we calibrate formulas by the implication rank of that type.

The functions provable constructively (that is, over minimal or intuitionistic logic) using rank-k induction are seen to be precisely the functions defined by rank-k primitive recursion. Since formulas of PA are interpreted by relativizing quantifiers to N, the formulas in Π_1^0, Σ_1^0, Π_2^0, Π_{k+2}^0 and Σ_{k+3}^0 correspond indeed to ranks 0, 1, 1, 2 and 2, respectively. However, if double negations are introduced to capture the full classical classes, then the rank of formulas grows with quantifier alternation.

[*Research partially supported by NSF grant CCR-9309824.*]

[1] Wolfgang Burr, *The intuitionistic arithmetical hierarchy*, Preliminary manuscript, 2000.

[2] Daniel Leivant, *Intrinsic reasoning about functional programs I: First order theories*, ***Annals of Pure and Applied Logic***, vol. 114 (2002), pp. 117–153.

[3] Kai F. Wehmeier, *Fragments of HA based on Σ_1-induction*, ***Archive for Mathematical Logic***, vol. 37 (1997), pp. 37–49.

► YEVGENIY MAKAROV, *Another characterization of provably recursive functions*.
Department of Computer Science, Indiana University, Bloomington, IN 47405-7104, USA.
E-mail: emakarov@cs.indiana.edu.

A new characterization of provably recursive functions of first-order arithmetic is described. Its main feature is using only terms consisting of 0, the successor S and variables in the quantifier rules, namely, universal elimination and existential introduction.

Consider Peano arithmetic with functional symbols for all primitive recursive functions, and defining equations for them. Consider also a set F of new functional symbols and a set P of equations for them. These equations don't have to be primitive recursive, and they even don't have to define total functions. For $f \in F$, the function defined by P for f is

$$\{(n, m) \mid f(n) = m \text{ is provable from } P \text{ in equational logic}\}.$$

If P does not prove $m = n$ for closed terms m, n consisting of 0, S only then this is indeed a function.

We claim that a function defined by P for f is provably recursive iff the formula $\forall x \exists y$ $f(x) = y$ is provable from P in Peano arithmetic using only 0, S and variables in the rules of universal elimination and existential introduction. (Natural deduction is used; we also have the the following rules for equality: reflexivity and $A[t]$ with $t = s$ imply $A[s]$ for any formula A and terms t, s.) There is no restriction on induction.

The proof is very similar to the one of the analogous statement about Intrinsic Theories described in [1]. In fact, one direction uses Intrinsic Theories directly.

[1] Daniel Leivant, *Intrinsic reasoning about functional programs I: first order theories*, ***Annals of Pure and Applied Logic***, vol. 114 (2002), no. 1–3, pp. 117–153.

► KERRY OJAKIAN, *Ramsey lower bounds in bounded arithmetic*.
Carnegie Mellon University, Department of Mathematics, 6113 Wean Hall, Pittsburgh, PA 15217, USA.
E-mail: keo@andrew.cmu.edu.

Working in bounded arithmetic, Pudlak [2] proves a Ramsey upper bound statement. We investigate lower bounds, both non-constructive (via the probabilistic method) and constructive ones. The weak pigeon hole principle (WPHP) is key in much of this work; it states that there is no injection from $[2n]$ to $[n]$. For the multi-color Ramsey statement (call it "Ram"), formalizing the constructive lower bound yields a sort of "reversal" to Pudlak's result. He shows that $WPHP \to Ram$. We show that $Ram \to WPHP$, using an idea from Krajicek [1].

[1] JAN KRAJICEK, *On the weak pigeonhole principle*, ***Fundamenta Mathematicae***, vol. 170 no. 1–3, (2001), pp. 123–140.

[2] PAVEL PUDLAK, *Ramsey's theorem in bounded arithmetic*, ***4th Workshop, Computer Science Logic***, Lecture notes in computer science, vol. 533, Springer-Verlag, Berlin Heidelberg, 1991, pp. 308–317.

► PAULO OLIVA, *On the extraction of polynomial-time algorithms from ineffective proofs in feasible analysis*.
Department of Computer Science, University of Aarhus, Ny Munkegade, DK-8000 Aarhus C, Denmark.
E-mail: pbo@brics.dk.

Consider as a *base for feasible analysis* Cook and Urquhart's [1] system CPV^ω extended with the axiom of choice for numbers restricted to quantifier-free formulas QF-AC. This system has a functional interpretation (via negative translation) in IPV^ω, which allows one to extract polynomial-time computable realizers from proofs of Π^0_2-theorems (i.e., formulas of the kind $\forall x \exists y A(x, y)$, A being quantifier-free) in $\mathsf{CPV}^\omega + \mathsf{QF\text{-}AC}$. In [3] an extension of this functional interpretation to include a 'feasible' formulation of weak König's lemma for Π^0_1-definable trees is given by extending IPV^ω with a simple form of binary bar recursion $\mathcal{B}$, i.e., it is shown that the theory $\mathsf{CPV}^\omega + \mathsf{QF\text{-}AC} + \Pi^0_1\text{-}\mathsf{WKL}^\omega$ has a functional interpretation (via negative translation) in $\mathsf{IPV}^\omega + \mathcal{B}$. Moreover, in [3] it is also proven that the type one terms of the system $\mathsf{IPV}^\omega + \mathcal{B}$ are polynomial-time computable. This gives a procedure for extracting polynomial-time realizers from proofs of Π^0_2-theorems in $\mathsf{CPV}^\omega + \mathsf{QF\text{-}AC} + \Pi^0_1\text{-}\mathsf{WKL}^\omega$. The Π^0_2-theorems are even allowed to make use of 0-1 oracles as free-variables.

The base system $\mathsf{CPV}^\omega + \mathsf{QF\text{-}AC}$, which when extended with $\Pi^0_1\text{-}\mathsf{WKL}^\omega$ is strong enough for proving e.g. the Heine/Borel covering lemma, is an extension to higher types of a subsystem of Ferreira's [2] BTFA (Base Theory for Feasible Analysis), for which Π^0_2-conservation of WKL has been non-constructively proven.

BRICS – Basic Research in Computer Science, funded by the Danish National Research Foundation.

[1] S. COOK AND A. URQUHART, *Functional interpretations of feasibly constructive arithmetic*, ***Annals of Pure and Applied Logic***, vol. 63 (1993), pp. 103–200.

[2] F. FERREIRA, *A feasible theory for analysis*, ***The Journal of Symbolic Logic***, vol. 59 (1994), no. 3, pp. 1001–1011.

[3] P. OLIVA, *Polynomial-time algorithms from ineffective proofs*, ***Proceedings of the Eighteenth Annual IEEE Symposium on Logic in Computer Science LICS***, 2003.

► MAURICIO OSORIO AND JUAN ANTONIO NAVARRO, *Modal Logic $S5_2$ and FOUR*.
Universidad de Las americas, Puebla, Santa Catarina Martir s/N, Departamento de Ingenieria en Sistemas, Cholula Puebla 72820 Mexico.
E-mail: josorio@mail.udlap.mx.
Departamento de Matematicas, Santa Catarina Martir S/N, San Andres Cholula, Puebla 72820 Mexico.
E-mail: ma108907@mail.udlap.mx.

Our connectives for $S5$ are b (Box), $\sim$ (negation) and $\vee$ (or). $A \to B$, $A\ \&\ B$, and $d\ A$ are considered as abbreviations in the standard way.
Consider the axiom schemata:

$$F1 := d\ A \to b\ A,$$

$$F2 := ((d\ A1\ \&\ d\ A2)\ \&\ b{\sim}(A1\ \&\ A2)) \to b(A1 \vee A2), \qquad \text{and so on.}$$

For every Natural number i the reader can picture the axiom schema F_i.

For every Natural number i, $S5_i$ denotes $S5$ extended with the schema F_i.

We show that $S5_i$ is determined by the class of reflexive, transitive, and symmetric frames of size at most i. $S5_1$ is the "not very interesting" (sometimes) called Trivial modal logic. This family of logics define a strictly descending chain, where $S5_i$ is strictly stronger than $S5_{(i+1)}$. Moreover, we present a translation of $S5_2$ into the well known bilattice FOUR that preserves theorems. FOUR has the for values $\{0, 1, t, f\}$. We write & 1 and $\vee 1$ to denote the meet and joint operators w.r.t. truth ordering. We have also two negation operators -1 (negation) and -2 (conflation):

$$-1(t) := f, \quad -1(f) := t, \quad -1(1) := 1, \quad \text{and} \quad -1(0) := 0.$$
$$-2(t) := t, \quad -2(f) := f, \quad -2(1) := 0, \quad \text{and} \quad -2(0) := 1.$$

We define the function f from modal formulas into FOUR formulas as follows:

$$f(A) := A \text{ if } A \text{ is atomic.}$$
$$f(b\,A) := f(A) \quad \&\, 1 \quad -f(A).$$
$$f(\sim A) := -1\ -2\ f(A).$$
$$f(A \vee B) := f(A)\ \vee 1\ f(B).$$

A t-tautology is a formula that evaluates always to t. We show that A is theorem of $S5_2$ iff $f(A)$ is a t-tautology.

We observe that $S5_2$ agrees with $S5$ in a non trivial fragment of formulas, interestingly enough for applications in computer science. Hence, we show that a small but relatively interesting fragment of $S5$ can be translated to FOUR.

► WIM RUITENBURG, *Intuitionistic theories whose Kripke models are all T-normal ones*.
Department of Mathematics, Marquette University, P.O. Box 1881, Milwaukee WI 53201, USA.
E-mail: wimr@mscs.mu.edu.

Given a set of sentences T, a Kripke model is T-normal, or locally T, if all its node structures are (classical) models of T. Samuel Buss constructs a theory H(T) which is sound and complete for the locally T Kripke models. We show that if, additionally, all models of H(T) are locally T, then H(T) is axiomatizable by geometric sentences. This answers a question implied by Wolfgang Burr's Mathematical Review MR 2001h:03115.

[1] SAMUEL R. BUSS, *Intuitionistic validity in T-normal Kripke structures*, ***Annals of Pure and Applied Logic***, vol. 59 (1993), pp. 159–173.

► KSENIJA SIMIC, *Reverse mathematics of Hilbert spaces*.
221 Gross St., Pittsburgh, PA 15224, USA.
E-mail: ksimic@andrew.cmu.edu.

To date, little research has been done in the area of Hilbert spaces from the point of view of weak subsystems of second order arithmetic. In this talk, I will give the definitions and introduce basic concepts relevant to developing the theory of Hilbert spaces in this framework, and then state some results regarding orthogonal projections and closed sets. I will also discuss the mean ergodic theorem, and show that it is equivalent to arithmetic comprehension over the base theory RCA_0.

► STEPHEN M. WALK, *Blanketing functions and a conjecture about array computable degrees*.
Department of Mathematics, ECC 139, 720 4th Avenue South, St. Cloud State University, St. Cloud, Minnesota 56301-4498, USA.
E-mail: smwalk@stcloudstate.edu.

We define a *blanketing function* for a c.e. degree $\boldsymbol{a}$ to be a function $f \leq_{wtt} K$ that dominates all $\boldsymbol{a}$-computable functions. The concept comes from Downey, Jockusch, and Stob's definition of *array computable* [1]: A degree $\boldsymbol{a}$ is array computable, by definition, if and only if such a function f exists.

Every blanketing function must have high degree, and it is natural to wonder *which* high c.e. degrees contain blanketing functions. It is shown in [1] that $\boldsymbol{0}'$ contains a blanketing function for *every* a.c. degree, and similarly every high c.e. degree contains a blanketing function for $\boldsymbol{0}$. But it is not immediately clear whether any *incomplete* c.e. degree contains a blanketing function for any *noncomputable* a.c. degree.

We show that every high degree does contain a blanketing function for some noncomputable a.c. degree; that, similarly, every a.c. degree is "blanketed" by some incomplete degree; and that no two a.c. degrees are "blanketed" by the same set of degrees, even when we restrict our attention to high degrees above *both* of them. We present negative results in the same vein and consider larger questions related to a result of Kummer [2] and to a conjectured duality between the high degrees and the a.c. degrees. (All degrees considered in these results are c.e.)

[1] RODNEY G. DOWNEY, CARL G. JOCKUSCH, and MICHAEL STOB *Array nonrecursive degrees and genericity*, ***Computability, enumerability, unsolvability: Directions in recursion theory*** (S. B. Cooper, T. A. Slaman, and S. S. Wainer, editors), London Mathematical Society Lecture Series, no. 224, Cambridge University Press, 1996, pp. 93–104.

[2] MARTIN KUMMER *Kolmogorov complexity and instance complexity of recursively enumerable sets*, ***Siam Journal on Computing***, vol. 25 (1996), pp. 1123–1143.

► FRANK WROBLEWSKI, *The completion of classical propositional-quantificational logic accommodates indeterminancy*.
1662 Coughlin St., Laramie, WY 82072, USA.
E-mail: fwroblewski@hotmail.com.

Since Aristotle pondered a third truth-value for indeterminate, i.e., neither true nor false propositions, the true-false dichotomy has been disputed. Classical logic is tasked to guide truth preserving discourse and performs well with determinate, i.e., true or false propositions, but founders on truth-value gaps occasioned by indeterminacies such as Heisenberg's uncertainty and '$x \in y$' of mathematics. Charles S. Peirce, a firm believer in unavoidable indeterminacy, hoped to complete classical logic by extending truth tables to three truth-values. But truth tables are tabulations derived from interrelated received hypotheses where tinkering violates classical logic.

We complete classical logic via Sheffer's reduction. Two hypotheses are found wanting: the law of bivalence doesn't exhaust the truth-values, and Sheffer's hypothesis falsifying joint-denial neglects the false-conferring condition where one proposition is the denial of the other. Accordingly, the truth-values are exhausted via the law of excluded middle, yielding the complementary denial of 'true or false,' namely, the third truth-value 'neither true nor false.' By completing Sheffer's deficient hypothesis, propositional logic is completed wherein the core two-valued logic is preserved to become the special case for determinate propositions. It remains to deduce the truth conditions conferring the 'indeterminate' truth-value on joint-denial, and deduce the truth conditions conferring each of the three truth-values on the other connectives.

The quantification hypotheses cleansed of Quine's expedient closure, with truth predicates restored, suffice to deduce quantificational truths accommodating indeterminacy. Thus the correct form of existential instantiation is deduced. Quantification proves idle for determinate propositions. Undecidable propositions bear two or three alternate truth-values; e.g., the identity '$x = y$' is true or indeterminate.

We assume familiarity with Quine's *Mathematical Logic*, especially Sheffer's reduction.

► GUOHUA WU, *Complementing the cappable degrees in the difference hierarchy*.
School of Mathematical and Computing Sciences, Victoria University of Wellington, P.O. Box 600, Wellington, New Zealand.
E-mail: wu@mcs.vuw.ac.nz.

In [1], Downey proved that the diamond lattice can be embedded into the d.c.e. degrees preserving 0 and 1. Wu proves in [2] that such diamond embeddings can also be obtained by showing that there are c.e. degrees $\mathbf{a}$, $\mathbf{c}$ and a d.c.e. degree $\mathbf{d}$ such that $\mathbf{c}$ cups $\mathbf{d}$ to $\mathbf{0}'$, caps $\mathbf{a}$ to $\mathbf{0}$, and $\mathbf{d}$ is isolated by $\mathbf{a}$. In this talk we will prove that any nonzero cappable degree has an isolated degree as its complement. As a consequence, a c.e. degree is cappable if and only if it has a nonzero d.c.e. degree as its complement. This gives a new characterization of cappable degrees. (Recently, Wu [3] showed that any nonzero cappable degree can also have a nonisolated degree as its complement.) This is a joint work with Rod Downey (Victoria University of Wellington) and Angsheng Li (Chinese Academy of Sciences).

[1] R. G. Downey, *D.r.e. degrees and the nondiamond theorem*, ***Bulletin of the London Mathematical Society***, vol. 21 (1989), pp. 43–50.

[2] G. Wu, *Isolation and diamond embeddings*, ***The Journal of Symbolic Logic***, vol. 67 (2002), pp. 1055–1064.

[3] ———, *Diamond embeddings into the d.c.e. degrees with 0 and 1 preserved*, ***Proceedings of the 7th and 8th Asian Logic Conferences***, World Scientific, accepted, 2003.

Abstracts presented by title

► LEONA F. FASS, *Intelligent applications of modeling techniques: logic-based and commonsense*.
P.O. Box 2914, Carmel CA 93921, USA.
E-mail: lff4@cornell.edu.

Formal behavioral modeling techniques can be utilized effectively in the development and refinement of practical systems. We find that logic-based research in the constrained theoretical realm, producing "perfect" results, can be adapted to produce improved approximating and "commonsense" models in actual practice. We describe applications [2,3] and potential applications to the behavioral data-mining of link analysis; agent design; synthesis of specified systems; and detection of defects in systems already deployed.

In link analysis, we show that behavior of an economic sub-domain can be modeled, approximating an entire domain's (often unpredictable) behavior. For agent design, our approach to problem decomposition and minimized realization of components has utility, as in the congregation formation of Brooks and Durfee [1]. We see that applications of formal modeling techniques abound in Khatib and Pecheur [6] and Fischer and Smith [4], where logic-based construction of deployed systems and refinement/correction of systems are described. Examples include Waldinger's [7] deductive construction of goal-directed agent systems, and Kant's [5] analyst-specified refinement of mathematical modeling code.

In numerous applications, we find that local commonsense experts, with information unanticipated in the development of global formal models, can help to produce accurate results and achieve problem goals.

[1] C. H. Brooks and E. H. Durfee, *Congregation formation in information economies*, Papers from the ***AAAI workshop on artificial intelligence for electronic commerce***, Orlando FL, July 1999, AAAI Press WS99-01, pp. 62–68.

[2] L. F. Fass, *Establishing software 'correctness' by logical and algebraic means*, ***Proceedings of the fifth international joint conference on information sciences***, Atlantic City, NJ, February 2000, vol. I, pp. 639–642.

[3] ———, *Modeling techniques for intelligent business*, preliminary version, invited for

presentation at the ***American Association for Artificial Intelligence national meeting, workshop on artificial intelligence for intelligent business***, Edmonton AB, July 2002.

[4] B. Fischer and D. R. Smith, editors, Papers from the ***AAAI Spring symposium on logic-based program synthesis: state of the art and future trends***, Stanford University, March 2002, AAAI Press SS02-05.

[5] E. Kant, *A commercial program synthesis system for computational finance*, invited symposium talk, abstracted in [4], p. 3.

[6] L. Khatib and C. Pecheur, editors, Papers from the ***AAAI Spring symposium on model-based validation of intelligence***, Stanford University, March 2001, AAAI Press SS01-04.

[7] R. Waldinger, *Deductive chat lines for multiple agents*, invited symposium talk, abstracted in [4], p. 5.

► LEV YU. GLEBSKY AND YEVGENIY GORDON, *On a class of word sets and extension of monadic second order language*.
IICO-UASLP, Av. Karakorum 1470, Lomas 4TA Session, San Luis Potosi SLP 7820 Mexico.
E-mail: glebsky@cactus.iico.uaslp.mx.
Eastern Illinois University, Department of Mathematics, 600 Lincoln Ave., Charleston, IL, 61920-3099, USA.
E-mail: cfyig@eiu.edu.

A new class Π_L of languages (word sets) with polynomial algorithms for the membership problem will be discussed in the talk. This class is a generalization of the class Π of languages introduced by Yu. V. Glebsky in "A certain class of word sets", ((Russian) *Izvestia. Vysših. Učebnyh. Zavediny. Radiofizika* 13 (1970), 1256–1258) and thus includes all regular languages. But Π_L includes also some languages, such as Correct Bracket Structures and the set of palindromes, that are not in Π. We consider also a similar to Π class of languages for words on trees. We introduce also a weak second order language MSOC_L that generalizes the well-known J. R. Büchi's and M. O. Rabin languages for finite automata and finite automata on trees. Since the class Π_L is closed only about Boolean operations but not about word projection, there does not exist a one-to-one correspondence between the Π_L languages and formulas of MSOC_L. But we describe a subset K_L of MSOC_L that is in one-to-one correspondence with Π_L languages. For any formula $\varphi \in K_L$ there exists an algorithm, checking if $M \models \varphi$ in polinomial time with respect to size M in the standard interpretation. This implies the following statement: a problem about graphs which can be formulated in K_L has polynomial time algorithm for graphs with bounded tree depth. For example, maximum planar subgraph problem can be formulated on K_L.

► MARC A. MOFFETT, *Generalized quantifiers and NP conjunction in intensional algebraic logic*.
Department of Philosophy, University of Colorado, Boulder, Colorado, 80309, USA.
E-mail: moffett@ucsub.colorado.edu.

NP conjunction is not defined in intensional algebraic logic [1] nor, in its standard development, is there any way of introducing it that preserves the benefits of a cross-categorial boolean interpretation. We develop a variant of this logic that treats boolean conjunction as a level-shifting operation [3] conjoining non-boolean entities whose extensions are defined over boolean domains.

We assume a sorted domain (consisting of kinds D_{-2}, particulars D_{-1}, propositions D_0, and n-ary relations-in-intension D_n) and a set $\mathcal{E}$ of extensionalization functions: for all $\partial \in \mathcal{E}$, if $x \in D_{-2}$, then $\partial(x) \subseteq D$; if $x \in D_{-1}$, then $\partial(x) \subseteq D_1$; if $x \in D_0$, then $\partial(x) = n$ for $n \in \{0, 1\}$; if $x \in D_1$, then $\partial(x) \subseteq D$; if $x \in D_n$, then $\partial(x) \subseteq D_n$. The extension of a particular is effectively a generalized quantifier [2]: $\partial(x) = \{\varphi \in D_1 \mid \varphi(x) = 1\}$.

Determiners are treated as extension-shifting operations on kinds:

$$\partial(\mathbf{det}_\forall\, k) = \{\varphi \mid [\forall x \in \partial(k)]\varphi(x) = 1\}.$$
$$\partial(\mathbf{det}_\exists\, k) = \{\varphi \mid [\exists x \in \partial(k)]\varphi(x) = 1\}.$$

This yields uniform boolean extensions for NP semantic values. Consequently, we are able to define both boolean conjunction and an associated predication operation for generalized quantifiers:

$$x \in \partial(\mathbf{conj}\langle\varphi_1, \varphi_2\rangle) \text{ iff}_{\text{def}}\, x \in \partial(\varphi_1) \wedge x \in \partial(\varphi_2).$$
$$\partial(\mathbf{pred}_{\text{GQ}}\langle\varphi, x\rangle) = 1 \text{ iff}_{\text{def}}\, \varphi \in \partial(x)).$$

[1] G. BEALER, ***Quality and concept***, Oxford University Press, 1982.

[2] J. BARWISE and R. COOPER, *Generalized quantifiers and natural language*, ***Linguistics and Philosophy***, vol. 4 (1981), pp. 159–219.

[3] B. PARTEE, *Noun phrase interpretation and type shifting principles*, ***Studies in Discourse Representation Theory and the Theory of Generalized Quantifiers*** (Groenendijk, de Jong, and Stokhof, editors), Dordrecht, Foris.

► SAEED SALEHI, *Decidable formulas of intuitionistic primitive recursive arithmetic*.
Turku Center for Computer Science, Lemminkäisenk. 14 A, FIN-20520 Turku.
E-mail: saeed@cs.utu.fi.

By formalizing some classical facts about provably total and provably recursive functions of intuitionistic primitive recursive arithmetic ($iPRA$) we prove that the set of decidable formulas of $iPRA$ and of $i\Sigma_1^+$ (intuitionistic Σ_1-induction in the language of PRA, [3]) coincide with the set of their provably Δ_1-formulas and the set of their provably atomic formulas. So, based on quantifier logic, $iPRA$ differs from PRA afterward the decidability of atomic (and Δ_1) formulas, although the propositional counterpart of these two theories are equal. By the same methods we shall give another proof of a theorem of Marković and De Jongh [1]: the decidable formulas of Heyting Arithmetic HA are its (provably) Δ_1-formulas.

[1] ZORAN MARKOVIĆ, *On the structure of Kripke models of Heyting arithmetic*, ***Mathematical Logic Quarterly***, vol. 39 (1993), pp. 531–538.

[2] SAEED SALEHI, *Decidable formulas of intuitionistic primitive recursive arithmetic*, ***Reports on Mathematical Logic***, vol. 36 (2002), pp. 55–61.

[3] KAI F. WEHMEIER, *Fragments of HA based on Σ_1-induction*, ***Archive for Mathematical Logic***, vol. 37 (1997), pp. 37–49.