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TWELFTH ASIAN LOGIC CONFERENCE

CO-SPONSORED BY THE ASSOCIATION FOR SYMBOLIC LOGIC

Victoria University of Wellington, Wellington, New Zealand
December 15–20, 2011
with Student Day on December 14, 2011

The Program Committee consisted of Toshiyasu Arai, Rod Downey (Chair), Qi Feng, Sergei S. Goncharov, Byunghan Kim, Greg Restall, and Yang Yue. The Local Organizing Committee consisted of Rod Downey (Chair), Noam Greenberg, and Ginny Whatarau.

There were eight invited talks:

Mic Detlefsen (Notre Dame), *Cantorian freedom*.
Isaac Goldbring (UCLA), *Definability in metric structures*.
Noam Greenberg (Victoria University Wellington), *Stong jump-traceability*.
Wu Guohua (NTU, Singapore), *Variants of constructions of noncuppable degrees*.
Hiroakira Ono (JAIST), *Algebraic perspective on nonclassical logics*.
Grigor Sargsyan (Rutgers University), *The Solovay hierarchy*.
Simon Thomas (Rutgers University), *The descriptive set theory of unitary group representations*.
Akito Tsuboi (University of Tsukuba), *Indiscernible trees*.

Four-hour tutorials were given by Martin Grohe (Humboldt University Berlin) on *Logical aspects of graphs* and by Zlil Sela (Hebrew University of Jerusalem) on *Logical aspects of groups*. Grohe and Sela also gave two-hour student tutorials on the Student Day; due to travel difficulties Yijia Chen spoke in place of Grohe.

Special sessions on the following topics were held (with organizers in parentheses): Algorithmic randomness (Rod Downey and Andre Nies), Computability and algebraic structures (Rod Downey), Logical aspects of graphs and matroids (Geoff Whittle), Modal logic (Rob Goldblatt and Edwin Mares), and Set theory (Qi Feng).

There were over 110 attendees including 26 students.

Abstracts of the invited talks and contributed talks given (in person or by title) by members of the Association for Symbolic Logic follow.

For the Organizing Committee
ROD DOWNEY

Abstracts of invited tutorials

► YIJIA CHEN, *Basic descriptive complexity*.
Department of Computer Science and Engineering, Shanghai Jiao Tong University, Dongchuan Road, No. 800, 200240 Shanghai, China.
E-mail: yijia.chen@cs.sjtu.edu.cn.

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Descriptive complexity is the main branch of finite model theory, showing that the computational complexity of problems can be matched by their logic definability, and vice versa. In this tutorial, I will cover some basic materials in this area, including:

- Inflationary fixed point logic.
- The general framework of descriptive complexity.
- Fagin's Theorem and Immerman–Vardi Theorem.

► MARTIN GROHE, *Logical aspects of graphs*.
Institut für Informatik, Humboldt University, Unter den Linden 6, 10099, Berlin, Germany.
E-mail: grohe@informatik.hu-berlin.de.

As an integral part of the proof of their famous Graph Minor Theorem, Robertson and Seymour developed a deep structure theory for graphs with excluded minors. Deleting vertices and edges and contracting edges obtain a minor of a graph. In recent years, the structure theory has found many applications in graph theory, algorithms, and complexity theory. Some of the most powerful applications crucially involve logic.

In this tutorial I will give an introduction into the Robertson and Seymour's structure theory for graphs with excluded minors and a recent extension to graphs with excluded topological subgraphs. My main focus will then be on the logical definability of the structural decompositions. I will also discuss applications of the structure theory at the boundaries of logic, algorithms and complexity.

► ZLIL SELA, *Logical aspects of groups*.
The Hebrew University of Jerusalem, The Edmond J. Safra Campus, Givat Ram, Jerusalem 91904, Israel.
E-mail: zlil@math.huji.ac.il.

Talk for students (first two hours): We surveyed some basic results about elementary equivalence between groups. We stated a quantifier elimination result over free groups, and Tarski's problems that follow from it. The we continued to explain how finitely generated groups the are elementarily equivalent to a free group look like, and some further generalizations to (Gromov) hyperbolic groups.

In the second hour we talked about system of equations over a free group, its Makanin–Razborov diagram, and basic connections between algebraic geometry over groups and low dimensional topology.

A sequence of 4 talks in the conference: The first two talks were deveoted to results on the elementary theory of free and other groups. We stated the quantifier elimination theorem for free groups, Tarski problems, the classification of finitely generated groups that are elementarily equivalent to a free group, and then discussed generalizations of all these theorems to (Gromov) hyperbolic groups, including the fact the a f.g. group that is elementarily equivalent to hyperbolic group is hyperbolic, and that it is decidable if two hyperbolic groups are elementarily equivalent or not. We further stated the theorem about stability of free and hyperbolic groups, and stated a theorem on geometric elimination of imaginaries in these theories.

We continued to results about free products of groups. These include a solution to Vaught's problem on the elementary equivalence of free product of pairs of groups that are elementarily equivalent, the stability of free products of stable groups, as well as some stabilization phenomenas on sentences that are defined over sequences of free products of groups.

The last two talks were devoted to the basic techniques that are involved in this theory. We started with the structure of the set of solutions to a system of equations over a free group. We explained the connection to low dimensional topology, the JSJ decomposition, and the Makanin–Razborov diagram. We further explained the structure of the set of solutions of a system of equations with parameters.

In the last talk we talked about sentences with two quantifiers. We explained Merzlyakov theorem, and its its generalizations. Then we explained the main difficulties that occur in trying to use Merzlyakov's theorem to analyze general (not positive) sentences and formulas over a free group.

Abstracts of invited plenary talks

► MICHAEL DETLEFSEN, *Cantorian freedom*.
University of Notre Dame, Notre Dame, IN 46556, USA.
E-mail: `mdetlef1@nd.edu`.

The freedom proper to mathematical investigation was an important concern of nineteenth and twentieth century writings in the foundations of mathematics. I will survey some of this literature and attempt to distill how freedom in mathematics was understood by writers of this period. I will pay particular attention to the questions of (i) what conditions were generally thought to govern its legitimate exercise and (ii) what value its exercise was commonly taken to have. Finally, I will consider a general argument, which purports to show that there is little meaningful scope for the legitimate exercise of freedom.

► ISAAC GOLDBRING, *Definability in metric structures*.
University of California, Los Angeles, 405 Hilgard Avenue, Los Angeles, CA 90095, USA.
E-mail: `isaac@math.ucla.edu`.

Continuous logic is a relatively new logic better equipped for studying the model theory of structures based on complete metric spaces. There are continuous analogs of virtually every notion and theorem from classical model theory, often with equalities replaced by approximations. However, most of the work done in continuous logic has centered around sophisticated topics concerning stability and its generalizations. In this talk, I will discuss the more basic notion of definability in metric structures. More specifically, I will consider the question of which functions and sets are definable in some concrete metric structures. I will present concrete descriptions of the class of functions that are definable in Urysohn's metric space as well as which linear operators are definable in infinite-dimensional Hilbert spaces. If time permits, I will discuss the definable functions in some other metric structures as well as make a few remarks about definable sets in Urysohn's space. I will not assume that the audience has been exposed to continuous logic and will begin my talk by introducing the subject.

► NOAM GREENBERG, *Strong jump-traceability*.
Victoria University of Wellington, PO Box 600, Wellington 6012, New Zealand.
E-mail: `noam.greenberg@msor.vuw.ac.nz`.
E-mail: `der.erlkoenig@gmail.com`.

Strong jump-traceability is a lowness notion, which displays fascinating interactions between randomness and the Turing degrees. It exhibits the robustness of its older cousin K-triviality by being the common locus of several equivalent definitions. Unlike K-triviality, though, these definitions come from both sides of the continuous / discrete divide. Analogues of important open problems regarding the K-trivial degrees are solved for the strongly jump-traceable degrees, prime among them being random covering. Among the unexpected fruit of this investigation (conducted in recent years, among others, by Downey, Diamondstone, Hirschfeldt, Kucera, Ng, Nies, and Turetsky) are applications to classical c.e. degree theory.

► WU GUOHUA, *Variants of constructions of noncuppable degrees*.
Nanyang Technological University, Singapore, 50 Nanyang Avenue, 639798, Singapore.
E-mail: `guohua@ntu.edu.sg`.

In this talk, I will talk about recent work on computably enumerable degrees, including locally noncappable degrees, noncuppable pairs, etc., and topics related to algorithmic randomness, such as jump-traceability, K-trivials, anti-complex sets, etc. Here a set A is anti-complex if and only if it is reducible to another set B with the use function for reducing A to B growing arbitrarily slowly. A result of Franklin, Greenberg, Stephan and Wu shows that A is anti-complex iff the wtt degree of A is c.e. Traceable iff A is weak truth table reducible to a Schnorr trivial set.

► HIROAKIRA ONO, *Algebraic perspective on nonclassical logics*.
Japan Advanced Institute of Science & Technology, Asahidai, Nomi, Ishikawa 923-1292, Japan.
E-mail: ono@jaist.ac.jp.

Algebraic view on logic, in particular on nonclassical logic, provides us with important and powerful techniques and also with deeper understanding of its semantics. Algebraic study has been done successfully to individual nonclassical propositional logics, like many-valued logics, superintuitionistic logics and modal logics. On the other hand, because of high generality of algebraic techniques, abstract algebraic logic, another branch of algebraic logic combined with the theory of universal algebra, has emerged in the middle of the last century. The development of algebraic study of substructural logics from the 1990s gave fresh impetus to algebraic approach to nonclassical logics. Substructural logics, which can be understood algebraically as logics satisfying the law of residuation, can cover a great deal of interesting nonclassical logics, e.g., Lukasiewicz's many-valued logics, superintuitionistic logics and relevant logics. Thus their algebraic study holds a right place for combining these two branches of algebraic logic. On the one hand, it will give a uniform view of a large class of nonclassical logics, and on the other hand it may offer interesting, concrete topics in abstract algebraic logic. In our talk we will give an overview of some of our recent works in algebraic study of substructural logics. Though we will focus on substructural logics, these results hold also for many other nonclassical logics. After a brief introduction to algebraic logic and universal algebra, rather an unexpected connection between proof theory and algebra will be mentioned. It was pointed out in [1] that there is a close relation between algebraic proof of cut elimination for a sequent system and the closure under MacNeille completions of the corresponding class of algebras. The direction has been developed much further by Ciabattoni–Galatos–Terui into algebraic proof theory. Then, connections between logical properties and algebraic properties will be discussed. In particular, based on the work [4], connections among several interpolation properties of a (non- commutative) substructural logic and several amalgamation properties of the corresponding variety of algebras will be explained in details. It is shown that algebraization theorem plays an important role in bridging between these two types of properties. Our third topic is to see how algebraic methods work well also for predicate logics. Certain limitations will be expected from the outset, since only finitary operations can be treated in algebra while quantifiers are interpreted as infinitary lattice operations in our semantics. Even so, it will be worthwhile to pursue this direction since any suitable and manageable semantics is not known for nonclassical predicate logics. Our research is still in an initial stage and is limited mostly to completeness problems with respect to algebraic semantics. Our algebraic semantics is given by using algebraic frames consisting of "complete" algebras and individual domains. Then the main issue of showing algebraic completeness of a given substructural predicate logic is to find a complete algebra into which the Lindenbaum algebra of a given logic can be "regularly" embedded. Some attempts to this problem will be explained in our talk, in connection with MacNeille completions, Crawley completions and Rasiowa–Sikorski lemma.

[1] F. Belardinelli, P. Jipsen and H. Ono, *Algebraic aspects of cut elimination*, ***Studia Logica***, vol. 77 (2004), pp. 209–240.

[2] N. Galatos and H. Ono, *Algebraization, parametrized local deduction theorem and interpolation for substructural logics over FL*, ***Studia Logica***, vol. 83 (2006), pp. 279–308.

[3] ———, *Cut elimination and strong sepration for substructural logics: an algebraic approach*, ***Annals of Pure and Applied Logic***, vol. 161 (2010), pp. 1097–1133.

[4] H. Kihara and H. Ono, *Interpolation properties, Beth definability properties and amalgamation properties for substructural logics*, ***Journal of Logic and Computation***, vol. 20 (2010), no. 4, pp. 823–875.

[5] H. Ono, *Algebraic logic*, ***Journal of Indian Council of Philosophical Research***, Special Issue on Logic and Philosophy Today Part-I, vol. 27 (2010), pp. 221–246.

► GRIGOR SARGSYAN, *The Solovay hierarchy*.
Rutgers University, 110 Frelinghuysen Road, Piscataway, NJ 08854-8019, USA.
E-mail: grigor@math.rutgers.edu.

It is a well-known and fascinating phenomenon that large cardinal hierarchy forms a consistency strength hierarchy in the sense that the consistency of any natural mathematical statement can be reduced to that of a large cardinal axiom. What makes the above interesting is that often times the above can be reversed. However, such reversals have only been worked out for a very small initial segment of large cardinal hierarchy. Recently the Solovay hierarchy, which is a determinacy hierarchy, has been used to establish many such reversals. These recent results can be viewed as part of a general program for establishing such reversals while using the Solovay hierarchy as an intermediary. In this talk, the speaker will give the details of this program.

► SIMON THOMAS, *The descriptive set theory of unitary group representations*.
Rutgers University, 110 Frelinghuysen Road, Piscataway, NJ 08854-8019, USA.
E-mail: sthomas@math.rutgers.edu.

In this tribute to Greg Hjorth, I will discuss some of his many fundamental contributions to the theory of Borel equivalence relations, focusing mainly on his work on the Borel complexity of the unitary equivalence relation for the irreducible unitary representations of countable discrete groups.

► AKITO TSUBOI, *Indiscernible trees*.
University of Tsukuba, Japan, 1-1-1 Tennodai, Tsukuba, Ibaraki 305-8577, Japan.
E-mail: tsuboi@math.tsukuba.ac.jp.

Let $O = (O, <)$ be a tree. Roughly speaking, $A = (a_\eta)_{\eta \in O}$ is called an indiscernible tree if whenever X and Y are subsets of O having a similar shape (as ordered sets), then the two sets $(a_\eta)_{\eta\in X}$ and $(a_\eta)_{\eta\in Y}$ have the same L-type. Let $\Gamma = \Gamma((x_\eta)_{\eta\in\omega^{<\omega}})$ denote a set of L-formulas with free variables from $(x_\eta)_{\eta\in\omega^{<\omega}}$. Under some homogeneity conditions on Γ, we prove that Γ is realized by an indiscernible tree. We apply our results to the study of unstable theories.

Abstracts of talks in the special session on Computability and Algebraic Structures

► URI ANDREWS, *Computability of strongly minimal groups*.
Department of Mathematics, University of Wisconsin, 513 Van Vleck Hall, Madison, WI 53706, USA.
E-mail: andrews@math.wisc.edu.

Model theory gives a characterization of modular strongly minimal expansions of groups as quasi-vector spaces over a division ring. By carefully considering this analysis in a computable way, we derive results about computable presentations of these structures and the complexity of their theories, answering questions in computable model theory. This more careful analysis requires a reworking of some tools from both model theory and basic linear algebra.

This is joint work with Alice Medvedev.

► MINGZHONG CAI, *A generalized high degree with the finite maximal chain property*.
Department of Mathematics, University of Wisconsin, 519 Van Vleck Hall, Madison, WI 53706, USA.
E-mail: mcai@math.wisc.edu.

We present some recent results on the connection between minimality and jump classes. We show that there is a generalized high (GH_1) degree, which is a minimal cover of a minimal degree, i.e., the top of a maximal chain of length 3. This result contrasts with a classical result by Jockusch and Posner that all minimal degrees are GL_2. GH_1 is also the highest jump class one can reach by finite iterations of minimality.

► ROD DOWNEY, *Big theorems from small minds*.
Victoria University of Wellington, PO Box 600, Wellington, New Zealand.
E-mail: rod.downey@vuw.ac.nz.

In this talk we will describe how we tried to solve a major open question and failed dismally, but proved enough not to be too boring, hopefully.

► DAMIR DZHAFAROV, *Computably enumerable partial orders*.
University of Notre Dame, Notre Dame, IN 46556, USA.
E-mail: damir.dzhafarov@gmail.com.

I will present recent joint work with Cholak, Schweber, and Shore on c.e. and co-c.e. partial orders. Such orders arise naturally in different contexts in computability theory. For example, the inclusion ordering on a uniformly computably family of sets (that may have repetition) is co-c.e. Although there are c.e. partial orders with no co-c.e. isomorphic copy and conversely, it is easy to see that the degree spectra of the two classes of orders coincide. We extend this to show that c.e. partial orders are in fact universal for $0'$-computable structures: for every structure of the latter kind (or indeed, for any structure of c.e. degree) there is a c.e. (or co-c.e.) partial order with the same degree spectrum, and of the same degree if the structure has c.e. degree. As a corollary, we obtain a new example of the Slaman–Wehner theorem that there is a structure with a copy in every nonzero degree. Specifically, it follows that such a structure can be found among the c.e. and co-c.e. partial orders in any nonzero c.e. degree.

► ASHER KACH, *Orders on computable torsion-free abelian groups*.
Department of Mathematics, The University of Chicago, 5734 University Avenue, Chicago, IL 60637, USA.
E-mail: asher.kach@gmail.com.

In this talk, we discuss the (Turing) degrees of bases of and degrees of orders on computable torsion-free abelian groups. After providing the requisite algebraic background, we will review known results and discuss new results. In particular, we show the set of degrees of orders need not be upward closed.

This is joint work with Karen Lange and Reed Solomon.

► JIAMOU LIU, *The isomorphism problem for automatic structures with some transitive relations*.
School of Computing and Mathematical Sciences, Auckland University of Technology, Private Bag 92006, Auckland 1142, New Zealand.
E-mail: jiamou.liu@aut.ac.nz.
E-mail: liujiamou@gmail.com.

Automatic structures are finitely presented structures where the universe and all relations can be recognized by finite automata. It is known that the isomorphism problem for automatic structures is complete for Σ^1_1, the first existential level of the analytical hierarchy.

Positive results on ordinals and on Boolean algebras raised hope that the isomorphism problem is simpler for transitive relations. In this talk, I will prove that this is not the case. More precisely, I will discuss the following results:

1. The isomorphism problem for automatic equivalence relations is complete for Π^0_1. 2. The isomorphism problem for automatic order trees is Σ^1_1-complete. 3. The isomorphism problem for automatic linear orders is Σ^1_1-complete.

This is joint work with Markus Lohrey and Dietrich Kuske.

► ALEXANDER MELNIKOV, *Interactions of computability and effective group theory*.
University of Auckland, Private Bag 92019, Auckland 1142, New Zealand.
E-mail: vokinlem@bk.ru.

The study of computably-theoretic problems in group theory was initiated by Rabin and Mal'cev in 1960's. It has become clear that new computability-theoretic concepts are needed to capture computability-theoretic properties of groups [3], [4]. Furthermore, in the recent years the computably theoretic notion of limitwise monotonicity, which originally was introduced to study computable abelian groups [3], has proved to be important in other fields of computability theory (see, e.g., [1] and [2]).

In our recent work we study Δ^0_n categoricity of computable abelian groups of the form $\oplus_{i\in\omega}\mathrm{H}$, where H is a subgroup of $(\mathrm{Q}, +)$, for $n > 1$. We introduce a new algebraic notion of S-independence which is a generalization of the classical notion of p-independence. We develop the theory of S-independent sets. We apply these techniques to show that every homogeneous completely decomposable group is Δ^0_3-categorical. We prove that a homogeneous completely decomposable group of infinite rank is Δ^0_2-categorical if and only if it is isomorphic to the free module over the localization of Z by a computably enumerable set of primes P with the semi-low complement (within the set of all primes). We introduce a new computability-theoretic concept of computable setting time which seems to be crucial for the proof. We expect that this concept may be applied outside computable group theory.

[1] R. Downey and A. Kach, and D. Turetsky, *Limitwise monotonic functions and applications*, ***Proceedings of the Asian Logic Conference***, to appear.

[2] I. Kalimullin, B. Khoussainov, and A. Melnikov, *Limitwise monotonic sequences and degree spectra of structures*, to appear.

[3] N. Khisamiev, *Constructive abelian groups*, ***Handbook of recursive mathematics, Volume 2***, Studies in Logic and the Foundations of Mathematics, vol. 139, North-Holland, Amsterdam, 1998, pp. 1177–1231.

[4] ———, *On a class of strongly decomposable abelian groups*, ***Algebra Logika***, vol. 41 (2002), no. 4, pp. 493–509, 511–512.

► JENNIFER CHUBB REIMANN, *Distances on graphs and other approximable functions*.
University of San Francisco, 2130 Fulton Street, San Francisco, CA 94117, USA.
E-mail: jennifer.chubb@usfca.edu.
E-mail: jcchubb@usfca.edu.

We investigate algorithmic properties of functions that can be approximated by computable functions by adapting strong reducibilities (refinements of Turing reducibility) for sets to corresponding reducibilities for functions. We describe an Ershov-type hierarchy for these functions and study them in that context.

Our main focus is on the properties of functions having non-increasing computable approximations. One natural example of such a function is the distance function of a given computable connected graph, and we will give special attention to this case.

This is joint work with Wesley Calvert and Russell Miller.

► DANIEL TURETSKY, *Computably categorical structures*.
Victoria University of Wellington, PO Box 600, Wellington 6012, New Zealand.
E-mail: dan@msor.vuw.ac.nz.

This talk will cover several recent results on computably categorical structures and the relationship of computable categoricity to relative computable categoricity. In particular, the construction of a computably categorical structure, which is not relatively arithmetically categorical, will be sketched.

Abstracts of talks in the special session on Logical Aspects of Graphs and Matroids

► MICHAEL FELLOWS, *Constructive and non-constructive aspects of WQOs*.
School of Engineering and IT, Charles Darwin University, Darwin, NT 0909, Australia.
E-mail: michael.fellows@cdu.edu.au.

The talk will survey constructivity issues for computational complexity results based on well quasi ordering. In particular, some recent developments will be described, including a novel operator on lower ideals that seems to be highly nonconstructive.

This is joint work with Frances Rosamond and Danny Hermelin.

► JOHANN MAKOWSKY, *Why shall we study graph polynomials*?
Faculty of Computer Science, Israel Institute of Technology, Technion, Haifa 32000, Israel.
E-mail: janos@cs.technion.ac.il.

We survey recent progress in the study of graph polynomials. We concentrate on dichotomy theorems for the complexity of evaluations of graph polynomials, and discuss recent progress on the difficult point conjecture for graph polynomials formulated by the author five years ago. The difficult point conjecture is a natural generalization of the Theorem by Jaeger, Vertigan and Welsh characterizing the complexity of evaluations of the Tutte polynomial.

► DILLON MAYHEW, *A hierarchy of matroid descriptions*.
Victoria University of Wellington, PO Box 600, Wellington 6012, New Zealand.
E-mail: dillon.mayhew@msor.vuw.ac.nz.

There are numerous ways we can describe a matroid by listing subsets. We can list independent sets, bases, circuits, hyperplanes, and so on. These different choices can lead to radical differences in the complexity of computational problems. For example, some problems are NP- complete if the description consists of a list of circuits, but can be solved in polynomial-time if the description is a list of bases.

These considerations lead to the following definitions. A matroid description is an injective function from the set of all matroids to the set of binary strings. If f and g are descriptions, we say that f is below g if there is a polynomial-time Turing machine which, given the input $f(M)$, produces the output $g(M)$, for any matroid M. In this talk we will discuss properties of this ordering on the set of matroid descriptions.

This is joint work with Michael Snook.

► MIKE NEWMAN, *Axiomatic descriptions of real-representable matroids*.
Department of Mathematics and Statistics, University of Ottawa, 585 King Edward, Ottawa, Ontario K1N 6N5, Canada.
E-mail: mnewman@uottawa.ca.

Matroids are defined axiomatically, in a way that can be thought of as generalizing finite point sets of vector spaces. Whitney asked whether it was possible to give a similar description of real-representable matroids. Vamos gave a negative answer of sorts to this question, in that he showed that no finite set of first order axioms could characterize real-representable matroids. However this didn't really settle the question, since an infinite number of such axioms are required to characterize matroids.

We consider second order axioms more natural for matroid theorists, and in fact show that these are not sufficient to characterize real-representable matroids. This gives an extreme contrast with Rota's conjecture, which would imply that such a characterization is possible for matroids representable over a finite field.

This is joint work with Dillon Mayhew and Geoff Whittle.

► GEOFF WHITTLE, *Fractal classes of matroids*.
Victoria University of Wellington, PO Box 600, Wellington 6012, New Zealand.
E-mail: geoff.whittle@msor.vuw.ac.nz.
E-mail: geoff.whittle@vuw.ac.nz.

A natural way to characterise a minor-closed class of matroids $\mathcal{M}$ is to find the set of matroids that are minor-minimal with respect to not belonging to $\mathcal{M}$, that is, via the set of *excluded minors* for $\mathcal{M}$. Rota famously conjectured that if $\mathcal{M}$ is the set of matroids representable over a fixed finite field, then the set of excluded minors for $\mathcal{M}$ is finite.

Consider the most extreme alternative behaviour. A class of matroids is *fractal* if as n tends to infinity, the number of n-element excluded minors fro $\mathcal{M}$ becomes larger than the number of n-element matroids that belong to $\mathcal{M}$. Perhaps surprisingly fractal classes exist. Indeed, in contrast to Rota's Conjecture we conjecture that the class of matroids representable over an infinite field is fractal. This work was motivated by work on the axiomatic characterisation of matroids representable over infinite fields.

Abstracts of talks in the invited special session on Modal Logic

► MAX CRESSWELL, *Topics in the pre-history of possible-worlds semantics*.
Victoria University of Wellington, PO Box 600, Wellington 6012, New Zealand.
E-mail: max.cresswell@vuw.ac.nz.

Carnap's 1946 semantics for S5 modal logic depends on the claim that $\Box$ A is true iff A is L-true, i.e., valid. I investigate some problems with this definition, and then look at J. C. C. McKinsey's 'syntactical' account of validity for a modal logic between S4 and S5. Finally I consider the relation between these early attempts, and work in the late 1950s by Kanger, Hintikka and Kripke, which led to the development of the current possible worlds semantics for modal logic.

► ROB GOLDBLATT, *Program equivalence is highly undecidable in dynamic logic*.
Victoria University of Wellington, PO Box 600, Wellington 6012, New Zealand.
E-mail: rob.goldblatt@msor.vuw.ac.nz.

Propositional Dynamic Logic (PDL) is a multimodal logic designed to formalize reasoning about the behavior of computer programs and other state-based transition systems. We enrich the language of PDL by adding formulas expressing the equivalence of pairs of programs, where two programs are considered to be equivalent if they induce the same input/output relation between states.

We show that the set of valid formulas of this extended system is not computably enumerable, and so is not effectively axiomatizable. In fact the validity problem is 'highly undecidable' in the sense of lying beyond the arithmetical hierarchy of problems definable in first-order arithmetic.

The proof involves the following tiling problem: can a given finite set of dominoes tile the first quadrant of the plane in such a way that a specific type of domino recurs infinitely often on the diagonal? This problem is highly undecidable, by reduction from the known highly undecidable problem of whether a nondeterministic Turing machine started on a one-way infinite blank tape has a computation that returns infinitely often to its start state. The tiling problem itself can be reduced to the satisfiability problem of our logic.

The high undecidability result holds for any version of dynamic logic that can express composition of programs, while-commands and equivalence of a program to the 'skip' program that does nothing.

This is joint work with Marcel Jackson.

► IAN HODKINSON, *Sahlqvist formulas in the modal mu-calculus*.
Department of Computing, Imperial College London, South Kensington Campus, London SW7 2AZ, UK.
E-mail: `i.hodkinson@imperial.ac.uk`.

Sahlqvist's completeness and correspondence theorems have long been important tools in the modal logician's bag. Sahlqvist formulas are a syntactically defined subset of modal formulas that is large enough to include many common modal axioms. Any Sahlqvist formula S has a frame correspondent—a first-order sentence expressing the validity of S over a Kripke frame; moreover, the normal modal logic axiomatised by S is sound and complete for the class of frames satisfying the correspondent. I will report on recent joint work with Johan van Benthem and Nick Bezhanishvili, in which we try to extend Sahlqvist's theorems to the modal mu-calculus.

► EDWIN MARES, *The converse of deducibility*.
Victoria University of Wellington, PO Box 600, Wellington 6012, New Zealand.
E-mail: `Edwin.Mares@vuw.ac.nz`.

One of the original motivations for the development of modern modal logic was to represent deducibity within a logical system. This paper looks at the historical importance of this, through the debate between C. I. Lewis and Bertrand Russell and the (in)adequacy of Lewis's preferred systems with regard to this task.

► GREG RESTALL, *Logical constants, sequent structures and speech acts: The case of modal operators*.
School of Historical and Philosophical Studies, The University of Melbourne, Parkville Victoria 3010, Australia.
E-mail: `restall@unimelb.edu.au`.

In this talk I will consider the connections between the logicality of elements of the vocabulary of an object language, the structural features available in a proof system for a logic, and the different ways those structures can be connected to kinds of speech acts (such as assertion and denial), structural features of speech acts (including substitution and other transformations) and transitions between speech acts (such as the making of different kinds of suppositions). The focus of my attention will be the hypersequent calculus for the two-dimensional modal logic of Humberstone and Davies, and I will consider the different ways that kinds of modal operators could be taken to be either logical or non-logical parts of our vocabulary, depending on what features of our structures of our discourse we hold constant.

► ADRIANE RINI, *No scope for Aristotle*.
Massey University, Turitea Site, Sir Geoffrey Peren Building, Manawatu Campus, Palmerston North, New Zealand.
E-mail: `a.rini@massey.ac.nz`.

There are many phenomena in logic that we study by different placement of the same sentential operator—e.g., the negation operator and the necessity operator. This can only work in conjunction with complex propositions. Aristotle has only simple categorical propositions, and so he cannot have sentential operators with scope. He is, however, aware of a lot of the distinctions that we make with scope. Since he didn't have sentential operators he developed methods in order to make these distinctions. This paper goes through the mechanisms Aristotle uses . . . , and shows how they work and how they sometimes lead him astray.

► JEREMY SELIGMAN AND PATRICK GIRARD, *Ceteris paribus: A flexible approach*.
University of Auckland, Private Bag 92019, Auckland 1142, New Zealand.
E-mail: j.seligman@auckland.ac.nz.
E-mail: p.girard@auckland.ac.nz.

Ceteris parisbus clauses in reasoning are used to allow for defeaters of norms, rules or laws, such as in von Wright (1963)'s example "I prefer my raincoat over my umbrella, everything else being equal". In recent work by Girard, Roy and van Benthem (2008), a logical analysis is offered in which sets of formulas Γ, embedded in modal operators, provide necessary and sufficient conditions for things to be equal in ceteris parisbus clauses. They formulate this as the modal logic $L_c p$. For most laws, the set of things allowed to vary is small, often finite, and so Γ is typically infinite. Yet the axiomatisation they provide is restricted to the special and atypical case in which Γ is finite.

We address this problem by being more flexible about ceteris paribus conditions, in two ways. The first is to offer an alternative, slightly more general semantics, in which the set of formulas are, only give necessary but not (necessarily) sufficient conditions. This permits a simple axiomatisation.

The second is to consider those sets of formulas which are sufficiently flexible to allow the construction of a satisfying model in which the stronger necessary-and-sufficient interpretation of $L_c p$ is maintained.

Abstracts of talks in the special session on Randomness

► LAURENT BIENVENU, *Von Neumann's biased coin revisited*.
LIAFA, Université Paris Diderot, Paris 7 – Case 7014, 75205 Paris Cedex 13, France.
E-mail: laurent.bienvenu@liafa.jussieu.fr.

Suppose you want to generate a random sequence of zeros and ones, but all you have at your disposal is a coin, which you suspect to be biased (but do not know the bias). Can "perfect" randomness be produced with this coin? The answer is positive, thanks to a little trick discovered by von Neumann. In this talk, we investigate a generalization of this question: if we have access to a source of bits produced according to some probability measure M in some class C of measures, and suppose we know C but not M (in the above example, C would be the class of all Bernoulli measures), can perfect randomness be produced? We will look at this question in terms of algorithmic randomness, and give a positive answer for a wide variety of classes of measures. We will also explain the connections between our work and Kjos-Hanssen's concept of Hippocratic randomness.

This is joint work with Benoit Monin.

► CRISTIAN S. CALUDE, *How random is quantum randomness*?
University of Auckland, Private Bag 92019, Auckland 1142, New Zealand.
E-mail: cristian@cs.auckland.ac.nz.

Quantum randomness, probably the best natural form of randomness, has been hailed as the "true randomness". In this talk we will use AIT to discuss some recent results and open questions regarding the nature and quality of quantum randomness.

► ADAM DAY, *A random Turing degree*.
University of California at Berkeley, 110 Sproul Hall # 5800, Berkeley, CA 94720-5800, USA.
E-mail: adam.r.day@gmail.com.
E-mail: adam.day@math.berkeley.edu.

The theory of algorithmic randomness provides a means of defining when a subset of the natural numbers is random. This definition can be carried over to the Turing degrees by defining a Turing degree as random if it contains a random set. In this talk we will examine the properties a random Turing degree, focusing on those Turing degrees that contain a 2-random set.

One surprising fact is that a number of properties of such a degree are shared by all non-zero degrees below it. We will outline why every non-computable set below a 2-random set computes a 1-generic set (an extension of a result of Kurtz). We will explain why similar techniques can be used to prove that all degrees below a 2-random degree have the join property and related results.

This is joint work with George Barmpalias and Andy Lewis.

► DAVID DIAMONDSTONE, *Inherent enumerability of strong jump-traceability*.
Victoria University of Wellington, PO Box 600, Wellington 6012, New Zealand.
E-mail: david.diamondstone@msor.vuw.ac.nz.
E-mail: ddiamondstone@gmail.com.

This talk will present a recent result that every strongly jump-traceable real is below a c.e. Strongly jump-traceable real, discussing some of the history of jump-traceability. The main technique here is "box promotion." I will present the technique and discuss the difficulty in applying the technique to a non-c.e. oracle, and the key idea we use to resolve this difficulty in our proof that strong jump-traceability (like K-triviality) is an inherently enumerable property. This result has a number of interesting consequences, such as showing that strong jump-traceability and strong superlowness coincide, and every strongly jump-traceable real obeys every benign cost function.

This is joint work with Noam Greenberg and Dan Turetsky.

► WILLEM FOUCHE, *Martin-Löf randomness, invariant measures and countable homogeneous structures*.
University of South Africa, Preller Street, Muckleneuk, Pretoria, PO Box 392, South Africa.
E-mail: fouchwl@gmail.com.

We use ideas from topological dynamics (amenability), combinatorics (structural Ramsey theory) and model theory (Fraïssé limits) to study closed amenable subgroups G of the symmetric group S_∞ of a countable set, where S_∞ has the topology of pointwise convergence. We construct G-invariant measures on the universal minimal flows associated with these groups G in, moreover, an algorithmic manner. This leads to an identification of the generic elements, in the sense of being Martin-Löf random, of these flows with respect to the constructed invariant measures. Along these lines we study the random elements of S_∞, which are permutations that transform recursively presented universal structures into such structures which are Martin-Löf random.

► CAMERON FREER, *Aspects of randomness in analysis, graph theory, and probability theory*.
University of Hawaii, 32 Vassar Street, Cambridge, MA 02139, USA.
E-mail: freer@math.hawaii.edu.,
E-mail: freer@math.mit.edu.

We describe three projects in computable analysis, the model theory of graphs, and computable probability theory, highlighting their connections to algorithmic randomness. In joint work with Kjos-Hanssen and Nies, we characterize Schnorr and computable randomness in terms of the sets of differentiability for computable Lipschitz functions and functions computable in the variation norm, extending a program of Demuth and Brattka–Miller–Nies. We also discuss joint work with Ackerman and Patel characterizing countable structures admitting probability measures invariant under the logic action, extending work of Petrov-Vershik. We highlight the interplay between measure and category, and the connection to algorithmic randomness via work of Fouche. Finally, we discuss joint work with Ackerman and Roy on the computability of conditional distributions, and its relationship to algorithmic randomness with respect to non-uniform measures via work of Bienvenu–Hoyrup–Shen.

► RUPERT HÖLZL, *The Denjoy alternative for computable functions*.
LIAFA, 175 rue du Chevaleret, 75013 Paris, France.
E-mail: r@hoelzl.fr.

The Denjoy–Young–Saks Theorem from classical analysis states that for an arbitrary function $f\colon \mathbb{R} \to \mathbb{R}$, the Denjoy alternative holds outside a null set. This means that for almost every real x, either the derivative of f exists at x, or the derivative fails to exist in the worst possible way. Algorithmic randomness allows us to define randomness notions giving rise to different concepts of *almost everywhere*. It is then natural to wonder which of these concepts corresponds to the *almost everywhere* notion appearing in the Denjoy–Young–Saks theorem. To answer this question Demuth investigated effective versions of the theorem. In one of these versions the function f is Markov computable. For this version, Demuth introduced a strong notion of randomness (stronger for example than Martin-Löf randomness) now known as Demuth randomness, which he proved to be sufficient to satisfy the Denjoy alternative for all Markov computable functions. In this paper, we in turn investigate these two effective theorems. We show that the set of points that fulfil the Denjoy alternative for Markov computable functions is strictly bigger than the set of Demuth random reals showing that Demuth's sufficient condition was too strong and moreover is incomparable with Martin-Löf randomness.

This is joint work with L. Bienvenu, R. Hölzl, J. Miller, A. Nies.

► KENSHI MIYABE, *Characterization of Kurtz randomness by a differentiation theorem*.
Kyoto University, Kitashirakawa-Oiwakecho, Sakyo-ku, Kyoto 606-8502, Japan.
E-mail: kmiyabe@kurims.kyoto-u.ac.jp.

Brattka, Miller and Nies showed that some major algorithmic randomness notions are characterized via differentiability. In this talk I explain that an integral test helps to understand the relation between randomness and differentiation. Then a characterization of Kurtz randomness by a differentiation theorem is given on a computable metric space. This is a version of Kurtz randomness of Brattka–Miller–Nies' result and it is not only a stronger form but also on a general space.

► SELWYN NG, *Generalizations of computable domination and effectively closed sets*.
School of Physical and Mathematical Sciences, Nanyang Technological University, 21 Nanyang Link, 637371, Singapore.
E-mail: kmng@ntu.edu.sg.

In this talk we discuss ways of generalizing computable domination. We show that there are uncountably many 2-computably dominated reals, while every 3-computably dominated real is computable.

This is joint work with Frank Stephan, Yang Yue and Yu Liang.

► ANDRE NIES, *Measuring the complexity of a Delta-2 set via its changes*.
University of Auckland, Private Bag 92019, Auckland 1142, New Zealand.
E-mail: andre@cs.auckland.ac.nz.

The Limit Lemma states that a Delta-2 set has a computable 0–1 valued approximation. We measure the complexity of such a set by quantifying the amount of changes in any such approximation. We will discuss three results.

Firstly we consider (Martin-Löf) random sets Z. By a result with Figueira, Hirschfeldt, Miller and Ng [1], there is a low random set with a computable approximation such that the initial segment of Z up to n changes $o(2^n)$ times. However, any superlow random set changes more than 2^n times.

Next we consider computably enumerable sets, where the amount of changes is measured through the strength of cost functions a computable enumeration can obey. We show that K-trivial sets can be characterized through a simple cost function where the price of changing

$A(x)$ at stage s is the increment of Chaitin's Omega from x to s.[2]

Finally we combine the two approaches. In [2] we show that, given a cost function c with the limit condition, each nonempty Pi-0-1 class contains a set Z such that each c.e. set A Turing below Z obeys c. Informally, the more Z is allowed to change, the less A can change.

(Refer to `http://www.cs.auckland.ac.nz/ nies/`):

[1] S. Figueira, D. Hirschfeldt, J. Miller, S. Ng, and A. Nies, *Counting the changes of random Δ_2 sets*, ***CiE 2010***, journal version to appear in ***Journal of Logic and Computation***.

[2] A. Nies, *Calculus of cost functions*, in preparation.

► JAN REIMANN, *Algorithmic independence and PA Degrees*.
Department of Mathematics, McAllister Building, Pennsylvania State University, University Park, PA 16802, USA.
E-mail: `reimann@math.psu.edu`.

We study the question of when two reals A, B are independent with respect to their mutual information. We interpret the question rather qualitatively and ask whether there exists a probability measure mu such that A and B are relatively mu-random. We prove a general version of Van Lambalgen's Theorem and use it reduce the question to randomness for product measures. We will exhibit rather strong obstacles for r.e. sets to be random for product measures, and apply it to obtain results on PA degrees.

This is joint work with Adam Day.

► JASON RUTE, *Computable randomness for arbitrary measure spaces*.
Department of Mathematical Sciences, Carnegie Mellon University, Pittsburgh, PA 15213, USA.
E-mail: `jrute@andrew.cmu.edu`.

On the Cantor space with the uniform measure, a sequence X is said to be computably random if no computable martingale succeeds on X. It is straightforward to extend this definition to the real interval [0, 1] and to other measures on the Cantor space, however it is less obvious how to do this for arbitrary computable measure spaces such as the vector space $[0, 1]^n$. We give such a definition for computable randomness on arbitrary computable measure spaces. We then show that this definition is robust in that it is equivalent to other definitions of computable randomness involving Martin-Löf tests, martingales, and isomorphism's. Particular subtleties arise when the measure has null open sets. Also, we will mention a new notion of randomness between Martin-Löf randomness and Kolmogorov–Loveland randomness (possibly equal to either) that is derived from measure-preserving transformations and computable randomness. This new notion encapsulates the most general notion of computable betting strategy.

Abstracts of talks in the special session on Set Theory

► JOERG BRENDLE, *Mad families constructed from perfect almost disjoint families*.
Kobe University, Rokko-dai 1-1, Nada, Kobe 657-8501, Japan.
E-mail: `brendle@kurt.scitec.kobe-u.ac.jp`.

A classical theorem of Mathias says that a maximal almost disjoint (mad) family of subsets of the natural numbers ω cannot be analytic. In particular, if we define $\mathfrak{a}_{\text{closed}}$ to be the least size of an infinite family of closed almost disjoint (a.d.) families whose union is mad, then $\mathfrak{a}_{\text{closed}}$ must be uncountable. On the other hand, $\mathfrak{a}_{\text{closed}}$ is bounded above by the almost disjointness number $\mathfrak{a}$, the smallest cardinality of an infinite mad family. A natural question is whether $\mathfrak{a}_{\text{closed}}$ and $\mathfrak{a}$ can be distinct. In joint work with Yurii Khomskii (Amsterdam) we show this is possible. Namely, in the Hechler model, $\mathfrak{b} > \mathfrak{a}_{\text{closed}}$ (and, a fortiori, $\mathfrak{a} > \mathfrak{a}_{\text{closed}}$) holds.

Using Hechler forcing over the constructible universe L we infer that the existence of a $\mathbf{\Sigma}^1_2$ mad family is consistent with $\mathfrak{b} > \aleph_1$. This answers a question of Friedman and Zdomskyy.

► SU GAO, *Colorings on countable groups*.
Department of Mathematics, University of North Texas, 1155 Union Circle #311430, Denton, TX 76203-5017, USA.
E-mail: `sgao@unt.edu`.

I will talk about the notion of 2-colorings on countable groups and its connection with the study of free Bernoulli subflows. I will also talk about some variations of the notion and give a survey of the results about these variations.

► NOAM GREENBERG, *Computable linear orderings of size* $\aleph_1$.
Victoria University of Wellington, PO Box 600, Wellington 6012, New Zealand.
E-mail: `noam.greenberg@msor.vuw.ac.nz`.
E-mail: `der.erlkoenig@gmail.com`.

The theory of admissible computability allows us to extend effective considerations of models to uncountable objects. We focus on linear orderings of the least uncountable cardinality. While some effective properties of countable linear orderings carry over to the uncountable case, often we see contrasting behaviour, for example regarding degree spectra. This is often due to the fundamental difference between “truly finite” and its infinite analogue, but not always. Our main result is a characterisation of computable categoricity for linear orderings. This generalises the Remmel–Dzgoev theorem and sheds new light on the countable case. We also consider degree spectra of the successor relation.

This is joint work with Dan Turetsky, Asher Kach and Steffen Lempp.

► FENG QI, *On the inner model problem for a supercompact cardinal*.
Department of Mathematics, National University of Singapore, Block S17,10, Lower Kent Ridge Road, 119076, Singapore.
E-mail: `matfengq@nus.edu.sg`.

I shall discuss some progress in trying to solve the problem by showing a possible construction of an inner model of κ^{+n}-supercompact using subextenders under an iteration hypothesis.

This is joint work with Hugh Woodin.

Abstracts of contributed papers

► LIBOR BEHOUNEK, *Naive set theory over the logic IMTL*.
Academy of Sciences of the Czech Republic, Pod Vodarenskou vezi 2, Prague 8, 182 07, Czech Republic.
E-mail: `behounek@cs.cas.cz`.

Hajek and Yatabe recently published several papers on naive set theory over infinite-valued Lukasiewicz logic. However, the consistency status of the theory is uncertain, since Terui (personal communication, 2010) has found a serious gap in White’s 1979 consistency proof. The consistency of naive comprehension can nevertheless be established (Terui, personal communication, 2011) for the (slightly weaker) logic IMTL, i.e., the extension of affine linear logic without exponentials by the prelinearity axiom ((A implies B) plus (B implies A)). It is therefore of importance to investigate which of Hajek’s and Yatabe’s results can be reconstructed in (or modified for) naive set theory over the weaker logic. The talk will present the current state of this investigation.

The main difficulty in transferring Hajek’s and Yatabe’s theorems from Lukasiewicz logic to IMTL stems from the fact that the proof of bivalence of the Leibniz identity of sets does not work in the weaker logic. Besides other results, I will show how the difficulty can be circumvented for some of the theorems by using weaker properties of Leibniz identity that are still provable in IMTL.

► MARTIN BUNDER, *The simplest foundation for logic and mathematics*.
Mathematics & Applied Statistics (SMAS), University of Woolengong, Wollongong NSW 2522, Australia.
E-mail: mbunder@uow.edu.au.

The usual foundations for mathematics has variables, constants, functions, predicates, terms and well formed formulas formed by formation rules and then axioms and rules of inference. The SKΞ Logic outlined in this talk requires only these three constants, one formation rule and the predicates $\vdash$ and $=$ (combinatory equality). In addition to the postulates for $=$, three simple axioms and four rules lead to an intuitionistic logic of arbitrarily high order as well as much of set theory and arithmetic. The addition of a few more axioms is enough to give the remaining Peano axioms, full set theory and even category theory. Two of these rules may even be replaceable by further axioms.

► BRUCE BURDICK, *A topological game with set-theoretic consequences*.
Mathematics Department, Roger Williams University, 1 Old Ferry Road, Bristol, RI 02809, USA.
E-mail: bburdick@rwu.edu.
E-mail: bruce1729@cox.net.

We investigate a game played on a topological space, which is motivated by the uniform property of cofinal completeness. The game can be used to characterize the existence of a compatible cofinally complete metric in the case of metrizable spaces.

The game is played on a topological space X with an ordinal κ given. For $\iota < \kappa$, the ιth turn of the game consists of the first player choosing a point $x_\iota \in X$, then the second player chooses a neighborhood O_ι of x_ι, then the first player chooses a filter on O_ι.

The second player wins the game at any turn if there exists a point in the space such that for every neighborhood of that point, there is some filter that the first player has chosen that is compatible with it. The first player wins if the play reaches order type κ without the second player winning.

The motivation for the game is the following. Suppose X admits a cofinally complete uniformity with a basis of cardinality less than or equal to the cardinality of κ. Then the second player has a winning strategy.

For metrizable spaces, with $\kappa = \omega$, the game is determined, and characterizes the existence of a cofinally complete metric.

A side effect is that this game has several set-theoretic consequences. Among these is the following: Let κ be a regular uncountable cardinal and let X_κ be the space ${}^\kappa 2$ with the κ-product topology. Then the second player has a winning strategy for the game played on space X_κ with ordinal κ iff κ is weakly compact.

► JOHN CASE, *Tutorial example of a self-learning class witnessing the power of data counters*.
Department of Computer and Information Sciences, University of Delaware, Newark, DE 19716, USA.
E-mail: case@mail.eecis.udel.edu.

This talk is within the domain of computability-theoretic learning theory [6]. It involves the subdomain re learning (in the limit) programs/grammars/indices for c.e. Languages L from presentations/texts/enumerations of L (and from no explicit information about L). Many corresponding, sensible criteria of successful learning have been defined and compared for relative learning power. Many times self-referential techniques have been employed to obtain results that one criterion admits learning classes of languages another does not. The talk will carefully define, motivate and compare in learning power two data-memory limited such criteria, where only one involves explicit access to a data counter. It will provide a nice example of a relatively new self-referential technique and its advantages over older such techniques. The self-learning class SC for a learning criterion C is based on a learner which runs (on C-relevant inputs) the numerical data elements seen in its input as if they were program indices and which uses their outputs if any as the learner's outputs. The corresponding self-learning class SC is, then, whatever is actually learned according to the learning criterion C by this seemingly irrational learner. It has been shown that, surprisingly, for other criteria C′: SC cannot be C′-learned if some class can be C-learned but not C′-learned [4, 3, 5]. The interest herein is in presenting a typical, not inordinately difficult self-learning class criteria-separation proof and, secondarily, in witnessing an advantage of data counters for learning. This proof will employ the Operator Recursion Theorem [1, 2]. If time permits, some motivated, seemingly difficult open problems will be sketched.

[1] J. Case, *Periodicity in generations of automata*, ***Mathematical Systems Theory***, vol. 8 (1974) pp. 15–32.

[2] ———, *Infinitary self-reference in learning theory*, ***Journal of Experimental and Theoretical Artificial Intelligence***, vol. 6 (1994), pp. 3–16.

[3] J. Case and T. Kötzing, *Solutions to open questions for non-U-shaped learning with memory limitations*, (M. Hutter et al., editors), ***21st International Conference on Algorithmic Learning Theory*** (***ALT'10***), Lecture Notes in Artificial Intelligence, vol. 6331, pp. 285–299, 2010.

[4] ———, *Strongly non U-shaped learning results by general techniques*, ***Proceedings of the 23rd Annual Conference on Learning Theory*** (***COLT 10***), Omnipress, 2010.

[5] ———, *Measuring learning complexity with criteria epitomizers*, ***STACS 2011***, (T. Schwentick and C. Dürr, editors), Leibniz International Proceedings in Informatics (LIPIcs), vol. 9, pp. 320–331, Schloss Dagstuhl–Leibniz-Zentrum für Informatik, Dagstuhl, Germany, 2011.

[6] S. Jain, D. Osherson, J. Royer, and A. Sharma, ***Systems that learn: An introduction to learning theory***, MIT Press, Cambridge, Massachusetts, second edition, 1999.

► JOHN CASE, *Non-obfuscated yet unprovable programs*.
Department of Computer and Information Sciences, University of Delaware, Newark, DE 19716, USA.
E-mail: `case@mail.eecis.udel.edu`.

The International Obfuscated C Code Contest (abbreviated IOCCC) was a programming contest for the most creatively obfuscated C code, held annually between 1984 and 1996, and thereafter in 1998, 2000, 2001, 2004, and 2006 (see `en.wikipedia.org/wiki/International Obfuscated C Code Contest`). In many cases, the winning programmer did something simple in such an obscure but succinct way that it was hard for other (human) programmers to see how his/her code actually worked.

By contrast, the interest herein is in programs which are in a sense easily seen to be correct, but which cannot be proved correct in preassigned, computably axiomatized, powerful, true theories T.

A sample theorem from the talk is below. Let $\varphi\mathrm{TM}$ be the very efficiently laid out and Gödel-numbered acceptable programming system (numbering) from [1] which is based on multi-tape Turing Machines (mtTMs). Let $\Phi\mathrm{TM}$ be the corresponding mtTM step-counting Blum Complexity Measure. For p a numerically named program in $\varphi\mathrm{TM}$, let $|p|$ = the minimal integer number of bits for storing p, i.e., the size of p. Let T be a computably axiomatized first order (fo) theory extending fo arithmetic and in which no sentence of fo arithmetic false in the standard model can be proved. T could be, for example, fo arithmetic or, perhaps, ZFC + ones favorite large cardinal axiom.

Theorem. *There exists computable g and small constants c, d such that, for any p,* $\mathrm{card}(D_{g(p)}) = 2$ *and there is a $q \in Dg(p)$ for which*: $\varphi\mathrm{TM}_q = \Phi\mathrm{TM}_p$; *for all x*, $\Phi\mathrm{TM}_q(x) \leq c \cdot (|p| + |x| + \Phi\mathrm{TM}_p(x))$; $|q| \leq d \cdot |p|$; *yet* $T \nvdash pqp\langle\langle \varphi\mathrm{TM}_q = \varphi\mathrm{TM}_p \rangle\rangle$.

As will be seen in the talk, the proof makes it quickly transparent that $\varphi_{\mathrm{TM}_q} = \varphi_{\mathrm{TM}_p}$. Hence, q is not obfuscated, yet its correctness (at computing φ_{TM_p}) is unprovable in T. From the time and program size p complexity content of the above theorem, q is nicely only slightly more complex than p. The question of whether one can make in the theorem above $\mathrm{card}(D_{g(p)}) = 1$ involves some mild but, perhaps, surprising subtleties.

This is joint work with Michael Ralston.

[1] J. Royer and J. Case, *Subrecursive programming systems: Complexity and succinctness*, ***Research monograph in Progress in Theoretical Computer Science***, Birkhäuser, Boston, 1994.

► YIJIA CHEN, *The parameterized complexity of k-edge induced subgraphs*.
Department of Computer Science and Engineering, Shanghai Jiao Tong University, Dongchuan Road, No. 800, 200240 Shanghai, China.
E-mail: `yijia.chen@cs.sjtu.edu.cn`.

We prove that finding a k-edge induced subgraph is fixed-parameter tractable, thereby answering an open problem of Leizhen Cai. Our algorithm is based on several combinatorial observations, Gauss' famous *Eureka* theorem, and a generalization of the well-known fpt-algorithm for the model-checking problem for first-order logic on graphs with locally bounded tree-width due to Frick and Grohe. On the other hand, we show that two natural counting versions of the problem are hard. Hence, the k-edge induced subgraph problem is one of the rare known examples in parameterized complexity that are easy for decision while hard for counting.

This is joint work with Bingkai Lin.

► PETR CINTULA, *Almost (MP)-based logics*.
Institute of Computer Science, Academy of Sciences of the Czech Republic, Pod Vodárenskou věží 2, 182 07 Prague 8, Czech Republic.
E-mail: `cintula@cs.cas.cz`.

This talk (based on joint work with C. Noguera) is a contribution to the theory of logical consequence (in the sense of Tarski). A logic is *almost* (MP)-*based* w.r.t. a set of *basic deduction terms* bDT if it is axiomatizable with modus ponens as the only binary deduction rule and unary rules of a form $v \vdash \varphi(v)$ for $\varphi \in$ bDT. This definition covers the most of (global) modal logics (e.g., K, S4, S5), the prominent substructural logics [2] (e.g., FL, FL_e, FL_{ew}), many-valued logics (e.g., Łukasiewicz or Gödel–Dummett), and many others.

We show that almost (MP)-based logics enjoy a particular form of Local Deduction Theorem:

$$T, \varphi \vdash \psi \quad \text{iff} \quad T \vdash \chi(\varphi) \to \psi \text{ for some } \chi \in \mathrm{DT},$$

where the set DT is determined by bDT. This provides an alternative (abstract) proof of the well-known deduction theorems for the particular logics mentioned above. Furthermore, we also prove the converse: each logic enjoying such form of deduction theorem is almost (MP)-based.

Then we deal with the Proof by Cases Property (PCP) (from $\Gamma, \varphi \vdash \chi$ and $\Gamma, \psi \vdash \chi$ infer $\Gamma, \varphi \vee \psi \vdash \chi$) which is known to fail, e.g., in K, S4, S5, FL, FL_e. We show that a generalized 'disjunction' (as studied, e.g., in [1]) can be built using bDT of a given logic to obtain a variant of PCP.

$$\frac{\Gamma, \varphi \vdash \chi \qquad\qquad \Gamma, \psi \vdash \chi}{\Gamma \cup \{\alpha(\varphi) \vee \beta(\psi) \mid \alpha, \beta \in \mathrm{bDT}^*\} \vdash \chi}$$

[1] J. Czelakowski, ***Protoalgebraic logics***, Kluwer, 2001.

[2] N. Galatos, P. Jipsen, T. Kowalski, and H. Ono, ***Residuated lattices: An algebraic glimpse at substructural logics***, Elsevier, 2007.

► JAMES DENT, *An introduction to constructive reverse mathematics*.
University of Canterbury, PO Box Private Bag 4800, Christchurch, New Zealand.
E-mail: semajdent@gmail.com.

Constructive reverse mathematics (CRM) is a project in which non- and semi-constructive principles are classified in accordance with which other principles they imply or are implied by, relative to the system of Bishop-style constructive mathematics. Of particular interest are the various versions of Brouwer's fan theorem and several antitheses of Specker's theorem (a characteristic result of Russian recursive mathematics): principles that belong in the hierarchy of fan theorems are semi-constructive in the sense that they are intuitionistically valid, and a result of Berger and Bridges shows that this is also true of the so-called anti-Specker properties.

We give an exposition of the current state of the CRM programme, showing how these principles are related to one another, and framing the scope for further investigation particularly of certain principles at the weaker end of the spectrum.

► SHIGUANG FENG, *Complexity and expressive power of second-order extended Horn logic*.
Department of Philosophy, Sun Yat-sen University, 135 Xin'gang Xi Road, Guangzhou, 510275, China.
E-mail: shig.feng@gmail.com.

In this paper we introduce SO-HORN^r, an revised version of SO-HORN and show that SO-HORN^r captures Ptime on ordered finite structures. We also introduce Second-Order extended HORN logic (SO-EHORN) and revised Second-Order extended HORN logic (SO-EHORN^r). We show that SO-EHORN^r captures co-NP and SO-EHORN and SO-EHORN^r coincide on ordered finite structures. We also show that every SO-EHORN^r formula is equivalent to a Π^1_2-EHORN^r formula.

► NIR FRESCO, *What is information processing*?
University of New South Wales, Sydney, NSW 2052, Australia.
E-mail: fresco.nir@gmail.com.

It is often claimed, specifically in cognitive science discourse, that digital computing systems can freely be described as information processing systems. This claim is not limited to symbolic computation, but also to other (arguably computing) systems such as discrete neural networks. Still, when 'information' comes under scrutiny, this claim becomes less obvious. Two quantitative readings of information are examined in this paper, namely Shannon Information and Algorithmic Information. Arguably, any plausible account of concrete digital computation (i.e., digital computation as it is actualised in physical systems) has to be capable of explaining Turing computability. But the explanatory power of processing Shannon Information concerning Turing computability is very limited. The processing of Algorithmic Information is better suited to explain Turing computability, if one adopts some variation on Algorithmic Information theory. This variation is the substitution of the universal Turing machine with finite state transducers as a means of measuring the length of optimal algorithms for producing certain strings. Nevertheless, even with this proposed variation, a characterisation of concrete digital computation in terms of processing Algorithmic Information faces problems.

► SAKAE FUCHINO, *On reflection of countable list chromatic number of graphs*.
Kobe University, Rokko-dai 1-1, Nada, Kobe 657-8501, Japan.
E-mail: fuchino@diamond.kobe-u.ac.jp.

For a graph $G = \langle G, E\rangle$, let us denote with $\mathrm{Chr}(G)$, $\mathrm{List}(G)$ and $\mathrm{Col}(G)$ the chromatic number, the list chromatic number and the coloring number of G, respectively. We have $\mathrm{Chr}(G) \leqq \mathrm{List}(G) \leqq \mathrm{Col}(G)$ but these numbers can be quite different for some finite and infinite graphs.

For infinite graphs, let us consider the following reflection property where xxx is either 'Chr', 'List' or 'Col'. Refl(xxx): For any graph G, if $xxx(G') = \aleph_0$ for all subgraph G' of G of cardinality $\leqq \aleph_1$, then we also have $xxx(G) = \aleph_0$. Refl(Col) is known to be consistent over ZFC (under some large cardinal). Actually Refl(Col) is shown to be equivalent to the so called Fodor-type Reflection Principle (FRP) introduced in [2] over ZFC (see [4]). Refl(Chr) is known to be inconsistent ([1]).

Applying a recent result by Péter Komjáth on list chromatic number, we could show the following:

THEOREM (S. F. and Hiroshi Sakai, in preparation). (1) *FRP* $+$ *MA*(*Cohen*) $+ \neg$*CH implies* $\neg$*Refl*(*List*). (2) *In the model obtained by Levy collapsing a strongly compact* κ *to* $\aleph_2$, *we have FRP* $+$ *Refl*(*List*).

I will talk about these and some other related results.

[1] PAUL ERDÖS AND ANDRÁS HAJNAL, *On chromatic number of graphs and setsystems*, ***Acta Mathematica Academiae Scientiarum Hungaricae***, vol. 17 (1966), no. 1–2, pp. 61–99.

[2] SAKAÉ FUCHINO, ISTVÁN JUHÁSZ, LAJOS SOUKUP, ZOLTÁN SZENTMIKLÓSSY AND TOSHIMICHI USUBA, *Fodor-type Reflection Principle and reflection of metrizability and meta-Lindelöfness*, ***Topology and Its Applications***, vol. 157 (2010), no. 8, pp. 1415–1429.

[3] SAKAÉ FUCHINO AND ASSAF RINOT, *Openly generated Boolean algebras and the Fodor-type Reflection Principle*, ***Fundamenta Mathematicae***, vol. 212 (2011), pp. 261–283.

[4] SAKAÉ FUCHINO, HIROSHI SAKAI, LAJOS SOUKUP AND TOSHIMICHI USUBA, *More about the Fodor-type Reflection Principle*, preprint.

► KOJIRO HIGUCHI, *Non-empty open intervals of the effectively closed Muchnik degrees*.
Tohoku University, PO Box Flower Height Aoyama 302 3-3 Keiwamachi, Taihaku, Sendai, Japan.
E-mail: `sa7m24@math.tohoku.ac.jp`.

The density of the effectively closed Muchnik degrees is a big open problem. In this talk, we give a partial result on the problem. For effectively closed Muchnik degrees p and q with $p < q$, we investigate a sufficient condition on p and q for the existence of a degree between them. We see many examples satisfying the sufficient condition.

► ZHU HUILING, *Distributive proper forcing axiom*.
Department of Mathematics, 10 Lower Kent Ridge Road, National University of Singapore, 119076, Singapore.
E-mail: `zhuhl02@gmail.com`.

DPFA is the forcing axiom for the class of proper forcing notions that add no new reals. On one hand, DPFA implies the Mapping Reflection Principle , which in turn implies that the continuum equals the second uncountable cardinal. On the other hand, it is proved that there are many consequences of CH, which are provably false under PFA, are consistent with DPFA assuming large cardinals.

► FARIDA KACHAPOVA, *The relative consistency of an intuitionistic theory with functionals*.
Auckland University of Technology, Private Bag 92006, Auckland 1142, New Zealand.
E-mail: `farida.kachapova@aut.ac.nz`.

Bernini's intuitionistic theory of lawless functionals and proofs is modified into the theory LP, where the axiom of existence of k-type functionals is restricted to formulas without parameters of types over k. The purpose is to contribute to the program of justifying classical analysis from the intuitionistic point of view.

We show that the theory LP is equiconsistent with the sub-theory I of the classical simple type theory with "almost predicative" comprehension axiom. In particular, we show the equiconsistency of their fragments LP(s) and I(s) without types over s.

The interpretation of I(s) in LP(s) uses modified "negative" interpretation of Bernini. For the inverse interpretation we construct a Beth–Kripke model of LP(s) in I(s) by generalizing van Dalen's Beth model for lawless sequences. From a result of Tarsky it follows that every I$(n+1)$ is stronger than I(n) in the sense that the consistency of I(n) is derivable in I$(n+1)$. Hence I is stronger than the second-order arithmetic.

► TAKAYUKI KIHARA, *Topological aspects of the degrees of difficulty of Π^0_1 classes*.
Tohoku University, 6-3 Aoba, Aramaki, Aoba-ku Sendai, 980-8578, Japan.
E-mail: kihara.takayuki.logic@gmail.com.

Lewis–Shore–Sorbi studied topological aspects of the Medvedev lattice of subsets of Baire space.

We introduce various new computable topological properties, and we show that various degree—theoretic properties of Π^0_1 classes are determined by these topological properties.

► HIROTAKA KIKYO, *On superstable generic structures*.
Kobe University, Rokko-dai 1-1, Nada, Kobe 657-8501, Japan.
E-mail: kikyo@kobe-u.ac.jp.

We construct an ab initio generic structure for a predimension function with a positive rational coefficient less than 1 which has a superstable non-omega-stable theory. This is a solution to a problem by Baldwin.

This is joint work with Koichiro Ikeda.

► TOMASZ KOWALSKI, *Relation algebras and relevant logic*.
University of Melbourne, The Provost, Victoria 3010, Australia.
E-mail: tomaszk@unimelb.edu.au.

In 2007, Roger Maddux observed that certain classes of representable relation algebras (RRAs) form sound semantics for some relevant logics. In particular, (a) R is sound w.r.t. RRAs of transitive relations, and (b) RM is sound w.r.t. RRAs of transitive, dense relations. He asked whether they were complete as well. In 2008, Mikulas Szabolc proved a negative result: R is not complete w.r.t. RRAs of transitive relations. Recently, Maddux proved a contrasting positive result: RM is complete w.r.t. transitive, dense RRAs. I will show that if we give up the requirement of representability, the positive result holds for R as well. To be precise:

THEOREM. *Every normal subdirectly irreducible De Morgan monoid in the language without the Ackermann constant can be embedded into a square-increasing relation algebra. Therefore, R is complete w.r.t. the variety of such RAs.*

► WEI LI, *Σ_1 Induction and d-r.e. degrees*.
Department of Mathematics, National University of Singapore, Block S17,10, Lower Kent Ridge Road, 119076, Singapore.
E-mail: g0800875@nus.edu.sg.

The existence of proper d-r.e. degrees was shown by Cooper using finite injury method. A classical result of Reverse Recursion Theory claims Σ_1 induction is enough for a finite injury construction, thus for the existence of proper d-r.e. degrees. Here we consider the case when Σ_1 induction fails. This is a joint work with Professor Chong Chi-tat and Professor Yang Yue in National University of Singapore. We will show, in that case, there is a proper d-r.e. degree; furthermore, such a degree could be the degree of a bounded d-r.e. set. Nevertheless, without Σ_1 induction, no proper d-r.e. degree could be below $0'$. That is, the existence of proper d-r.e. degrees below $0'$ is equivalent to Σ_1 induction. Moreover, we will show that all degrees below $0'$ are r.e. degrees for some models not satisfying Σ_1 induction but having enough saturation. Thus, it is necessary to have Σ_1 induction for the existence of non-r.e. degrees below $0'$. In addition, most of the results here can be applied to parallel results of Σ_n induction for any natural number n.

► PRABHU MANYEM, *ESO universal Horn logic: Expressibility at machine level versus structure level*.
Department of Mathematics, Shanghai University, Shang-Da Road #99, Bao-Shan district, Shanghai 200444, P. R. China.
E-mail: prabhu.manyem@gmail.com.

We show that ESO universal Horn logic (existential second logic where the first order part is a universal Horn formula) is insufficient to capture **P**, the class of problems decidable in polynomial time. This statement is true in the presence of a successor relation in the input vocabulary. We provide two proofs—one based on reduced products of two structures, and another based on approximability theory (the second proof is under the assumption that **P** is not the same as **NP**). The difference between the results here and those in (Grädel 1991) is due to the fact that the expressions this paper deals with are at the "structure level", whereas the expressions in (Grädel 1991) are at the "machine level"—a case of *Easier done than said*.

► MAARTEN MCKUBRE-JORDENS, *Constructing weak solutions of the Dirichlet problem*.
University of Canterbury, Private Bag 4800, Christchurch 8140, New Zealand.
E-mail: maarten.jordens@canterbury.ac.nz.

We present, first, a constructive proof of the existence of the weak solution to the Dirichlet problem when the domain is internally approximable by certain compact subsets, and, second, a Brouwerian example showing that the existence of a weak solution in the general case of the Dirichlet problem is an essentially non-constructive proposition.

► DAVID MILLER, *Probabilistic generalizations of deducibility*.
University of Warwick, Coventry CV4 7AL, UK.
E-mail: dwmiller57@yahoo.com.

The guiding idea of the *logical interpretation of probability* (von Kries, Waismann, Popper, Kneale, and others) is that the upper limit of probability is certainty or logical necessity. The relation $p(c \mid a) = 1$ (or, more accurately, $\forall b\, p(c \mid ab) = 1$) represents a *logically necessary connexion* between the sentences a and c, that is, the *deducibility* of c from a, while lesser values of p indicate that, whatever connexion there may be between a and c, it falls short of necessity. It is generally understood, in addition, that p is a measure on the ranges of its arguments, the sets of possibilities that they admit; whence the conditional probability $p(c \mid a)$ measures the proportion (in an appropriately generalized sense) of those possibilities admitted by a that are admitted also by c, and takes its maximum value, namely 1, when they all are. As anticipated, $p(c \mid a) = 1$ when c is deducible from a. At the other extreme $p(c \mid a) = 0$ if the range of a excludes every possibility that is admitted by c, that is, if $\neg c$ is deducible from a. The function p, so construed, satisfies all the usual (finitary) axioms for probability, such as those of Kolmogorov, or those of the more general system given in [1, appendix $*$v].

Less often considered are several other functions that provide alternative, and perhaps more illuminating, generalizations of deducibility. Since c is deducible from a if & only if $\neg a$ is deducible from $\neg c$, for example, and also if & only if c is deducible from $a \vee c$, the functions $q(c \mid a) = p(\neg a \mid \neg c)$ and $d(c \mid a) = p(c \mid a \vee c)$, which are not in general equal to $p(c \mid a)$, also suggest necessary conditions for deducibility. Deducibility itself may be defined by $\forall b\, q(b \to c \mid a) = 1$ and by $\forall b\, d(cb \mid ab) = 1$. The full range of possibilities is explored, and some philosophical consequences are drawn.

[1] KARL R. POPPER, ***The logic of scientific discovery***, Hutchinson, London, 1959.

► ANTHONY MORPHETT, *Promptness, randomness, capping and cupping*.
University of Melbourne, The Provost, Victoria 3010, Australia.
E-mail: awmorp@gmail.com.

The notion of prompt simplicity has been very fruitful in the study of c.e. sets and degrees.

Of particular note is the close connection between prompt simplicity and the properties of low cupping and non-capping in the upper semi-lattice of c.e. Turing degrees. Strengthenings of the notion of prompt simplicity have recently been examined, including strong promptness [Diamondstone and Ng] and prompt non-low-for-randomness. One aim of ongoing research is to determine the connections between these notions and cupping or capping properties of c.e. sets and degrees. We present some work in this direction, in particular regarding the relationship between strong promptness, prompt non-low-for-randomness and cupping properties such as low-for-random cuppability.

► TEOFILO REIS, *A topos-theoretic approach to paraconsistent possibilistic logic*.
State University of Campinas, Rua Sergio Buarque de Holanda, 251, Cidade Universitaria Zeferino Vaz, Campinas, 13083-859, Brazil.
E-mail: teofilo.reis@gmail.com.

We deal with the problem of obtaining a logic that can handle uncertainty and inconsistency. In our approach we use possibilistic logic to treat uncertainty. Although possibilistic logic's ability to manage some contradictory formulas, we note that this logic is unable to handle contradictory formulas whose weights are above the inconsistency level. This justifies the search for an extension of possibilistic logic, which can cope with stronger forms of inconsistency.

We present a careful study of C. Sossai's topos-theoretic approach to possibilistic logic, and analyse which points of this construction can be modified. We take advantage of the relation between closed sets in a topology and paraconsistent algebra (as pointed out, e.g., by W. Carnielli and C. Mortensen), as well as of the description of sheaves in terms of the closed sets of a space. We investigate to what extent the modification of Sossai's treatment is able exhibit paraconsistent features. A study of the internal language of the obtained topos is presented, and we emphasize some of its more interesting characteristics.

► HIROSHI SAKAI, *Chang's Conjecture and weak square*.
Kobe University, Rokko-dai 1-1, Nada, Kobe 657-8501, Japan.
E-mail: hsakai@people.kobe-u.ac.jp.

It is well known, due to Todorcevic, that Chang's conjecture implies the failure of the square principle at ω_1. In this talk we show that Chang's conjecture is consistent with the weak square principle $\square_{\omega_1,2}$. We also discuss the consequences of generalizations of Chang's conjecture on weak square principles.

► ANTON SETZER, *How to reason coinductively informally*.
Department of Computer Science, Swansea University, Singleton Park, Swansea SA2 8PP, UK.
E-mail: a.g.setzer@swan.ac.uk.
URL Address: http://www.cs.swan.ac.uk/~csetzer/.

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Whereas formally an inductively defined set is defined as a least fixed point, one rarely argues directly using this definition. Instead we use usually the induction rules derived from this principle. In fact we have developed a culture of informally arguing inductively by referring to the induction hypothesis, and often use extended induction principles such as course of value induction. Coinductively defined sets are greatest fixed points, however proofs about coinductively defined sets are usually either carried out by referring directly to the definition, or using game theoretic approaches. Therefore coinductive proofs appear to be quite complicated and are usually not taught in the early parts of a mathematics or computer science curriculum.

In the interactive theorem prover Agda, proofs by induction are given as recursive functions which pass a termination checker. The termination checker verifies that the induction hypothesis is used correctly. In a similar way coinductive proofs are given as well as recursive functions, passing the termination checker. The termination checker checks whether the recursive call, which we call the *coinduction hypothesis* is used correctly.

In this talk we will develop rules for coinduction in the same way as it is done for induction. We show how informal proofs by coinduction can be carried out by referring to the coinduction hypothesis in an appropriate way. As when referring to the induction hypothesis for inductive proofs the same care has to be applied when referring to the coinduction hypothesis in coinductive proofs.

We will illustrate this by showing how to carry out informal proofs by bisimulation.

► SHU-HE SHIU, *Fitch's paradox and anti-realism*.
National Taiwan University, 4 Roosevelt Road, Taipei, 10617 Taiwan.
E-mail: bookitchen@yahoo.com.tw.

Anti-realists claim that truth and knowledge go hand in hand in the sense that p is true if only if p is known. If this were the correct interpretation of anti-realists' position, Fitch's paradox (1963) would become an inevitable thorn for them. For there is, according to Fitch, an unknowable fact. Some may attempt to remove this thorn for anti-realists by means of giving an intuitionistic notion of knowledge or reformulate Fitch's paradox and claim it could be solved in temporal logic. I think neither of these approaches will succeed. Because any theory of knowledge, as Williamson analyzed in his Knowledge and its Limit (2000), cannot be modeled in S4 frame, but the above two solutions to Fitch's paradox are explicitly or implicitly S4-framed model. Hence anti-realists, as I shall argue in this paper, need to find other way to resist the challenge from Fitch's paradox.

► NICHOLAS SMITH, *Fuzzy logic, probability and degree of belief*.
Department of Philosophy, The University of Sydney, NSW 2006, Australia.
E-mail: njjsmith@sydney.edu.au.

If we think, as Ramsey did, that a degree of belief that P is a stronger or weaker tendency to act as if P, then it is clear that not only uncertainty, but also vagueness, gives rise to degrees of belief. Suppose that we take degrees of belief arising from uncertainty to obey the laws of probability and that we model vagueness using a fuzzy logic. We then encounter a problem: it does not look as though degrees of belief arising from vagueness should obey the laws of probability. One response would be to countenance two quite different sorts of degrees of belief: those arising from uncertainty, which obey the laws of probability, and those arising from vagueness, which obey a different set of laws. I argue, however, that if a degree of belief that P is a stronger or weaker tendency to act as if P, then this option is not open. Instead, I propose an account of the behavior of degrees of belief, which integrates probability and fuzzy logic. On this account, degrees of belief are expectations of degrees of truth. Justifications of the account in terms of Dutch books, and in terms of epistemic accuracy, are presented.

► LEANDRO SUGUITANI, *Beyond the limits of relation algebra*.
Federal University of Santa Catarina, Brazil, Rua Virginia Pattaro Adami 198, Jd. Santa Izabel, Campinas – SP, 13084045, Brazil.
E-mail: losugui@hotmail.com.

Relation Algebra (RA), as introduced by Tarski, forms the base of Givant and Tarski's logical formalism, within which set theory can be axiomatized. Despite being adequate to formalize mathematics, it is known that RA has some limitations when it is compared to other logical formalisms, for instance, first order logic (FOL).

It was shown by the mentioned authors that RA is "equipollent" with a three variable fragment of FOL, which means that RA has the same expressive and deductive power of this fragment. It was also proved that no finite extension of RA by adding "logical" operators will attain more than this. Nonetheless, if finiteness and logical operators are not imposed, then it is possible to find some interesting extensions of RA with full FOL expressiveness, for instance, Fork Algebra, Cylindric Algebra, Relation Algebra with Binders and Polyadic Algebra.

In this work we investigate the possibility of a new extension of RA, in which a "least fixed point" operator is in focus. Our interest is checking if it is possible to have a more powerful RA- based formalism within which one could achieve (at least) a fragment of second order logic as far as expressiveness is concerned.

► TOSHIO SUZUKI, *Resource-bounded randomness and computable Dowd-type generic sets*.
Tokyo Metropolitan University, Minami-Osawa, Hachioji-shi, Tokyo 192-0397, Japan.
E-mail: toshio-suzuki@tmu.ac.jp.

Ambos-Spies et al. introduced the concept of resource-bounded random sets by extending the works of Schnorr and Lutz. They show many relationships between resource-bounded randomness and resource-bounded genericity, where this concept of generic sets is based on time-bound of finite-extension strategy.

In contrast, the concept of Dowd-type generic sets, the main topic of this talk, is based on an analogy of forcing theorem. And, the relationship between resource-bounded randomness and Dowd-type genericity has been not clear so far. In the current talk, we show that there exists a primitive recursive function $t(n)$ such that every $t(n)$-random set is r-Dowd (r-generic in the sense of Dowd) for each positive integer r.

A proof is done by means of constructing resource-bounded martingales.

This is joint work with Masahiro Kumabe.

► KOHTARO TADAKI, *Robustness of statistical mechanical interpretation of algorithmic information theory*.
Chuo University, Research and Development Initiative, 1-13-27 Kasuga, Bunkyo-ku, Tokyo 112-8551, Japan.
E-mail: tadaki@kc.chuo-u.ac.jp.

The statistical mechanical interpretation of algorithmic information theory (AIT, for short) was introduced and developed in our former work [K. Tadaki, ***Local Proceedings of CiE 2008***, pp. 425–434, 2008], where we introduced the thermodynamic quantities into AIT. In this talk, we reveal a certain sort of the robustness of statistical mechanical interpretation of AIT. The thermodynamic quantities in AIT are originally defined based on the set of all programs, i.e., all halting inputs, for an optimal prefix-free machine, which is a universal decoding algorithm used to define the notion of program-size complexity. We show that we can recover the original properties of the thermodynamic quantities in AIT if we replace all programs by all minimal-size programs in the definitions of the thermodynamic quantities in AIT. We also consider another modifications of the original definition of the thermodynamic quantities and show that the same holds. The results of this talk illustrate the generality and validity of the statistical mechanical interpretation of AIT.

► RAFAEL TESTA, *External revision operation in belief sets via paraconsistency*.
University of Campinas, Afonso Celso, 270, Jd. Itália, Jundiaí, 13219710, Brazil.
E-mail: rafaeltesta@gmail.com.

AGM theory defines operations over theories (logically closed sets of belief-representing sentences). Contraction, the removal of a sentence from the theory, is pointed as the most basic operation since the others can be defined using it e.g., revision: $K * p = (K \div \neg p)'p$ (K revised by p is K contracted by not p and expanded by p). Belief base theory, on the other hand, defines operations over arbitrary sets. Differently from AGM theory, in belief bases the revision can be defined externally as $K * p = (K +' p) \div \neg p$. Notice that this is not possible in AGM theory since $K +' p$ may be trivial (because it is logically closed).

LFIs are paraconsistent logics such that inconsistency and triviality don't necessarily coincide. Hence, we propose to use LFIs in order to define external revision in AGM theory. Logical and philosophical justifications will also be given.

► HSING-CHIEN TSAI, *Finite inseparability of some strong mereological theories*.
National Chung-Cheng University, 168 University Road, Minhsiung Township, Chiayi County, 62102, Taiwan.
E-mail: pythc@ccu.edu.tw.

The signature of the formal language of mereology contains only one binary predicate P, which stands for the relation "being a part of". It is believed that P must at least define a partial ordering. The theory of partial orderings is called Ground Mereology (GM). On top of GM, the following mereological axioms can also be found in the literature: extensionality principle (EP), weak supplementation principle (WSP), strong supplementation principle (SSP), finite sum (FS), finite product (FP), complementation (C), the existence of the greatest member (G), atomicity (A) and fusion schema (F). Consider Closure Mereology (CM) = GM + (FS) + (FP) and Extensional Closure Mereology: (CEM) = CM + (SSP). Previously I have shown that CEM + (C) and CEM + (G) are finitely separable, but now I will show that any mereological theories up to CEM + (Negation C) + (Negation G) + (A) are finitely inseparable. Furthermore, using similar methods, I will also show that any mereological theories up to CM + (EP) + (C) + (G) + (A) + (F) or CM + (EP) + (Negation C) + (G) + (A) + (F) or CM + (EP) + (Negation C) + (Negation G) + (A) + (F) or CM + (EP) + (C) + (Negation G) + (A) are finitely inseparable too.

► PETER VERDEE, *Minimizing inconsistent instances of unrestricted comprehension*.
Centre for Logic and Philosophy of Science, Ghent University, Blandijnberg 2, Ghent, 9000, Belgium.
E-mail: peter.verdee@ugent.be.
E-mail: pverdee@gmail.com.

In this paper I present an adaptive logic approach to the axioms of naive set theory. The greatest advantage of such a set theory is that one can use full comprehension without the very limited expressive power of approaches based on usual paraconsistent logics. More particularly, the whole cumulative hierarchy can be formalized in this theory, while at the same time it proves useful statements about paradoxical sets (such as the Russel-set or the set of all ordinals). The price one has to pay for this expressivity is the computational complexity of the theory: it is not semi-recursive, but Σ^0_3-complex. I will discuss and solve an important problem one is confronted with when devising such a theory: the inability of standard adaptive logics to handle unnamed abnormal objects (in this context: unnamed inconsistent sets) individually.

► WEI WANG, *M5 is embeddable into the c.e. ibT degrees*.
Department of Philosophy, Sun Yat-sen University, 135 Xin'gang Xi Road, Guangzhou, 510275, China.
E-mail: wwang.cn@gmail.com.

Strongly weak reducibility was introduced by Downey, as a variant of weak reducibility. The degree structure on c.e. sets induced by sw-reducibility is very different from tt-, wtt-, or Turing degrees, as shown by Bampalias, Lewis, Yu and others. In this work, we look at a further strengthening of sw-reduciblity, the so-called identity bounded reducibility. Ambos-Spies, Bodewig, Kraling and I show that M5 is embeddable into the c.e. ibT degrees. As a corollary, S8 is embeddable too. Note that S8 is not embeddable into the c.e. Turing degrees.

► SYRAYA YANG, *Knowledge, belief and assertion: TW-models for epistemic logic*.
Department of Philosophy, National Taiwan University, Taiwan.
E-mail: cmyang@ntu.edu.tw.

I propose a kind of TW-models for epistemic logic, which includes modal operators K ('knowing'), B ('believing') and A ('asserting'). TW-models satisfy most of the disputable theses that Timothy Williamson proposes in Knowledge and Its Limits (OUP, 2000), including (i) a characterization of belief in terms of knowledge—'To believe that p is to treat p as if one knows that p'; (ii) cognitive-homelessness thesis, typically a rejection of KK-principle; and (iii) knowledge account of assertion—'One must: assert p only if one knows that p'. Semantic rules for 'K', 'B' and 'A' will be given. In particular, semantic rules for 'Bp' and 'Ap' are stipulated based on that of Kp: For any TW-model M, any world w, Kp is true in w if for some world u in M with wRu p is true in u; Bp is true in w if for some world u in M with wRu Kp is true in u; Ap is true in w if (i) for all world u in M with wRu, Kp is true in u and (ii) for all worlds s in M with sRw, Kp is true is s.

The result will shed a light on how an adequate epistemic logic of knowledge, belief and assertion should be.