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1995–1996 WINTER MEETING OF THE ASSOCIATION FOR SYMBOLIC LOGIC

Orlando, Florida, January 12–13, 1996

The Winter Meeting of the Association was held in Orlando, Florida, on January 12–13, 1996, in conjunction with the annual meeting of the American Mathematical Society. The program committee consisted of Jean Larson, William Mitchell (Chair), Theodore Slaman, and Carol Wood. The program included seven invited talks, six contributed talks, and four papers presented by title only.

The following invited talks were presented:

Peter Cholak (University of Notre Dame), *Definability, automorphisms, and the computably enumerable sets*.

Randall Dougherty (Ohio State University), *Narrow coverings of ω-product spaces*.

Joan Feigenbaum (ATT Bell Laboratories), *Games, complexity classes, and approximation algorithms*.

Greg Hjorth (UCLA), *Glimm-Effros type dichotomies*.

Kitty Holland (Northern Illinois), *Constructing strongly minimal sets via dimension functions*.

David Marker (University of Illinois Chicago), *Models of exponentiation*.

David Reed (Duke University), *Elementary equivalence and the topology of varieties*.

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

For the Program Committee
WILLIAM MITCHELL

Abstracts of invited talks

► PETER CHOLAK, *Definability, automorphisms, and the computably enumerable sets*.
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We discuss recent work concerning the construction of non-Δ^0_3- automorphisms of the computably enumerable sets. We relate this to recent work by Harrington and Soare on definability in the computably enumerable sets.

► RANDALL DOUGHERTY, *Narrow coverings of ω-product spaces*.
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Results of Sierpinski and others have shown that certain finite-dimensional product sets can be written as unions of subsets, each of which is "narrow" in a corresponding direction;

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that is, each line in that direction intersects the subset in a small set. For example, if the set $(\omega \times \omega)$ is partitioned into two pieces along the diagonal, then one piece meets every horizontal line in a finite set, and the other piece meets each vertical line in a finite set. Such partitions or coverings can exist only when the sets forming the product are of limited size. This talk considers such coverings for products of infinitely many sets (usually a product of omega copies of the same cardinal kappa). In this case, a covering of the product by narrow sets, one for each coordinate direction, will exist no matter how large the factor sets are. But if one restricts the sets used in the covering (for instance, requiring them to be Borel in a product topology), then the existence of narrow coverings is related to a number of large cardinal properties: partition cardinals, the free subset problem, nonregular ultrafilters, and so on. One result presented here is a relative consistency proof for a hypothesis used by S. Mrowka to construct a counterexample in the dimension theory of metric spaces.

► JOAN FEIGENBAUM, *Games, complexity classes, and approximation algorithms*.
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Game theory provides a framework in which to model and analyze conflict and cooperation among independent decision makers. Many areas of computer science have benefitted from this framework, including artificial intelligence, distributed computing, security and privacy, and lower bounds. In complexity theory, games are used to characterize complexity classes, to understand the power and limitations of those classes, and to interpret the complete problems for those classes. A very well known example of such a result [Chandra, Kozen, and Stockmeyer, Journal of the ACM, 28 (1981), 114-133] is that two-person, perfect-information games with polynomial-time referees, in which the length of a played game is polynomial in the length of the initial board position, exactly capture the class of sets recognizable in polynomial space. More recently, the celebrated results on interactive proof systems ([Lund, Fortnow, Karloff, and Nisan, Journal of the ACM, 39 (1992), 859-868], [Shamir, Journal of the ACM, 39 (1992), 869-877]) can be interpreted to mean that polynomial-length, perfect-information games still give a tight characterization of polynomial space, even if the referee is required only to approximate the value of the game instead of finding the value exactly, and even if one of the two players uses the trivial strategy of choosing a move uniformly at random from the set of all legal moves whenever it is his turn.

In this talk, I will briefly review the traditional connection between game theory and computer science and then present highlights of an ongoing effort to rethink and extend this connection in light of modern complexity theory's emphasis on interaction and randomness. Fruits of this effort include proofs that many combinatorial optimization functions are as hard to approximate closely as they are to compute exactly and a new approach to analyzing the relationship between imperfect-information games and standard complexity classes.

A revised version of this talk was given at the 1998 International Congress of Mathematicians in Berlin. The accompanying survey paper appears in Proceedings of the International Congress of Mathematicians, vol. III: Invited Lectures, Documenta Mathematica, Journal der Deutschen Mathematiker-Vereinigung, 1998, pp. 429-439.

► GREG HJORTH, *Glimm-Effros type dichotomies*.
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Let E and F be equivalence relations on Polish spaces X and Y. We write $E \leq_B F$ if there is a Borel function $\theta : X \to Y$ such that $\forall x, y \in X(xEy \Leftrightarrow \theta(x)F\theta(y))$. We define the Vitali equivalence relation, E_v, on $[0, 1]$, by setting

$$xE_v y \Leftrightarrow (x - y) \in \mathbb{Q}.$$

The key facts here are that Lebesgue measure is E_v-ergodic, E_v-non-atomic, and that E_v

admits no measurable selector. The following result is a refinement of an earlier theorem due to Glimm.

Theorem: (Effros). Let G be locally compact Polish group. Let X be a Polish space on which G acts continuously, with E_G the induced orbit equivalence relation. Then either:
(i) $E_v \leq_B E_G$ (and hence E_G has no Borel selector); or,
(ii) E_G is G_δ (and hence $E_G \leq_B \Delta([0,1])$).

So in some sense this states that an equivalence relation induced by a locally compact Polish group is at least as "bad" as the Vitali equivalence relation, or it is no more complicated than the equality relation on the unit interval.

The last few years have seen repeated attempts to extend this result both to other kinds of Polish groups acting on Polish spaces, and to general equivalence relations that satisfy some sort of definability criteria. In its most abstract form, the Glimm-Effros theorem provides a dichotomy for the structure of the ZF-cardinals in $L(\mathbb{R})$.

Abstracts of contributed talks

► IRVING H. ANELLIS, *Spitzfindigkeit - from Bochenski to Yanovskaya and van Heijenoort*.
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An indirect and interesting link between historians of logic Jean van Heijenoort and Sof'ya A. Yanovskaya may be found in a paper about Yanovskaya by Joseph Bocheński published in *Studies in Soviet Thought* in 1973. In that paper, Bocheński recounts an incident surrounding a paper which he once wrote for the obscure and privately published *Festgabe an die Schweizerkatholiken* of 1954. The paper in question, "Spitzfindigkeit", was intended to be a sardonic and humorous mockery of classical arguments against formal logic. In the paper on Yanovskaya, Bocheński wrote that no one took his "Spitzfindigkeit" paper seriously, except Yanovskaya, who replied with a scholarly discussion of some thirty or more pages, in her 1962 work on Descartes' geometry and mathematical method, and "the stern reviewer" of the *Journal of Symbolic Logic*. Bocheński was amazed that anyone at all should have taken his paper seriously. The "stern reviewer" of the *Journal of Symbolic Logic*, as it happened, was Jean van Heijenoort. Van Heijenoort wrote in 1957 of Bocheński's paper that with a militant tone, the article concluded that "either logic will be subtle or it will not be logic" and he spoke of Carl Prantl as displaying an "astonishing ignorance" which "sets in motion the prejudices which still reign among those who talk about the history of logic without knowing it close up". Bocheński's article on Yanovskaya gave the strong impression that van Heijenoort included him among those who vent their prejudices about logic while they talk about its history without knowing close up. But in fact, van Heijenoort was attacking Prantl, if anyone, not Bocheński.

Several Soviet historians of mathematics revised their views of both Bocheński and Yanovskaya when informed of Bocheński's article on Yanovskaya and van Heijenoort's review of the "Spitzfindigkeit" article.

► JOEL DAVID HAMKINS, *Small forcing makes any cardinal superdestructible*.
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Small forcing always ruins the indestructibility of an indestructible supercompact cardinal. In fact, after small forcing, any cardinal k becomes superdestructible. That is, after small forcing any further k-closed forcing which adds a subset to k will destroy the measurability and even the weak compactness of k. Nevertheless, after small forcing indestructible cardinals remain resurrectible, but never strongly resurrectible.

► STEPHEN HARNISH, *Bisimulation collapses and analogs of the solution lemma*.
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Aczel has presented several non-well-founded (NWF) set theories within a unifed framework. He defined axioms AFA$^{\sim}$ where the $\sim$ are regular bisimulations whose definitions are absolute for full systems. The resulting set theories AFA$^{\sim}$ + ZFC^{-} (ZFC-minus-foundation) are known to be consistent relative to ZFC. Most recent applications of NWF sets employ the solution lemma which is a consequence of Aczel's particular anti-foundation axiom named AFA.

In this paper we introduce the definition and basic properties of iterated collapses of accessible pointed graphs under regular bisimulations. We develop the related notions of canonical decorations of apgs, and canonical solutions of set equations. Finally, we prove analogs of the solution lemma for arbitrary AFA$^{\sim}$. These results might lead to wider use of anti-foundation axioms other than AFA.

► JEFFRY L. HIRST, *Strict inequality of ordinals and reverse mathematics*.
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For ordinals α and β, $\alpha < \beta$ if (i) $\alpha + 1 \leq \beta$, or equivalently if (ii) $\alpha \leq \beta$ and $\beta \not\leq \alpha$. Reverse mathematics [2] can be used to analyze the logical strength of this equivalence for strong comparability of countable well-orderings. The base system $\mathbf{RCA}_0$ suffices to prove that (i) implies (ii), but arithmetical comprehension is required to prove the converse, as shown by the following theorem.

Theorem: ($\mathbf{RCA}_0$) The following are equivalent:

(1) $\mathbf{ACA}_0$.

(2) If α and β are countable well-orderings such that $\alpha \leq \beta$ and $\beta \not\leq \alpha$, then $\alpha + 1 \leq \beta$.

The proof of this theorem is reminiscent of Dekker's [1] use of deficiency sets to prove the existence of a hypersimple set.

[1] J. C. E. Dekker, *A theorem on hypersimple sets*, ***Proc. Amer. Math. Soc.***, vol. 5 (1954), pp. 791–796.

[2] H. M. Friedman and J. L. Hirst, *Weak comparability of well orderings and reverse mathematics*, ***Ann. Pure Appl. Logic***, vol. 47 (1990), pp. 11–29.

► GREG RAY, *Logical consequence: A defense of Tarski*.
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In his classic 1936 essay "On the Concept of Logical Consequence", Alfred Tarski used the notion of satisfaction to give a semantic characterization of the logical properties. Tarski is generally credited with introducing the model-theoretic characterization of the logical properties familiar to us today. However, in his book, The Concept of Logical Consequence, Etchemendy argues that Tarski's account is actually incompatible with the standard model-theoretic account, and that both accounts are inadequate for quite a number of different reasons.

I discuss the following critical charges that Etchemendy makes against Tarski and his account of the logical properties:

1) (a) Tarski's account diverges from the standard model-theoretic account at points where the latter gets it right. (b) Tarski's account cannot be brought into line with the model-theoretic account, because the two are fundamentally incompatible.

2) There are simple counterexamples [enumerated by Etchemendy] which show that

Tarski's account is wrong.

3) Tarski committed a modal fallacy when arguing that his account captures our pre-theoretic concept of logical consequence, and so obscured an essential weakness of the account.

4) Tarski's account depends on there being a distinction between the "logical terms" and the "non-logical terms" of a language, but there are very simple languages for which no such distinction can be made.

Etchemendy's critique raises historical and philosophical questions about important foundational work. However, Etchemendy is mistaken about each of these central criticisms. In the course of justifying that claim, I give a sustained explication and defense of Tarski's account.

Abstracts presented by title only

► ARNON AVRON, *Multiplicative conjunction, weakening and contraction*.
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We show that the elimination rule for the multiplicative (or intensional) conjunction $\otimes$ is admissible in many important multiplicative substructural logics. These include LL_m (the multiplicative fragment of Linear Logic) and RMI_m (the system obtained from LL_m by adding the contraction axiom and its converse, the mingle axiom). An exception is R_m (the intensional fragment of the relevance logic R, which is LL_m together with the contraction axiom). Let SLL_m and SR_m be, respectively, the systems which are obtained from LL_m and R_m by adding this rule as a new rule of inference. The set of theorems of SR_m is a proper extension of that of R_m, but a proper subset of the set of theorems of RMI_m. Hence it still has the variable-sharing property. SR_m has also the interesting property that classical logic has a strong translation into it. We next introduce general algebraic structures, called strong multiplicative structures, and prove strong soundness and completeness of SLL_m relative to them. We show that in the framework of these structures, the addition of the weakening axiom to SLL_m corresponds to the condition that there will be exactly one designated element, while the addition of the contraction axiom corresponds to the condition that there will be exactly one nondesignated element (in the first case we get the system BCK_m, in the second - the system SR_m). Various other systems in which multiplicative conjunction functions as a true conjunction are studied, together with their algebraic counterparts.

► M'BOKA KIESE, *Modèles chaotiques*.
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La théorie de la cohérence développée dans le cadre du Cercle de Vienne par R. Carnap et O. Neurath, dans leur palabre avec M. Schlick, postule que la vérité repose sur une concordance entre des propositions au sein d'un système formel donné. Une théorie est syntaxiquement cohérente, si une proposition n'y est pas déduite en même temps que sa négation. Si non elle perturbe sa cohérence interne. Avec la création de la théorie des modèles depuis le théorème de Löwenheim-Skolem, la notion de vérité est relativisée. La vérité d'une proposition est *consubstantielle* à un modèle. Une proposition $p := 2 + 2 = 1$ est dite *fausse*, par rapport à $q := 2 + 2 = 4$ qui est *vraie* dans l'algèbre $\langle \mathbb{N}, + \rangle$ et les axiomes de l'addition. Par contre si nous restreignons cette algèbre à l'ensemble des classes d'entiers modulo 3 et que nous construisons sa table d'addition, alors dans ce cas p est *vraie* dans ce nouveau modèle. Grâce au théorème de Löwenheim, selon lequel toute théorie d'un langage au plus dénombrable qui admet un modèle infini, accepte un modèle dénombrable, Skolem découvrit un concept de vérité lié à l'existence des modèles non standard. La non-contradiction n'est pas exclusive à la logique classique. Elle est immanente à la *logique chaotique*. Il y a cependant un conflit d'interprétation et de représentation de la proposition entre la pensée classique et la pensée du chaos. La proposition chaotique, appelée *ngana*, est une actualisation de la proposition stoïcienne, qui elle, est différente de la proposition aristotélicienne. Un ngana q qui est $(pour)$ un autre ngana p, s'écrit: $q(p)$; quand q est $(contre)$ p, on note: $(p)q$. Pour nier un ngana p, nous n'introduisons pas la particule de négation non p. Cette logique du $(pour)$ et du $(contre)$ entre p et q laisse une troisième possibilité r tel que par exemple, $(p)q$ se définisse comme $p(r)/(r)q$. La contradiction chaotique se représente par, $\langle (p)p \rangle$ qui est une conséquence de, $p(r)/(r)p$. L'idée d'une complétude chaotique qui s'en dégage est la suivante :-sur un plan syntaxique, un *ngana* p est *déconstructible*, on écrit $|\models p$, si il faut $q(p)q$; sur un plan sémantique, la vérité d'un système formel, n'est pas inséparable d'un modèle:elle est désormais *consubstantielle* à un *modèle chaotique*, ayant son langage propre. Si l'on considère la théorie des ensembles selon Z.F. comme un univers, nous voulons que tout modèle de l'univers ne fasse pas partie de lui, cela va de soi, mais émigre d'un *antiunivers*. Plus techniquement nous voulons que tout modèle de la théorie des ensembles selon Z.F. ne soit pas bâti sur le même langage que celui de la théorie des ensembles selon Z.F. Ce que nous voulons, c'est une rupture du langage de base des théories.

Modèle chaotique d'un langage. - Une *L-conjoncture* $\mathbb{K}$, une *mode* ou un *système greegébral* $\mathbb{K} := (D, D', F, R)$ est composé:-d'un univers D et d'un *antiunivers* D', appelés *domaines concurrents* du chaos tel que D est écarté de D'; $-F$ est l'espèce des *symboles dysfonctionnels* sur la *percussion* d'univers D et D'de $\mathbb{K}$; $-R$, l'espèce des *syndicats* sur la *percussion* d'univers D et D' de $\mathbb{K}$; Quand R n'y figure pas, $\mathbb{K} := (D, D', F)$ est appelé un *Greegèbre*. Modèle chaotique d'un ngana.-Soient $(a)[x, y, z, .]$ et $[x, y, z, .](a)$ des ngana d'un langage L et $\mathbb{K}$ est un modèle chaotique; les *traductions* de $(a)[x, y, z, ..]$ et $[x, y, z, ..](a)$, dans $\mathbb{K}$ notées, $(a)^{\mathbb{K}}$ sont par définition: $\{b, c, d, ...$ des éléments de D' : $-\mathbb{K}\,|\!\models\!(a)[x, y, z, ...] \Rightarrow (b, c, d, ..)a; -\mathbb{K}\,|\!\models\!(a)[x, y, z, ..] \Rightarrow [b, c, d, ..](a); -\mathbb{K}\,|\!\models [x, y, z, ..](a) \Rightarrow (a)[b, c, d, ..]; -\mathbb{K}\,|\!\models\![x, y, z, ..](a) \Rightarrow (b, c, d, ..)a\}$. Les notations $\mathbb{K}\,|\!\models (a)[x, y, z, ..]$ et $\mathbb{K}\,|\!\models\![x, y, z, ..](a)$ signifient que les formules (a) sont *déconstructibles* dans $\mathbb{K}$ quand on remplace: i) x, y, z des éléments de D par b, c, d, qui sont des éléments de D', un antiunivers de $\mathbb{K}$;

Énoncé chaotique. $-[b, c, d, ..](a), (a)[b, c, d, ..]$ et $(b, c, d, ..)a$ sont appelés des énoncés chaotiques. Il est indifférent de lire $\mathbb{K}\,|\!\models\![b, c, d, ...](a)$ et $\mathbb{K}\,|\!\models\!(a)[b, c, d, ...]$ par $\mathbb{K}$ est un modèle chaotique de a ou a est à la *Mode* $\mathbb{K}$ ou $\mathbb{K}$ *déconstruit* a.

Conjonction. $\mathbb{K}\,|\!\models p$ et $p' \Rightarrow \mathbb{K}\,|\!\models p$ et $\mathbb{K}\,|\!\models p'$ il faut q il faut q', q et q' dans D' tel que $(p)q$ et $(p')q'$.

Implication. $\mathbb{K}\,|\!\models p \Rightarrow p'$ cela implique, $\mathbb{K}\,|\!\models p \Rightarrow \mathbb{K}\,|\!\models p'$, c'est-à-dire, il faut q il faut q', q et q' dans D' tel que $(p)q \Rightarrow (p')q'$.

Quantificateurs. $\mathbb{K}\,|\!\models Qx(x)p \Rightarrow Qr$ (lire, $\langle$pour un r quelconque$\rangle$), r dans $D'/p(r)$; $\mathbb{K}\,|\!\models Qxp(x) \Rightarrow Qr, r$ dans $D'/(r)p$; $\mathbb{K}\,|\!\models$ il faut $xx(r) \Rightarrow$ il faut q, q dans $D'/(r)q$; $\mathbb{K}\,|\!\models$ il faut $x(r)x$ il faut q, q dans $D'/q(r)$.

Conséquence chaotique. -Dans cette notion, nous avons deux *modèles chaotiques* $\mathbb{K}$ et $\mathbb{Q}$. Une formule il faut $xx(r)$ est une *conséquence chaotique* de $Qx(x)p$, en abrégé, $Qx(x)p \dashv\vdash$ il faut $xx(r)$, si $\mathbb{K}\,|\!\models Qx(x)p$ soudain $\mathbb{Q}\,|\!\models$ il faut $xx(r)$, c'est-à-dire, $p(r)$ soudain $(r)q$. Nous faisons le même raisonnment pour les trois cas suivants: $Qx(x)p \dashv\vdash Qxr(x)$, si $\mathbb{K}\,|\!\models Qx(x)p$ soudain $\mathbb{Q}\,|\!\models Qxr(x)$, c'est-à-dire, $p(r)$ soudain $(q)r$; $Qxq(x) \dashv\vdash Qxr(x)$, si $\mathbb{K}\,|\!\models Qxq(x)$ soudain $\mathbb{Q}\,|\!\models Qxr(x)$, c'est-à-dire, $(r)q$ soudain $(q)r$; $Qx(x)p \dashv\vdash Qx(x)r$, si $\mathbb{K}\,|\!\models Qx(x)p$ soudain $\mathbb{Q}\,|\!\models Qx(x)r$, c'est-'a-dire, $p(r)$ soudain $r(p)$.

► VLADIMIR V. RYBAKOV, *A sufficient condition for admissibility of inference rules with metavariables*.
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It is well known that the question about decidability for quasi-equational theory of the free algebra $\mathfrak{F}_\omega(\lambda)$ in the signature enriched with constants for free generators (from the variety $\mathrm{Var}(\lambda)$ corresponding to a non-standard algebraic logic λ) and the question of decidability for the problem of admissibility for inference rules with metavariables in λ are equipotent (cf. [2, 3]). The affirmative answers on decidability were known for some individual logics (cf. [2, 3]). In [1] some general sufficient condition for admissibility usual inference rules (without metavariables) is found. The aim of this research is to generalize the results of [1] and to find a general sufficient condition for (i) decidability the question of admissibility for inference rules with metavariables and (ii) solvability of logical equations in non-standard logics.

Theorem 1: Let λ be amodal logic over $K4$ (or a superintuitionistic logic) with fmp such that (i) λ has the branching property below 1; (ii) λ has the (strong) effective 1-drop points property; (iii) there is an algorithm which recognizes finite λ-frames(which holds if, in particular, λ is finitely axiomatizable). Then

(a) There is an algorithm which recognizes the admissibility for inference rules with metavariables in λ.

(b) There is an algorithm examining solvability of logical equations in λ and constructing some solution provided solvability.

Theorem 2: If λ is a modal logic over $K4$ (or a superintuitionistic logic) with fmp and having the branching property below 1 and the (strong) effective 1-drop points property. Then

(a) The quasi-equational theory of the free algebra $\mathfrak{F}_\lambda(\omega)$ in the signature enriched with constants for the free generators is decidable.

(b) There is an algorithm examining solvability of the algebraic equations in the free algebra $\mathfrak{F}_\lambda(\omega)$ and constructing some solution provided solvability equations.

(c) If λ has the disjunction property then the universal theory of the free algebra $\mathfrak{F}_\lambda(\omega)$ in the signature enriched with constants for the free generators is also decidable.

[1] V. V. Rybakov, *Criteria for admissibility of inference rules. Modal and intermediate logics with the branching property*, ***Studia Logica***, vol. 53, no. 2 (1994), pp. 203–225.

[2] ———, *Rules of inference with parameters for intuitionistic logic*, ***Journal of Symbolic Logic***, vol. 57 (1992), pp. 912–923.

[3] ———, *Problems of substitution and admissibility in modal logic Grz and intuitionistic propositional calculus*, ***Annals of Pure and Applied Logic***, vol. 49 (1990), pp. 1–34.