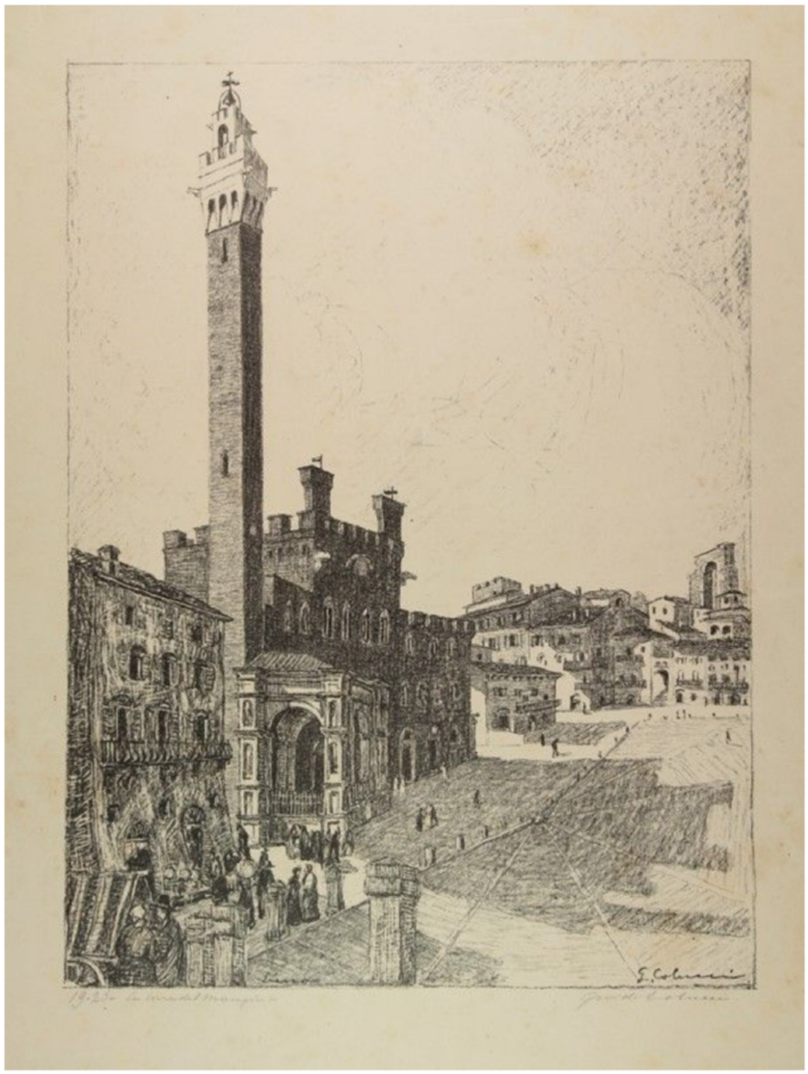
AAA99 - Workshop on General Algebra
(99. Arbeitstagung Allgemeine Algebra)



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The conference AAA99 is the 99th conference of the series "Arbeitstagung allgemeine Algebra" (Workshop on General Algebra) that was started in 1970 by Rudolf Wille (TU Darmstadt, Germany), and is now being coordinated by Erhard Aichinger (JKU Linz, Austria).
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Conference booklet: Stefano Fioravanti and Albert Vucaj.

Contents

Invited talks

Sheaves on spectral spaces and the patch monad

Mai Gehrke
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In this talk we will study sheaves over spectral spaces from the point of view of duality. A presheaf over a meet semilattice gives rise, via a construction introduced by Grothendieck, to a simple algebraic structure based on its elements, that is, the local sections of the presheaf. These are equipped with a semigroup structure given by the operation sometimes called restriction: given local sections s and t, the restriction of s to t is simply s restricted to the meet of the domains of s and t. The semigroups arising in this way are precisely the so-called normal bands studied early on by Kimura. Within this setting we will show that we can capture sheaves over spectral spaces, and that, in the special case of Boolean spaces these are in fact equivalent to skew Boolean algebras - a non-commutative variant of Boolean algebras introduced by Leech. In joint work with Andrej Bauer, Karin Cvetko-Vah, Sam van Gool, and Ganna Kudryavtseva, we showed in 2013 that skew distributive lattices are equivalent to sheaves on Priestley spaces. In order to capture this in the broader setting described here we have to study the monad on sheaves over spectral spaces induced by the identity map from the patch space of a spectral space to the spectral space itself. Indeed we show that skew distributive lattices are equivalent to algebras for this monad. This is recent joint work with Clemens Berger.

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Circuit satisfiability and solving equations

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The talk is intended to present latest achievements in searching structural algebraic conditions a finite algebra $\mathbf{A}$ has to satisfy in order to have a low complexity algorithm that decides if an equation $\mathbf{s}(x_1, \ldots, x_n) = \mathbf{t}(x_1, \ldots, x_n)$, where $\mathbf{s}, \mathbf{t}$ are polynomials over $\mathbf{A}$, has a solution in $\mathbf{A}$. In order to get such structural characterization (that is independent of the basic operations of $\mathbf{A}$) we translate this problem to circuit satisfiability $\textsc{Csat}(\mathbf{A})$ over the algebra $\mathbf{A}$.

In this new setting the paper [1] gives such conditions for a very broad class of algebras from congruence modular varieties. In particular it has been shown that if an algebra $\mathbf{A}$ fails to decompose nicely, i.e. into a direct product of a nilpotent algebra and an algebra that essentially is a subreduct of a distributive lattice then $\textsc{Csat}$ for $\mathbf{A}$ (or at least one of its quotients) is NP-complete. And, almost conversely, if $\mathbf{A}$ does decompose nicely (in the above sense), but with the additional assumption that the nilpotent factor is actually supernilpotent, then $\textsc{Csat}(\mathbf{A})$ is in fact in P. Subsequently, in [2] and [3], a polynomial time algorithm has been presented for 2-nilpotent algebras. However in general nilpotent but not supernilpotent algebras had not been put on any side of this borderline.

Very recently we started to fill this nilpotent/supernilpotent gap. The essential difference between this two concepts of nilpotency lies in fact that in supernilpotent algebras there is an absolute bound for the arity of expressible (by polynomials) conjunction. In nilpotent (but not supernilpotent) algebras conjunction-like polynomials of arbitrary arity n do always exist but the known ones are too long to be used to polynomially code NP-complete problems in $\textsc{Csat}$. We split nilpotent algebras into slices that will correspond to the measure how much a nilpotent algebra fails to be supernilpotent. This distance h is determined by the behavior of a multi-ary commutator operation on congruences of $\mathbf{A}$ which is used to define h-step supernilpotent algebras. On the other hand we show that it strictly corresponds to the longest chain of alternating primes hidden in the algebra. Then we show that, under the Exponential Time Hypothesis and Strong Exponential Size Hypothesis (saying that Boolean circuits need exponentially many modular counting gates to produce boolean conjunctions of any arity), satisfiability over these algebras have intermediate complexity between $\Omega(2^{c\log^{h-1} n})$ and $O(2^{c\log^{h} n})$, where $h \geqslant 3$ measures how much a nilpotent algebra fails to be supernilpotent.

Our examples are striking in view of the natural strong connections between circuits satisfiability and Constraint Satisfaction Problem for which the dichotomy had been shown by Bulatov and Zhuk.

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The Tarski irredundant basis theorem and the generation of finite groups

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Denote by $d = d(G)$ and $m = m(G)$, respectively, the smallest and the largest cardinality of a minimal generating set of a finite group G. The Tarski irredundant basis theorem implies that for every k with $d(G) \leq k < m(G)$ there exist a minimal generating set $\omega = \{g_1, \ldots, g_k\}$, an index $i \in \{1, \ldots, k\}$ and x_1, x_2 in G such that $\tilde{\omega} = \{g_1, \ldots, g_{i-1}, x_1, x_2, g_{i+1}, \ldots, g_k\}$ is again a minimal generating set of G. In this case we say that $\tilde{\omega}$ is an immediate descendant of ω. There are several examples of minimal generating set of cardinality smaller than $m(G)$ which has no immediate descendant and so it appears an interesting problem to investigate under which conditions an immediate descendant exists. We may investigate the same problem considering the invariable generation (a subset S of a group G invariably generates G if, when each element of S is replaced by an arbitrary conjugate,the resulting set generates G). One can try to apply Tarski's argument to the invariable generation. This however will produce only a weak result, and the natural generalisation of Tarski's theorem to the invariable setting remains an open problem.

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On some recent approaches to solving Frankl's Union-Closed Sets Conjecture

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The following conjecture was proposed by Peter Frankl in the 1970s:

Conjecture 1 (Frankl, 1979) *Let $\mathcal{F}$ be a finite family of finite sets closed under unions, which contains at least one nonempty set. Then there exists an element a which is in at least one-half of the sets in the family $\mathcal{F}$.*

Though it has no major application that I am aware of, the problem attracted a lot of attention over the years, due to its elementary statement and apparent difficulty. In fact, it is quite famous and the literature on the subject is extensive. In this talk I will survey some recent results and show some equivalent formulations. Though I will survey various recent attempts at solving Frankl's Conjecture, the main focus of the talk will be on Vladimir Božin's approach, outlining an equivalent formulation and a construction he invented.

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Why CSP is easy

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The Constraint Satisfaction Problem (CSP) is the problem of deciding whether there is an assignment to a set of variables subject to some specified constraints. For over twenty years one of the main question was to classify constraint languages giving a tractable (solvable in polynomial time) CSP (like system of linear equations, 2-CNF, and so on). In 2017 the conjecture describing all tractable cases was independently proved by A. Bulatov and D. Zhuk.

In this talk I will argue that despite the fact that plenty of deep algebraic results and even theories appeared while studying the complexity of CSP, now we can say that Constraint Satisfaction Problem is actually easy.

First, the classification is very simple. The CSP is tractable if and only if the constraint language admits a weak near-unanimity (WNU) polymorphism, i.e there exists an operation w satisfying $w(y, x, x, \dots, x) = w(x, y, x, \dots, x) = \cdots = w(x, x, \dots, x, y)$ and preserving the constraint language. Moreover, now we know that CSP can be solved by local methods if and only if the constraint language cannot express a system of linear equations, which is true if it admits a WNU polymorphism of every arity greater than 2.

Second, the most general tractable algorithm is just a smart combination of checking local consistency and solving of linear equations. Thus, instead of developing a completely new method for solving CSP, we learned how to use two well-known ideas for complicated constraint languages that combine several linear cases and several 2-CNF cases.

Third, the current proof does not really use any deep knowledge of universal algebra and tame congruence theory. Most facts can be proved just playing around with operations and relations (and a bit of absorption). Even though the current proof is still rather long and complicated, all key facts have simple and natural formulations.

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Contributed talks

Priestley duality above dimension zero: algebraic axiomatisability of the dual of compact ordered spaces

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Stone showed that the category of Boolean algebras with homomorphisms is dually equivalent to the category of totally disconnected compact Hausdorff spaces with continuous maps [6]. If we drop the assumption of total disconnectedness, we are left with the category KH of compact Hausdorff spaces and continuous maps. Duskin showed that the opposite category $\mathsf{KH}^{\mathrm{op}}$ is monadic over the category of sets and functions [1,5.15.3]. In fact, $\mathsf{KH}^{\mathrm{op}}$ is equivalent to a variety of algebras with primitive operations of countable arity; [3] exhibits a generating set of operations, while [4] provides a finite axiomatisation. Thus, Stone duality can be lifted to compact Hausdorff spaces, retaining the algebraic nature.

Stone established also a duality for (bounded) distributive lattices and homomorphism with the so-called spectral spaces and perfect maps [7]. While spectral spaces are non-Hausdorff, Priestley showed that they can be equivalently described as certain partially ordered topological spaces [5]. More precisely, the category of distributive lattices is dually equivalent to the full subcategory of Nachbin's compact ordered spaces on the totally order-disconnected objects. A *compact ordered space* is a pair $(X, \leq)$ where X is a compact space, and $\leq$ is a partial order on X, closed in the product topology of $X \times X$; a morphism is a monotone continuous map. Similarly to the case of Boolean algebras, one may ask if Priestley duality can be lifted to the category $\mathsf{KH}_{\leq}$ of compact ordered spaces, retaining its algebraic nature. In [2], $\mathsf{KH}_{\leq}^{\mathrm{op}}$ is shown to be equivalent to a quasi-variety of (infinitary) algebras, leaving as open the question whether it is equivalent to a variety. We show that the answer is affirmative.

Theorem 1 (Main result) *The opposite of the category of compact ordered spaces is equivalent to a variety of (infinitary) algebras.*

To prove the theorem, we use the fact that a quasi-variety is a variety if, and only if, every equivalence relation is effective. First, we characterise equivalence relations on a compact ordered space X in the category $\mathsf{KH}_{\leq}^{\mathrm{op}}$ as certain pre-orders on the order-topological coproduct $X + X$. Then, we rephrase effectiveness into an order-theoretic condition, and show that it is satisfied by every pre-order arising from an equivalence relation.

We also show that it is necessary to resort to infinitary operations.

Theorem 2 *The opposite of the category of compact ordered spaces is not equivalent to a variety of finitary algebras.*

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Some large numbers of subuniverses of lattices

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By a subuniverse, we mean a sublattice or the emptyset. We prove that the fourth largest number of subuniverses of an n-element lattice is $21.5 \cdot 2^{n-5}$, and the fifth largest number of subuniverses of an n-element lattice is $21.25 \cdot 2^{n-5}$. Also, we describe the n-element lattices with exactly $21.5 \cdot 2^{n-5}$ and $21.25 \cdot 2^{n-5}$ subuniverses.

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The degree of a function between two abelian groups

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To each function f from an abelian group A into an abelian group B, we assign a number $n \in \mathbb{N}_0 \cup \{\infty\}$, called the *functional degree* of f. The functional degree can be used in bounding the supernilpotence class of an algebra, and it provides an explanation for the occurrence of the *p-weight degree* in many improvements of the Chevalley Warning Theorems. We present the basic properties of the functional degree and show how it compares to the total degree of a polynomial function.

This builds on earlier work by Peter Mayr and is joint research with Jakob Moosbauer.

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Chains of clonoids and word orderings

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The proof of the fact that there is no infinite descending chain of clonoids from a finite set into a finite algebra with Mal'cev-term (Aichinger, Mayr 2016) relies on the well quasi-orderedness of a certain set of words. Our goal is to provide short and self-contained proofs of the basic facts of this word ordering and to investigate whether these facts could possibly be used for determining whether there is no infinite antichain of such clonoids.

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Infinity: Relevant or Irrelevant?

Kristina Asimi
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Promise Constraint Satisfaction Problem (PCSP) is a generalization of Constraint Satisfaction Problem (CSP). All the currently known tractable (i.e., solvable in polynomial time) PCSPs over finite templates can be reduced to tractable CSPs. I present a class of PCSPs for which that CSP has to have an infinite domain (unless P=NP).

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Reconstructing subproducts from projections

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The Baker-Pixley theorem implies that a subalgebra of a product of algebras from a variety V is uniquely determined by projections on k-tuples of coordinates, provided that V has a near unanimity term of arity $k+1$. A related reconstruction question was later considered by Bergman: under what conditions a prescribed system of k-fold projections comes from a subalgebra of a product? Bergman isolated a necessary property of such systems, a suitable consistency condition, and proved that in the presense of a near unanimity term of arity $k+1$ this necessary consistency condition is also sufficient. We improve this result to near unanimity terms of arity $k+2$ and show that these terms in fact provide a characterization: a variety has the reconstruction property (for consistent systems of k-fold projections) if and only if it has a near unanimity term of arity $k+2$.

This is a joint work with Marcin Kozik, Johnson Tan, and Matt Valeriote.

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Semirings of 0,1-preserving endomorphisms of semilattices

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This is a joint work with Prof. Tomas Kepka and Prof. Petr Nemec.

Various endomorphism semirings of semilattices are investigated. In particular, conditions are found under which these endomorphism semirings are (congruence-)simple.

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On the Burris-Willard conjecture

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The Burris-Willard conjecture is concerned with the (least) number n such that every centraliser clone on a k-element carrier set can be bicentrically generated by its n-ary part. In 1987 Burris and Willard proved that there are only finitely many centraliser clones for any k-element set, and hence it follows that a number n as above must exist. Inspection of Post's lattice gives that $n = 3$ for $k = 2$. Burris and Willard show that $n = 4 + k^{k^4-k^3+k^2}$ works and they mention without proof that $n = k^k$ does, as well. They conjecture that $n = k$ is sufficient for all $k \geq 3$. The only basis for this conjecture is a series of works by A. F. Danil'čenko from the 1970ies that give a complete description of all centraliser clones for $k = 3$. Unfortunately, the details of this classification are not easily accessible, and thus the result should be treated with care. The case $k = 4$ is unknown at present and still beyond reach of reasonable computational means.

In 2000 Snow considered the least number n such that the bicentraliser of a clone can be bicentrically generated from its n-ary part. He showed that there are clones on a k-element set, where $n \geq (k-1)^2$ is necessary. Since $(k-1)^2 > k$ for $k \geq 3$, the truth of the Burris-Willard conjecture would imply that these clones are no centraliser clones, i.e., that they are not bicentrically closed. We prove that the latter is actually true, and we see this as a fact supporting the Burris-Willard conjecture.

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The complexity of homomorphism factorization

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We investigate the computational complexity of the problem of deciding if an algebra homomorphism can be factored through an intermediate algebra. Specifically, we fix an algebraic language, $\mathcal{L}$, and take as input an algebra homomorphism $f\colon X \to Z$ between two finite $\mathcal{L}$-algebras X and Z, along with an intermediate finite $\mathcal{L}$-algebra Y. The decision problem asks whether there are homomorphisms $g\colon X \to Y$ and $h\colon Y \to Z$ such that $f = hg$. We show that this problem is NP-complete for most languages. We also investigate special cases where homomorphism factorization can be performed in polynomial time.

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Chasing model-complete cores

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An ω-categorical structure is called a *model-complete core* if and only if the closure of its automorphism group is equal to its endomorphism monoid. We know that every ω-categorical structure $\mathfrak{A}$ is homomorphically equivalent to a model-complete core which is unique up to isomorphism, and again ω-categorical. This structure is thus called *the* model-complete core of $\mathfrak{A}$. Although for an ω-categorical structure we know that its model-complete core always exists, in general we do not know how to describe it explicitly. In particular one could ask which classes of ω-categorical structures are closed under taking model-complete cores and which are not. During my talk I will present some natural examples of classes for both cases, and show how these questions relate to the study of infinite domain CSPs.

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Commutator theory for skew braces

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Skew braces are algebraic structures related to the solutions of the set-theoretic quantum Yang-Baxter equation. We develop a commutator theory for such algebraic structures in the sense of Freese-McKenzie and we compare the universal algebraic notion of nilpotence with the notion of right and left nilpotence developed by Vendramin and Smoktunowicz.

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Minimal-Taylor Algebras

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Define a minimal-Taylor algebra as a finite Taylor algebra such that no proper reduct is Taylor. I'll go over a number of basic results about such algebras, most of which follow easily from the existence of a cyclic term, such as the existence of a convenient collection of ternary terms which I call "daisy chain terms".

The most important structural result is that any subalgebra, quotient, or finite power of a minimal-Taylor algebra is also a minimal-Taylor algebra. This allows us to simplify the description of Bulatov's colored graph attached to the algebra.

Using results from Zhuk's proof of the dichotomy conjecture, we can give alternate characterizations of binary and ternary absorption in minimal-Taylor algebras, and show that if a minimal-Taylor algebra is hereditarily ternary-absorption-free, then it is a Mal'cev algebra.

I'll also go over a few nontrivial examples and open problems.

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Varieties corresponding to classes of complemented posets

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As algebraic semantics of the logic of quantum mechanics there are usually used orthomodular posets, i.e. bounded posets with a complementation which is an antitone involution and where the join of orthogonal elements exists and the orthomodular law is satisfied. When we omit the condition that the complementation is an antitone involution, then we obtain skew-orthomodular posets. To each such poset we can assign a bounded lambda-lattice in a non-unique way. Bounded lambda-lattices are lattice-like algebras whose operations need not be associative. We prove that any of the following properties for bounded posets with a unary operation can be characterized by certain identities of an arbitrary assigned lambda-lattice: complementarity, orthogonality, almost skew-orthomodularity and skew-orthomodularity. It is shown that these identities are independent. We prove that the variety of skew-orthomodular lambda-lattices is congruence permutable, congruence distributive and congruence regular.

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Strict quantum 2-groups vs simplicial objects

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The problem of the functorial relationship between strict quantum 2-groups and simplicial objects was studied recently in the category of cocommutative Hopf algebras.

Motivated by this, in this talk, we will forget for Hopf algebras about being cocommutative. Our aim will be to explain our understanding of how the general case of the same problem should be explored. Note that, in this case, our base category will be an arbitrary braided monoidal category (such a category always admits equalizers), instead of the category of vector spaces.

This is a joint work with Jan Paseka.

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A new perspective on duality for MV-algebras

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C.C. Chang introduced MV-algebras in the late 1950s in order to provide semantic content to Łukasiewicz logic, and have since been extensively scrutinized from this perspective as well as their connection to abelian lattice-ordered groups. Although MV-algebras are distributive lattice-ordered algebras, they have proven resistant to analysis using Priestley duality. In particular, despite attempts to offer simple descriptions of duals of MV-algebras as extended Priestley spaces, the defining equations of MV-algebras have not previously been expressible in terms of first-order conditions on (extended) Priestley duals. In this work, we apply extended Priestley duality for so-called double quasioperator algebras in order to describe the duals of MV-algebras. In this setting, the addition operation of MV-algebras is doubled and rendered in terms of two partial binary operations on Priestley duals. This more expressive environment allows us to offer transparent, first-order conditions dualizing the defining equations of MV-algebras.

This is joint work with Mai Gehrke, Sam van Gool, and Vincenzo Marra.

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Nondistributive rings

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Referring to a graduate course in Abstract Algebra, by a ring we mean a set R of no fewer than two elements, together with two binary operations called the addition and multiplication, in which (1) R is an abelian group with respect to the addition, (2) R is a semigroup with unit with respect to the multiplication, (3) $(r+s)t = rt+st$ and $r(s+t) = rs+rt$ for any $r, s, t \in R$. A nearring N is a generalization of a ring, namely the addition needs not be abelian and only the right distributive law is required, additionally the left distributive law is replaced by $n0 = 0$ for every $n \in N$. The last postulate means that we require a nearring to be zerosymmetric. The talk is intended as a discussion on sets N satisfying the nearring axioms except the right distributive law, which we replace by $0n$ for every $n \in N$.

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Distributive biracks and solutions of Yang-Baxter equation

Premysl Jedlicka
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Yang-Baxter equation is an equation used in particle physics. A birack is a binary algebra used in algebraic approach to solutions of Yang-Baxter equation. In our talk we present those biracks that satisfy distributive laws and we show a relation between the nilpotency degree of multiplication groups of distributive birack and certain algebraic properties of these distributive biracks.

The result comes from a joint work with Agata Pilitowska and Anna Zamojska-Dzienio.

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On the atomicity of the algebra of conditional logic

Venkata Krishna Kanduru
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(joint work with Gayatri Panicker and Purandar Bhaduri)

In [1], Guzmán and Squier gave a complete axiomatisation of McCarthy's three-valued logic (cf. [3]) and called the corresponding algebra a C-algebra, or the algebra of conditional logic. While studying `if-then-else` algebras, Manes in [2] defined an ada (algebra of disjoint alternatives) which is essentially a C-algebra equipped with an oracle for the halting problem.

In this work, we investigate the notions of atoms and atomicity of C-algebras. We first provide various characterisations for existence of suprema of subsets of C-algebras. Focussing on the C-algebra of transformations $\mathbb{3}^X$, we characterise the atoms in $\mathbb{3}^X$ by $\{\alpha \in \mathbb{3}^X : \alpha(x_o) \in \{T, U\}$ for some unique $x_o \in X\}$. Consequently, we establish that the C-algebra $\mathbb{3}^X$ is atomic. Further, we obtain some necessary and some sufficient conditions for the atomicity of C-algebras. Finally, we give a characterisation for finite atomic C-algebras and establish that they are precisely finite adas. A precise characterisation of arbitrary atomic C-algebras is an open problem.

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Cardinalities of automorphism groups of partial mono-unary algebras

Archil Kipiani

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A characterization is given of all those cardinal numbers which are cardinals of automorphism groups of partial mono-unary algebras. Some connections are also established between the notion of automorphisms of mono-unary algebras and the Continuum Hypothesis. The cardinals κ such that $\omega < \kappa < 2^\omega$ are characterized in terms of automorphisms of mono-unary algebras. Close connections of the obtained results with one problem of S. Ulam are also indicated. G. Fuhrken has shown that the additive group of rationals is not capable to be represented as the automorphism group of a mono-unary algebra. We prove that there are many pairwise non-isomorphic groups which cannot be represented as the automorphism group of a partial mono-unary algebra. In fact, we show that the cardinalities of such groups can be arbitrarily large.

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Failure of local-to-global

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For several strong idempotent Maltsev conditions it suffices to check if they hold locally (i.e. for every tuple) in order to determine if they are satisfied globally. This "local-to-global" approach is one of the few methods known to prove tractability of checking whether a finite algebra satisfies some fixed Maltsev condition.

In this talk I would like discuss the local-to-global approach for "G-terms", i.e. terms that are invariant under permuting their variables according to the elements of some permutation group G. In several cases, including symmetric terms (for $G = S_n$, $n > 2$) the local-to-global approach fails.

This is joint work with Alexandr Kazda.

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The lattice of monomial clones on finite fields

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In this talk we investigate the lattice of clones that are generated by a set of functions that are induced on a finite field $\mathbb{F}$ by monomials. To this end, we study whether this lattice contains infinite ascending chains, or infinite descending chains, or infinite antichains. We give a full characterization of the lattice of these clones if the field is of order $2^k = p + 1$ where p is a prime and $k \in \mathbb{N}$. Furthermore, for an arbitrary finite field, the sublattice of idempotent clones of this lattice is finite and every idempotent monomial clone is principal.

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Transfer-stable means on finite chains

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According to [5], the arithmetic mean is a function characterized by four features: it is non-decreasing, idempotent, symmetric and additive. The first three of them can be naturally converted to the theory of posets but the last one generally can not. Due to this problem, we will replace it with another suitable property, which is called transfer-stability. However, we do not get the exact arithmetic mean but some approximation. These functions will be called transfer-stable means.

The first aim of the paper is to show that transfer-stable means on a finite chain form a lattice which is isomorphic to the direct power of a finite chain. The second goal is to create a generating set of transfer-stable means, i.e., means that can generate all other transfer-stable means of the same arity by classical composition of functions. The last goal deals with question of how to generate all transfer-stable means of any arity by binary transfer-stable means only. For this problem we define special transfer-stable means composition.

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Associative spectra of graph algebras

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The associative spectrum was introduced by Csákány and Waldhauser in 2000 as a measure of non-associativity of a binary operation, and it has appeared in the literature under a number of different names, such as "subassociativity type" and "the number of $*$-equivalence classes of parenthesizations". In this talk, we focus on associative spectra of (groupoid reducts of) graph algebras.

A *bracketing* of size n is a groupoid term obtained by inserting pairs of parentheses in a valid way into the string $x_1 x_2 \ldots x_n$. The *associative spectrum* of a groupoid $\mathbf{A} = (A, \cdot)$ is the sequence $(s_n(\mathbf{A}))_{n=1}^{\infty}$, where $s_n(\mathbf{A})$ is the number of distinct term operations induced by the bracketings of size n on $\mathbf{A}$. Intuitively, the faster the associative spectrum grows, the less associative the operation is. We clearly have $1 \leq s_n(\mathbf{A}) \leq C_{n-1}$, where C_{n-1} is the $(n-1)$-th Catalan number. If $\mathbf{A}$ is associative, then $s_n(\mathbf{A}) = 1$ for all n. A groupoid $\mathbf{A}$ is *antiassociative,* if $s_n(\mathbf{A}) = C_{n-1}$ for all $n \geq 2$.

Introduced by Shallon in 1979, the *graph algebra* of a digraph $G = (V, E)$ is the algebra $\mathbb{A}(G) = (V \cup \{\infty\}; \cdot, \infty)$ of type $(2, 0)$, where ∞ is a new element distinct from the vertices, and $x \cdot y = x$ if $(x, y) \in E$, and $x \cdot y = \infty$ otherwise. The multiplication operation in $\mathbb{A}(G)$ provides a straightforward encoding of the edge relation of G, and any algebraic properties of $\mathbb{A}(G)$ can be viewed as properties of the digraph G itself.

We show that for an undirected graph G, the associative spectrum of $\mathbb{A}(G)$ is one of the just three possible sequences: $(1)_{n=1}^{\infty}$, $(\lceil 2^{n-2} \rceil)_{n=1}^{\infty}$, $(C_{n-1})_{n=1}^{\infty}$. The situation is drastically more complicated for arbitrary digraphs G. We can, nevertheless, describe the associative spectra of some simple families of digraphs, and we characterize the antiassociative digraphs in terms of a few graph structural parameters.

This is joint work with Tamás Waldhauser (University of Szeged).

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Generating congruence preserving functions of finite groups

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(joint work with Erhard Aichinger, Johannes Kepler University Linz)

For investigating 1-affine completeness of finite groups we generate congruence preserving functions with a CSP solver in Java. Beforehand, we reduce the number of functions we have to construct.

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Twist-products and Nelson-type algebras

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This is a joint work with M. Busaniche and N. Galatos.

By a twist-product of a lattice L we mean the cartesian product of $\mathbf{L}$ with its order-dual $\mathbf{L}^{\partial}$, equipped with the natural order involution $\sim (x,y) = (y,x)$. This idea goes back to Kalman's 1958 paper [4], but the denomination "twist" appeared thirty years later on Kracht's paper [5].

Kalman referred to lattices, but several authors considered lattices with additional operations which allow the definition of new operations on the basic twist-product. As a particular case, the algebraic models of Nelson's constructive logic with strong negation and Nelson's paraconsistent logic can be obtained via twist-products of Heyting algebras and generalized Heyting algebras, respectively [7,6].

Tsinakis and Wille [8] endowed the twist-product of a residuated lattice with a residuated monoid structure.

In [1] and [2], the authors show that the algebraic models of Nelson logics are termwise equivalent to residuated lattices, and moreover they describe their twist-product construction in the sense of Tsinakis and Wille.

On the other hand, in [3] they propose a particular case of residuated lattices that can be described as twist-products, called Kalman lattices.

In this work we present a more general construction, considering involutive residuated lattices with a conucleus satisfying some additional properties, and showing they not only can be described as twist-products, but they also encompass all previous cases.

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Morita equivalence of semigroups

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A property of semigroups is called a Morita invariant if it is shared by all semigroups in the same Morita equivalence class. For example, if two Morita equivalent semigroups are "sufficiently good" then they have isomorphic quantales of ideals, therefore all properties that are defined in terms of quantale operations are invariants. In our talk we will concentrate on Morita invariants of semigroups.

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Chevalley Warning type results on abelian groups

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A theorem of Chevalley and Warning states that the number of solutions of a system of polynomial equations over a finite field is divisible by its characteristic if the number of variables is strictly larger than the sum of the total degrees. We show a generalisation of this theorem to functions between abelian p-groups. To describe the degree of a function between abelian groups we use a concept of *functional degree*, which is based on similar concepts used, e.g., by M. Vaughan-Lee and P. Mayr. We apply this theorem to functions on not necessarily commutative rings, finite fields and additive subgroups of finite fields to obtain new results and to retrieve some already known improvements of the Chevalley Warning theorem.

This is joint research with Erhard Aichinger.

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Commutator sequences

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A commutator sequence is a sequence of operations on a given complete lattice such that it contains one operation for each arity and it satisfies properties of higher commutators. It is known that there are finitely many or at most countably many such sequences depending on the shape of the lattice. If we introduce an order among such sequences in a natural way using the order of the lattice then we obtain again a complete lattice. A natural question is, if we start even with a finite lattice, is it necessary to give infinitely many equations to define such a sequence. We contribute to this question in the case of chains.

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Obtaining axiomatizations for varieties generated by antiortholattices with the strong De Morgan property

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Pseudo–Kleene algebras are the bounded involution lattices $(L, \vee, \wedge, \cdot', 0, 1)$ which satisfy the *Kleene condition*: $x \wedge x' \leq y \vee y'$. They include ortholattices and Kleene lattices.

A *PBZ*–lattice* is an algebra $(L, \vee, \wedge, \cdot', \cdot^{\sim}, 0, 1)$ such that $(L, \vee, \wedge, \cdot', 0, 1)$ is a pseudo–Kleene algebra and $\cdot^{\sim}$ is an order–reversing unary operation on L, called *Brouwer complement*, which satisfies:

$$\begin{aligned} \textit{paraorthomodularity}: \quad & x \leq y \ \&\ x' \wedge y \approx 0 \rightarrow x \approx y; \\ & x \wedge x^{\sim} \approx 0,\ x \leq x^{\sim\sim} \approx x^{\sim\prime}; \\ (*): \quad & (x \wedge x')^{\sim} \approx x^{\sim} \vee x'^{\sim}. \end{aligned}$$

Antiortholattices are the PBZ*–lattices endowed with the *trivial Brouwer complement*: $0^\sim \approx 1$ and $x > 0 \rightarrow x^\sim \approx 0$.

We denote by $\mathbb{PKA}$ and $\mathbb{PBZL}^*$ the varieties of pseudo–Kleene algebras and PBZ*–lattices, respectively, and by $\mathbb{AOL}$ the positive proper universal class of antiortholattices.

Antiortholattices that satisfy the *Strong De Morgan* condition (**SDM**): $(x \wedge y)^\sim \approx x^\sim \vee y^\sim$, are exactly the pseudo–Kleene algebras with the 0 meet–irreducible, endowed with the trivial Brouwer complement. We denote by $\mathbb{SAOL}$ the subvariety of $\mathbb{PBZL}^*$ they generate.

For any subclass $\mathbb{C}$ of $\mathbb{PKA}$, we denote by $\mathcal{C}_2 \oplus \mathbb{C} \oplus \mathcal{C}_2 = \{\mathcal{C}_2 \oplus L \oplus \mathcal{C}_2 : L \in \mathbb{C}\} \subset \mathbb{AOL} \cap \mathbb{SAOL}$: the class of the ordinal sums of the two–element chain $\mathcal{C}_2$ with members of $\mathbb{C}$ and again $\mathcal{C}_2$, endowed with the naturally defined involution and the trivial Brouwer complement; then the subvarieties of $\mathbb{PBZL}^*$:

$$\mathcal{HSP}(\mathcal{C}_2 \oplus \mathbb{C} \oplus \mathcal{C}_2) = \mathcal{HSP}(\mathcal{C}_2 \oplus \mathcal{HSP}(\mathbb{C}) \oplus \mathcal{C}_2),$$

where $\mathcal{HSP}(\mathbb{C})$ is the subvariety of $\mathbb{PKA}$ generated by $\mathbb{C}$.

The map

$$\mathbb{V} \mapsto \mathcal{HSP}(\mathcal{C}_2 \oplus \mathbb{V} \oplus \mathcal{C}_2)$$

is a bounded lattice embedding of the lattice of subvarieties of $\mathbb{PKA}$ into $[\mathcal{HSP}(\mathcal{C}_3))$: the principal filter generated by the variety generated by the three–element antiortholattice chain in the lattice of subvarieties of $\mathbb{SAOL} = \mathcal{HSP}(\mathcal{C}_2 \oplus \mathbb{PKA} \oplus \mathcal{C}_2)$.

For any subvariety $\mathbb{V}$ of $\mathbb{PKA}$, from a relative axiomatixation of $\mathbb{V}$ w.r.t. $\mathbb{PKA}$ we can obtain a relative axiomatization of $\mathcal{HSP}(\mathcal{C}_2 \oplus \mathbb{V} \oplus \mathcal{C}_2)$ w.r.t. $\mathbb{PBZL}^*$.

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Solving systems of equations of fixed size over finite groups

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We investigate the complexity of solving systems of polynomial equations over finite groups. It is well known that this problem is NP-complete for non-abelian groups. We generalize a recent result by Földvári and Horváth showing that we can solve systems over groups which are semidirect products of a p-group and an abelian group in polynomial time if we fix the number of equations. This shows that for all groups for which the complexity of solving one equation has been proved to be in P so far, solving a fixed number of equations is also in P. Furthermore for groups of order pq we discuss a faster algorithm to solve systems of equations.

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Categories of orthogonality spaces

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An orthogonality space is a set equipped with a symmetric and irreflexive binary relation. We consider orthogonality spaces with the additional property that any collection of mutually orthogonal elements gives rise to the structure of a Boolean algebra. Together with the maps that preserve the Boolean substructures, we are led to the category $\mathcal{NOS}$ of normal orthogonality spaces. In general, an orthogonality space need not be normal.

We may observe that orthogonality spaces are essentially the same as undirected graphs, understood such that the edges are two-elements subsets of the set of nodes. The rank of an orthogonality space is under this identification the supremum of the sizes of cliques. The present work, however, is not motivated by graph theory, our guiding example rather originates in quantum physics.

In this lecture, we will focus exclusively on the case of a finite rank. Our guiding example is, accordingly, the orthogonality space associated with a finite-dimensional Hilbert space.

Moreover, an orthogonality space of finite rank is called linear if for any two distinct elements e and f there is a third one g such that exactly one of f and g is orthogonal to e and the pairs e, f and e, g have the same orthogonal complement. Linear orthogonality spaces arise from finite-dimensional Hermitian spaces. We are led to the full subcategory $\mathcal{LOS}$ of $\mathcal{NOS}$ and we establish that the morphisms are the orthogonality-preserving lineations.

Finally, we consider the full subcategory $\mathcal{COS}$ of $\mathcal{LOS}$ whose members arise from Hermitian spaces over subfields of $\mathbb{R}$ with the property that each positive element possesses a square root. We establish that the morphisms or $\mathcal{COS}$ are induced by generalised semiunitary mappings.

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Dominance relation on Triangular Norms

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Triangular norm is a binary operation defined on the real unit interval $[0, 1]$. It has been originally introduced within the framework of probabilistic metric spaces where it describes triangular inequality of probabilistic metrics. Later, it has found its use also as an interpretation of conjunction in many-valued logic. Dominance is a binary relation defined on the set of triangular norms and it is a crucial notion when one constructs Cartesian products of probabilistic metric spaces. It can be easily shown that dominance is both reflexive and anti-symmetric (hence a pre-order). We deal with the question, which has been an open problem for a long time, whether it is also transitive (hence an order).

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The structure of the maximal congruence lattices of algebras on a finite set

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The congruence lattices of algebras with a fixed finite base set A form a lattice $\mathcal{E}_A$ (with respect to inclusion). The coatoms of $\mathcal{E}_A$ are congruence lattices of monounary algebras (A, f), i.e., they are of the form $\mathrm{Con}(A, f)$ for a unary function $f : A \to A$. It is known from another paper of the authors that there are three different types I, II, III, of such coatoms which can be described explicitly by the corresponding type of f.

In this talk we are going to characterize these congruence lattices in more detail. Each such coatom is a particular union of some nontrivial intervals of the partition lattice $\mathrm{Eq}(A)$. Moreover, we can characterize the join- and meet-irreducible elements, the atoms, the coatoms, and the covering relation in these lattices.

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Fully filial rings

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All considered rings are associative, not necessarily with the unity. To denote that I is an ideal of a ring R we write $I \lhd R$. A ring R is called fully filial if $A \lhd B$ and $B \lhd C$ imply $A \lhd C$ for all subrings A, B, C of R. A ring R is called filial if $A \lhd B$ and $B \lhd R$ imply $A \lhd R$ for all subrings A, B of R. Obviously a fully filial ring is a ring in which every subring is filial. Filial rings and related topics were studied in many papers. The presented talk is devoted to the study of fully filial rings. The aim of this lecture is to present an overview of several recent results about these rings. The talk is based on a joint work with R. R. Andruszkiewicz.

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Description logics with concrete domains and general concept inclusions revisited

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Concrete domains have been introduced in the area of Description Logic to enable reference to concrete objects (such as numbers) and predefined predicates on these objects (such as numerical comparisons) when defining concepts. Unfortunately, in the presence of general concept inclusions (GCIs), which are supported by all modern DL systems, adding concrete domains may easily lead to undecidability. One contribution of this paper is to strengthen the existing undecidability results further by showing that concrete domains even weaker than the ones considered in the previous proofs may cause undecidability. To regain decidability in the presence of GCIs, quite strong restrictions, in sum called omega-admissiblity, need to be imposed on the concrete domain. On the one hand, we generalize the notion of omega-admissiblity from concrete domains with only binary predicates to concrete domains with predicates of arbitrary arity. On the other hand, we relate omega-admissiblity to well-known notions from model theory. In particular, we show that finitely bounded, homogeneous structures yield omega-admissible concrete domains. This allows us to show omega-admissibility of concrete domains using existing results from model theory.

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A partial order on transformation semigroups with restricted range that preserve double direction equivalence

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Let Y be a nonempty subset of X and $T(X,Y)$ the set of all functions from X into Y. Then $T(X,Y)$ with the composition is a subsemigroup of the full transformation semigroup $T(X)$. For an equivalence E on X, let

$$T_{E^*}(X,Y) = \{\alpha \in T(X,Y) : \forall x, y \in X, (x,y) \in E \Leftrightarrow (x\alpha, y\alpha) \in E\}.$$

Then $T_{E^*}(X,Y)$ is a subsemigroup of $T(X)$. In this work, we characterize the natural partial order on $T_{E^*}(X,Y)$. Then we find the elements which are compatible and describe the maximal and minimal elements. We also prove that every element of $T_{E^*}(X,Y)$ lies between maximal and minimal elements. Finally, the existence of an upper cover and a lower cover is investigated.

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Logic with atoms and undecidability of definable homomorphism problem for definable graphs

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Logic with Atoms, which comes from the Permutation Models, has been one of the main research topics of the computer science community in Warsaw. It allows one to introduce the orbit-finite property which, under some definable conditions, can be used to show that certain algorithms over infinite sets stop after finitely many steps. This opens the way to the possibility of writing algorithms over infinite sets (which are beyond the scope of classical computer science), and actually use them on machines. Working in this setup, after presenting some already known examples of decidable problems with the related algorithms, we show that the Definable Homomorphism Problem for Definable Graphs is still undecidable in this new context.

This work is part of the author's master thesis and is joint work with Lasota and Motto Ros.

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Subnormal subgroups in the framework of weak congruence lattices of groups

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The lattice of weak congruences of a group G is the lattice of all congruences on all subgroups of G, considered as subsets of G^2. In this context we analyze subnormal subgroups and composition series.

Theorem 3 *The set of all congruences on all composition subgroups of G is a lower semimodular sublattice of the weak congruence lattice of G.*

Let a be a codistributive element in a complete lattice L. L has the m**-chain property** if :

$$\text{for all } x, y \in \downarrow a, \text{ if } x \prec y, \text{ then } \overline{x} \prec \overline{x} \vee y \prec \overline{y},$$

where $\overline{x}$ is the top of the class $[x]_{\theta_a}$ (θ_a is the kernel of the endomorphism $x \mapsto x \wedge a$ in L).

Theorem 4 *The lattice of composition subgroups of a group fulfills the m-chain property.*

All subgroups of a finite group G are composition subgroups if and only if the lattice of weak congruences of G fulfills the m-chain property.

Theorem 5 *A finite group G is nilpotent if and only if the weak congruence lattice of G is lower semimodular.*

Joint research with Andreja Tepavčević and Jelena Jovanović

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Cancellable elements of lattices of semigroup varieties

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The lattice **SEM** of all semigrgoup varieties has been intensively studied since 1960's. There are hundreds of papers concerning this lattice so far. One of the general branches of this study is investiation of its special elements, i. e. neutral, distributive, codistributive, standard, costandard elements etc. Systematic study of such elements began in 2000's. A general view of the corresponding results is given in [1].

A notion which naturally arises in this context is the concept of cancellable element of a lattice. An element x of a lattice L is *cancellable* if

$$\forall y, z \in L \quad x \vee y = x \vee z \ \&\ x \wedge y = x \wedge z \rightarrow y = z.$$

The study of cancellable elements of the lattice **SEM** and its sublattices has begun recently. In [2], cancellable elements of **SEM** were completely described. In [3], a complete description is given for cancellable elements of the lattice of all *overcommutative* varieties, i. e. varieties containing all commutative semigroups.

In my report, I discuss the results mentioned above as well as a recent progress on cancellable elements of the lattice of all commutative varieties, i. e. varieties of commutative semigroups.

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Special elements of the lattice of epigroup varieties

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A semigroup S is called an *epigroup* if for any element x of S some power of x lies in some subgroup of S. The class of all epigroups includes all periodic semigroups, all completely regular semigroups (i.e., unions of groups), and many other important classes of semigroups. For an element a of a given epigroup, let e_a be the identity element of the maximal subgroup G that contains some power of a. It is known that $ae_a = e_a a$ and this element lies in G. We denote by $\overline{a}$ the element inverse to ae_a in G. This element is called the *pseudoinverse* of a. The mapping $a \longrightarrow \overline{a}$ defines a unary operation on an epigroup. Thus, epigroups can be treated as unary semigroups, that is, as algebras with two operations: multiplication and pseudoinversion.

By epigroup variety we mean a variety of epigroups treated just as unary semigroups. The class of all epigroup varieties forms a lattice under the following naturally defined operations: for varieties $\mathbf{X}$ and $\mathbf{Y}$, their join $\mathbf{X} \vee \mathbf{Y}$ is the variety generated by the set-theoretical union of $\mathbf{X}$ and $\mathbf{Y}$ (as classes of epigroups), while their meet $\mathbf{X} \wedge \mathbf{Y}$ coincides with the set-theoretical intersection of $\mathbf{X}$ and $\mathbf{Y}$. Let us denote this lattice by **EPI**. Note that the class of all epigroups is not an epigroup variety (because it is not closed under taking infinite direct products), so the lattice **EPI** does not have the largest element.

Some basic information about studying varieties of epigroups, in general, and the lattice **EPI**, in particular, can be found in, for example, [1]. This lattice has been intensively studied. In these investigations, much attention has been paid to so-called *special elements* of different types in this lattice. There are many articles devoted to special elements of the lattice **EPI** (see, for example, [2],[3]).

We continue study the special elements of the lattice **EPI**. In this talk I summarize recent works and present some new results.

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Classification of cyclic height 1 conditions

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A cyclic height 1 identity is an identity of the form

$$f(x_1, x_2, \ldots, x_n) \approx f(x_{\sigma(1)}, x_{\sigma(2)}, \ldots, x_{\sigma(n)})$$

where σ is a bijection. A height 1 condition is a finite set of height 1 identities. Height 1 conditions can naturally be ordered by strength. For example

$$\{f(x_1, x_2, x_3, x_4) \approx f(x_2, x_3, x_4, x_1)\} \text{ implies } \{g(x_1, x_2) \approx g(x_2, x_1)\}.$$

We present a complete classification of the poset of cyclic height 1 conditions ordered by strength. (Joint work with M. Bodirsky and A. Vucaj).

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Sets of prime power order generators of finite groups

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A subset X of prime power order elements of a finite group G is called *pp-independent* if there is no proper subset Y of X such that $\langle Y, \Phi(G)\rangle = \langle X, \Phi(G)\rangle$ ($\Phi(G)$ is the Frattini subgroup of G), and a *pp-base* of G, if X is a pp-independent generating set of G. We say that a finite group G

- has *property* $\mathcal{B}_{pp}$ (is a $\mathcal{B}_{pp}$ -group) if all pp-bases of G have the same size;

- has the *pp-embedding property* if every pp-independent set of G can be embedded into a pp-base of G;

- has the *pp-basis exchange property* if for any two pp-basis B_1, B_2 and $x \in B_1$ there exists $y \in B_2$ such that $(B_1 \setminus \{x\}) \cup \{y\}$ is a pp-base of G.

- is a *pp-matroid* group if G has property $\mathcal{B}_{pp}$ and the pp-embedding property.

During this talk we present some results about groups with the above properties.

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Parametrization of generalized Heisenberg groups: The skew-symmetric case

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Let M be a left module over a ring R with identity and let β be a skew-symmetric R-bilinear form on M. The generalized Heisenberg group consists of the set $M \times M \times R = \{(x, y, t) \colon x, y \in M, t \in R\}$ with group law

$$(x_1, y_1, t_1)(x_2, y_2, t_2) = (x_1 + x_2, y_1 + y_2, t_1 + \beta(x_1, y_2) + t_2).$$

Under the assumption of 2 being a unit in R, we prove that the generalized Heisenberg group decomposes into a product of its subset and subgroup, similar to the well-known polar decomposition in linear algebra. This leads to a parametrization of the generalized Heisenberg group that resembles a parametrization of the Euclidean group by vectors and rotations.

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On centralizers of finite (semi)lattices, and a simpler way to the centralizers on {0,1}

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We study centralizer clones of finite lattices and semilattices. For semilatices we extend the result of B. Larose describing operations belonging to the centralizer, and we also give our own characterization. With the help of these characterizations we derive formulas for the number of operations of a given essential arity in the centralizer. For distributive lattices we describe the appearance of an essentially n-ary operation in the centralizer, and for not necessarily distributive lattices we show that the essential arity of operations in the centralizer is always bounded. With the help of these results we can characterize the centralizer clones on the two-element set without any concrete calculations; we partition the Post lattice into five blocks, and the clones in these blocks can be dealt with only three general theorems.

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A description of finite commutative idempotent involutive residuated lattices

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A *(pointed) residuated lattice* is an algebraic structure $\mathbf{A} = \langle A, \wedge, \vee, \cdot, \backslash, /, 1, 0\rangle$ such that $\langle A, \wedge, \vee\rangle$ is a lattice, $\langle A, \cdot, 1\rangle$ is a monoid and $\cdot$ is residuated in the underlying lattice order with residuals $\backslash$ and $/$, i.e. for $a, b, c \in L$, $ab \leq c \Longleftrightarrow a \leq c/b \Longleftrightarrow b \leq a\backslash c$ [2]. From residuals, we can define two *negations*, that is $\sim x := x\backslash 0$ and $-x := 0/x$. A residuated lattice $\mathbf{A}$ is called *involutive* when $-{\sim}a = a = {\sim}{-}a$ for all $a \in A$, is called *idempotent* if $aa = a$ for all $a \in A$ and *commutative* if $ab = ba$ for all $a, b \in A$. When a residuated lattice is commutative both residuals and both negations coincide. The linearly ordered members of the variety of commutative idempotent residuated lattices have been studied in [3].

Let $\mathsf{CIdInRL}$ denote the variety of commutative idempotent involutive residuated lattices. Interesting subvarieties of $\mathsf{CIdInRL}$ include Sugihara monoids, the algebraic semantics of relevance logic RM^t [1].

We characterize the finite members of $\mathsf{CIdInRL}$ as a disjoint union of Boolean algebras under the distributive lattice order $\sqsubseteq$ given by $a \sqsubseteq b$ if and only if $a \cdot b = a$, with involution as complementation within each Boolean algebra. Starting from this characterization, we introduce a *gluing* construction that given $\mathbf{A}, \mathbf{B} \in \mathsf{CIdInRL}$ allow us to build a new commutative idempotent involutive residuated lattice $\mathbf{\Gamma}$ whose universe is $A \cup B$. Showing that we can decompose $\mathbf{\Gamma}$ to obtaining back $\mathbf{A}$ and $\mathbf{B}$, gives us the wanted structural description.

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Applying Farkas' lemma to infinite-domain valued CSPs

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Valued constraint satisfaction problems (VCSPs) are a class of computational optimisation problems. Given a set D, and a set of cost functions Gamma with domain D, the input of the VCSP for Gamma consists of an objective function, i.e., a sum of finitely many cost functions from Gamma, applied to finitely many variables, and a rational threshold u; the task is to decide whether there exists an assignment of values from D to the variables such that the corresponding cost of the objective function is at most u. The computational complexity of VCSPs for sets of cost functions Gamma over a finite set D has been completely classified. In fact, it can be characterised in terms of fractional polymorphisms, which can be seen as probability distributions on the set of operations over D whose expected cost improves the average cost for all cost functions in Gamma. We apply a non-standard generalisation of Farkas' lemma to show that in the case of VCSPs for cost functions over arbitrary countable sets, the sets of fractional polymorphisms provide a local characterisation of the computational complexity.

(Joint work with M. Bodirsky and F. M. Schneider).

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The power graphs of finite and some torsion-free groups

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The *directed power graph* of a group was introduced by Kelarev and Quinn as the simple digraph whose vertex set is the universe of the group, and with $x \to y$ if y is a power of x, while the *power graph* of a group as the underlying undirected graph of the directed power graph. The *enhanced power graph* of a group, which was introduced by Cameron et al., is the graph with the same vertex set such that two vertices x and y are adjacent if they are both powers of some element $z \in G$.

Cameron proved that the power graph of a finite group determines the directed power graph. We prove that the enhanced power graph determines the directed power graph too. Cameron, Guerra and Jurina proved that torsion-free groups of nilpotency class-2 have isomorphic power graphs, then they also have isomorphic directed power graphs, and they posed the question whether this implication also holds when at least one of the two groups is torsion-free of nilpotency class 2. We give the affirmative answer to this question.

Three versions of the definition of the power graph are going to be discussed, and we will prove that the power graph by any of the three versions of the definition determines the other two up to isomorphism.

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On free rs-g-dimonoids

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A *dimonoid* is a nonempty set equipped with two binary operations $\dashv$ and $\vdash$ satisfying the following axioms:

$$(x \dashv y) \dashv z = x \dashv (y \dashv z), \tag{$D1$}$$

$$(x \dashv y) \dashv z = x \dashv (y \vdash z), \tag{$D2$}$$

$$(x \vdash y) \dashv z = x \vdash (y \dashv z), \tag{$D3$}$$

$$(x \dashv y) \vdash z = x \vdash (y \vdash z), \tag{$D4$}$$

$$(x \vdash y) \vdash z = x \vdash (y \vdash z). \tag{$D5$}$$

For a general introduction and basic theory see [1–3]. A nonempty set equipped with two binary operations $\dashv$ and $\vdash$ satisfying the axioms $(D1)$, $(D2)$, $(D4)$, $(D5)$ is called a *generalized dimonoid* [4, 5] or a *g-dimonoid* for short. It is obvious that any dimonoid is a g-dimonoid and an associative 0-dialgebra [6] is a linear analog of a g-dimonoid. Examples of g-dimonoids can be found in [4, 5, 7]. The independence of axioms of a g-dimonoid follows from the independence of axioms of a dimonoid [2]. Free g-dimonoids, free n-nilpotent g-dimonoids and free commutative g-dimonoids were presented in [4, 5] and [7], respectively.

A semigroup S is called *rectangular* if $xyz = xz$ for all $x, y, z \in S$. For example, rectangular bands ($xyx = x$) and zero semigroups ($xy = zu$) are rectangular semigroups. A g-dimonoid $(D, \dashv, \vdash)$ will be called an *rs-g-dimonoid* if $(D, \dashv)$ and $(D, \vdash)$ are rectangular semigroups. The class of all rs-g-dimonoids forms a subvariety of the variety of g-dimonoids. A g-dimonoid which is free in the variety of rs-g-dimonoids will be called a *free rs-g-dimonoid*. Free rs-dimonoids were constructed in [3]. If ρ is a congruence on a g-dimonoid $(D, \dashv, \vdash)$ such that $(D, \dashv, \vdash)/\rho$ is an rs-g-dimonoid, we say that ρ is an *rs-congruence*.

We solve the problem of constructing a free rs-g-dimonoid. We also study separately singly generated free rs-g-dimonoids and describe the least rs-congruence on the free g-dimonoid.

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AAA99 – Schedule of Lectures

Friday, February 21st, Morning

The talks are scheduled for 20 (or 50) minutes in length, followed by a 5 minute discussion period and a 5 minute break in order to allow participants to change sessions.

(Early registration: Thursday 20th 17:00 - 20:00 **Lecture Hall 101**)

08:00 - 09:00	Registration

09:00 - 09:30	Opening: **Lecture Hall 101**

	Lecture Hall 101 Chair: Paolo Aglianò		
9:30 - 10:30	**Mai Gehrke** Sheaves on spectral spaces and the patch monad		

10:30 - 11:00	Coffee break

	Lecture Hall 101 Chair: Ivan Chajda	**Lecture Hall 103** Chair: Erkko Lehtonen	**Lecture Hall 149** Chair: Caterina Viola
11:00 - 11:30	**Miguel A. Marcos** Twist-products and Nelson-type algebras	**Mike Behrisch** On the Burris-Willard conjecture	**Philipp Nuspl** Solving systems of equations of fixed size over finite groups
11:30 - 12:00	**Diego Valota** A description of finite commutative idempotent involutive residuated lattices	**Sebastian Kreinecker** The lattice of monomial clones on finite fields	**Kevin Berg** The complexity of homomorphism factorization
12:00 - 12:30	**Jakub Rydval** Description logics with concrete domains and general concept inclusions revisited	**Florian Aichinger** Chains of clonoids and word orderings	**Archil Kipiani** Cardinalities of automorphism groups of partial mono-unary algebras
12:30 - 13:00	**Marco Abbadini** Priestley duality above dimension zero: algebraic axiomatisability of the dual of compact ordered spaces	**Reinhard Pöschel** The structure of the maximal congruence lattices of algebras on a finite set	**Zbyněk Kurač** Transfer-stable means on finite chains

13:00 - 15:00	Lunch

AAA99 – Schedule of Lectures

Friday, February 21st, Afternoon

	Lecture Hall 101 Chair: Kevin Berg		
15:00 - 16:00	**Pawel Idziak** Circuit satisfiability and solving equations		

16:00 - 16:30	Coffee break

	Lecture Hall 101 Chair: Zarathustra Brady	**Lecture Hall 103** Chair: Miguel Andrés Marcos	**Lecture Hall 149** Chair: Vyacheslav Yu. Shaprynskii
16:30 - 17:00	**Libor Barto** Reconstructing subproducts from projections	**Milan Petrík** Dominance relation on Triangular Norms	**Premysl Jedlicka** Distributive biracks and solutions of Yang-Baxter equation
17:00 - 17:30	**Michael Kompatscher** Failure of local-to-global	**Venkata Krishna Kanduru** On the atomicity of the algebra of conditional logic	**Kritsada Sangkhanan** A partial order on transformation semigroups with restricted range that preserve double direction equivalence
17:30 - 18:00	**Florian Starke** Classification of cyclic height 1 conditions	**Salvatore Scamperti** Logic with atoms and undecidability of definable homomorphism problem for definable graphs	**Teerapong Suksumran** Parametrization of generalized Heisenberg groups: The skew-symmetric case

AAA99 – Schedule of Lectures

Saturday, February 22nd, Morning

	Lecture Hall 101 Chair: Reinhard Pöschel		
9:00 - 10:00	**Dmitriy Zhuk** Why CSP is easy		

10:00 - 10:30	Coffee break

	Lecture Hall 101 Chair: Libor Barto	**Lecture Hall 103** Chair: Diego Valota	**Lecture Hall 149** Chair: Marco Bonatto
10:30 - 11:00	**Zarathustra Brady** Minimal-Taylor algebras	**Anatolii Zhuchok** On free rs-g-dimonoids	**Dmitry Skokov** Special elements of the lattice of epigroup varieties
11:00 - 11:30	**Kristina Asimi** Infinity: Relevant or Irrelevant?	**Vyacheslav Yu. Shaprynskii** Cancellable elements of lattices of semigroup varieties	**Samir Zahirović** The power graphs of finite and some torsion-free groups
11:30 - 12:00	**Caterina Viola** Applying Farkas' lemma to infinite-domain valued CSPs	**László Márki** Morita equivalence of semigroups	**Branimir Seselja** Subnormal subgroups in the framework of weak congruence lattices of groups

12:00 - 14:00	Lunch
14:00 - 15:30	Short tour of Siena

AAA99 – Schedule of Lectures

Saturday, February 22nd, Afternoon

	Lecture Hall 101 Chair: Michael Kompatscher		
15:30 - 16:30	**Andrea Lucchini** The Tarski irredundant basis theorem and the generation of finite groups		

16:30 - 17:00	Coffee break

	Lecture Hall 101 Chair: Nebojša Mudrinski	**Lecture Hall 103** Chair: Florian Starke	**Lecture Hall 149** Chair: Jan Paseka
17:00 - 17:30	**Erhard Aichinger** The degree of a function between two abelian groups	**Delbrin Ahmed** Some large numbers of subuniverses of lattices	**Agnieszka Stocka** Sets of prime power order generators of finite groups
17:30 - 18:00	**Jakob Moosbauer** Chevalley Warning type results on abelian groups	**Bertalan Bodor** Chasing model-complete cores	**Claudia Muresan** Obtaining axiomatizations for varieties generated by antiortholattices with the strong De Morgan property
18:00 - 18:30	**Lydia Lichtenberger** Generating congruence preserving functions of finite groups	**Endre Tóth** On centralizers of finite (semi)lattices, and a simpler way to the centralizers on $\{0,1\}$	

20:30	Social dinner

AAA99 – Schedule of Lectures

Sunday, February 23rd, Morning

	Lecture Hall 101 Chair: Erhard Aichinger	**Lecture Hall 103** Chair: Marco Abbadini	**Lecture Hall 149** Chair: Dmitry Skokov
09:00 - 09:30	**Nebojša Mudrinski** Commutator sequences	**Jan Paseka** Categories of orthogonality spaces	**Barbora Batíková** Semirings of 0,1-preserving endomorphisms of semilattices
09:30 - 10:00	**Marco Bonatto** Commutator theory for skew braces	**Ivan Chajda** Varieties corresponding to classes of complemented posets	**Małgorzata Hryniewicka** Nondistributive rings
10:00 - 10:30	**Erkko Lehtonen** Associative spectra of graph algebras	**Kadir Emir** Strict quantum 2-groups vs simplicial objects	**Karol Pryszczepko** Fully filial rings

10:30 - 11:00	Coffee break

	Lecture Hall 101 Chair: Mike Behrisch		
11:00 - 12:00	**Petar Markovic** On some recent approaches to solving Frankl's union-closed sets conjecture		

12:00 - 12:30	Closing: **Lecture Hall 101**