

# Group, Ring, Language and Related Areas in Computer Science

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The Kyoto University Research Institute for Mathematical Science  
Kyoto University

### Invited Speakers

**Collin Bleak**

University of St Andrews, School of Mathematics and Statistics,  
UK

**Title:** *Embeddings into Finitely Presented Simple Groups*

**Abstract:** In this talk, we describe a process whereby we can embed any hyperbolic group into a finitely presented infinite simple group. This gives a proof of what is, in some sense, the "typical" case of the Boone-Higman Conjecture of 1973 (that a finitely generated group  $G$  has a solvable word problem if and only if  $G$  can be embedded into a finitely presented simple group).

The talk will proceed in three roughly independent parts: A short history of the Boone-Higman Conjecture, a discussion of Hyperbolic groups and an embedding of these into the Rational group of Grigorchuk, Nekrashevych, and Suschanskii, and finally, a discussion of why the topological full group over this rational group is finitely presented and simple, or, at least provides a route to a further embedding in a group that is finitely presented and simple.

Joint with James Belk, Francesco Matucci, and Matthew Zaremsky.

## Alexander Meduna

Brno University of Technology, Department of Information Systems,  
Czech Republic

**Title:** *Grammars with Context Conditions and Their Applications*

**Abstract:** In the classical formal language theory, we can divide grammatical productions into context-dependent and context-independent productions, and based on this division, we can naturally distinct context-dependent grammars, such as phrase-structure grammars, from context-independent grammars, such as context-free grammars. Making a derivation step according to context-dependent productions depends on rather strict conditions satisfied by the context surrounding the rewritten symbol while making a step according to context-independent productions does not, so from this point of view, we obviously always prefer using context-independent grammars to the others. Unfortunately, compared to context-dependent grammars, context-independent grammars are significantly less powerful; in fact, most of them are incapable to grasp some aspects of quite common programming languages. On the other hand, most context-dependent grammars are equivalent to the Turing machines, and this remarkable power represents their indisputable advantage. These pros and cons inspired the modern language theory to introducing some new grammars that simultaneously satisfy these properties-(1) they are based on context-independent productions, (2) their context conditions are significantly simpler than the strict conditions of classical context-dependent productions, and (3) they are as powerful as classical context-dependent grammars.

In the present talk, we overview the most essential types of these grammars, whose alternative context conditions can be classical into these three categories-(A) context conditions placed on derivation domains, (B) context conditions placed on the use of productions, (C) context conditions placed on the neighborhood of the rewritten symbols. As already pointed out, we want the context conditions as small as possible. Therefore, we concentrate the investigation on the reduction of context conditions. Specifically, it reduces the number of some of their components, such as nonterminals or productions. It studies how to achieve this reduction without any decrease in this generative power, which coincides with the power of the Turing machines. By achieving this reduction, it actually makes the partially parallel rewriting more succinct and economical, and this economization is obviously highly appreciated both from a practical and theoretical standpoint. Regarding each of the discussed grammars, we introduce and study their parallel and sequential versions, which represent two basic approaches to grammatical rewriting in today's formal language theory. That is, during a sequential derivation step, a grammar rewrites a single symbol in the current sentential form while during a parallel derivation step, a grammar rewrites all symbols. As context-free and E0L grammars represent perhaps the most fundamental sequential and parallel grammars, respectively, we usually base the discussion of sequential and parallel rewriting upon them.

In the conclusion of this talk, we illustrate the applications of grammars with context conditions by several biologically oriented examples.

The talk is based upon the author's latest book [Handbook of Mathematical Models for Languages and Computation](#) (written along with his PhD students Petr Horáček and Martin Tomko), The Institution of Engineering and Technology, 2020.

Keywords: formal grammars; context conditions; basic properties; language families; reduction; simplification; descriptive complexity; applications; perspectives.

Author: Prof. Alexander Meduna (born 1957 in Olomouc, Czech Republic ) is a theoretical computer scientist and expert on compiler design, formal languages and automata. He is a full professor of Computer Science at the Brno University of Technology. Formerly, he taught theoretical computer science at various European and American universities, including the University of Missouri, where he spent a decade teaching advanced topics of formal language theory. He wrote over ninety papers related to theoretical computer science. His books include

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**Carl-Fredrik Nyberg Brodda**  
University Gustave Eiffel,  
France

**Title:** *Language-theoretic methods in semigroup theory*

**Abstract:** "Language-theoretic methods in combinatorial group theory go back to the fundamental work by Anisimov in the 1970s. Since then, the area has exploded, including such deep theorems as the Muller-Schupp theorem: a group has context-free word problem if and only if it is virtually free. In this talk, I will give a brief overview of historic developments, and then discuss how this area has a rich parallel in the theory of combinatorial semigroup theory. I will give a taste of the kinds of results that can be proved when using language-theoretic methods in semigroup theory, including results on free products, hyperbolic semigroups, analogues of the Muller-Schupp theorem, and how context-free semigroups can behave very differently from context-free groups. I will end by discussing how language-theoretic methods for semigroups can shed light on open questions in group theory, including groups admitting an ETOL/indexed multiplication table, or groups with ETOL/indexed word problem."

## Yuko Murakami

Rikkyo University, Graduate School of Artificial Intelligence and Science Doctoral Program in  
Artificial Intelligence and Science,  
Japan

**Title:** *Elucidation of completeness of achievement stit logic of agency*

**Abstract:** The see-to-it-that (stit) logic of agency is proposed in Belnap-Perloff-Xu(2001). Among stit logics, deliberative stit (dstit) logic has been popular in connection to other operators, especially epistemic and dynamic modalities. In the model of dstit agency, the moment of action evaluation coincides with that of the action itself. We do not have to consider any tacit tense behind the notion of action in dstit. The very notion of tense, however, is essential in the conceptual analysis of agency: the moment of action must precede the moment of evaluation of the action. Achievement stit (astit) logic of agency reflects the insight to model the concept of action on branching time model to allow indeterminism of action for rooms of free will. This talk aims to illustrate the line of thought behind the completeness theorem of achievement stit logic of agency, so as to invite audience to investigate extensions and variations of astit.

### References

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### In Japanese:

**Title:** 達成行為論理の完全性証明の説明

**Abstract:** Belnap-Perloff-Xu(2001) では stit 行為論理の背景となる哲学的洞察に基づく論理体系が提案されている。そのうちその後の研究が多くなされている (Olkhovikov-Wansing 2019) 熟考行為論理 (deliberative stit logic) では行為時点が行為の評価と同時点となっている。だが、より行為論へ適切に応用できる達成行為論理については後続研究がほとんどない。達成行為論理では、行為評価に先立つ時点で行為がなされるタイプの行為概念について、時制論理の樹状モデル上に行為様相にかかる真理条件を導入してモデル化することにより、行為論における非決定論の数理モデルを与えようとする。この論理を公理化した達成行為論理体系の完全性証明について、直観的な理解につながるように説明する。

## Takeo Uramoto

Kyushu University, Institute of Mathematics for Industry,  
Japan

**Title:** *On algebraic language theory, Galois theory, and class field theory*

**Abstract:** In this talk, I will introduce some of my recent works on algebraic language theory, and its connection to Galois theory and classical class field theory. Algebraic language theory generally concerns classification of formal languages by means of algebra; Eilenberg theory in particular focuses on classification of regular languages by means of finite semigroup theory, where typical results, say Schützenberger's pioneering result in 1965, states that a regular language  $L$  can be defined by first-order formula of Büchi's monadic second-order logic on finite words if and only if its syntactic monoid  $M(L)$  contains only trivial subgroups; this connects combinatorial/logical describability of regular languages with purely semigroup-theoretic property of their syntactic monoids; and Eilenberg theory has developed similar results on the connection between regular languages and finite monoids. These results in Eilenberg theory are analogous to classical results in Galois theory, where, say, Galois' theorem states that the solutions of a polynomial equation  $f(x)=0$  can be written by four arithmetic operations and taking roots if and only if its Galois group is soluble. This talk first introduces that this analogy can be in fact justified by a suitable category-theoretic duality theorem; and then that this connection between Eilenberg's theory and Galois' theory sheds new light on classical class field theory, in particular, the theory of complex multiplication. I may also discuss some future directions related to these results.