MEMO

To: Sabbatical Leave Committee

From: George Voutsadakis

Date: November 14, 2018

Subject: Sabbatical Leave Application Fall 2019-Spring 2020

Research Collaboration on Abstract Algebraic Logic and Explorations on Coalgebraic Methods in Computational Synthetic Biology

We propose a tour of three European cities to expand research collaboration in the field of Abstract Algebraic Logic and explore potential for future collaboration in the field of (co)algebraic methodologies in computational synthetic biology. The tour envisions both research on projects of common interest in overlapping areas of expertise with mathematicians at the host institutions, and seminars and tutorial lectures at the University of Aveiro, Aveiro, Portugal, the University of Minho, Braga, Portugal, and the National Technical University of Athens, Athens, Greece. The lectures shall have a dual goal: First, provide information regarding some very recent research developments and, second, explore potential for new collaborations between the hosts and the visiting logician. Among these, we plan to explore the potential for collaboration under the auspices of Project KLEE on coalgebraic methods in computational synthetic biology, housed at the Universities of Minho and Aveiro in Portugal.

Please, find enclosed:

1. My Sabbatical Leave Application for the academic year 2019-2020;
2. My proposal and goals for the sabbatical;
3. My resume;
4. Letters of Invitation and acceptance by:
    a. Professor Konstantinos Chrysafinos, Department of Applied Mathematics and Natural Sciences, National Technical University of Athens, Greece;
    b. Professor Manuel Antonio Martins, Department of Mathematics, University of Aveiro, Aveiro, Portugal;
    c. Professor Luis Soares Barbosa, Department of Informatics, School of Engineering, University of Minho, Braga, Portugal.

Title and Description of Sabbatical Project.

Provide a document that describes your proposed sabbatical activities. The document should include at a minimum the following components:

- *Project Abstract/Executive Summary:* A summary of the sabbatical project and outcome (150 word maximum).
- *Project Description: A detailed description of the sabbatical project with the following sections:*
  - *Introduction:* Provide an introduction to the topic/field of study.
  - *Background:* Provide information regarding previous work/activities related to the project.
  - *Outcome:* Describe the work to be completed and state the specific outcome(s) of the project. This section must address at least one of the following.
    i. The strength of the relationship between the sabbatical leave proposal involving applied or theoretical research related to professional activities and the advancement of knowledge within disciplinary areas.
    ii. The strength of the relationship between the sabbatical leave proposal involving an external, professionally-related experience/study in a business, industrial, health care, scientific or educational setting and the improvement of instructional/professional activities at the University.
    iii. The strength of the relationship between the sabbatical leave proposal involving travel or advanced study and its yield in improving the quality of instruction at the University.
  - *Timeline:* Provide a timeline for the proposed project activities.

Research Collaboration on Abstract Algebraic Logic and Explorations on Coalgebraic Methods in Computational Synthetic Biology

Sabbatical Leave Application, Year 2019-2020

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Abstract

We propose a tour of three European cities to expand research collaboration in the field of Abstract Algebraic Logic and explore potential for future collaboration in the field of (co)algebraic methodologies in computational synthetic biology. The tour envisions both research on projects of common interest in overlapping areas of expertise with mathematicians at the host institutions, and seminars and tutorial lectures at the University of Aveiro, Aveiro, Portugal, the University of Minho, Braga, Portugal, and the National Technical University of Athens, Athens, Greece. The lectures shall have a dual goal: First, provide information regarding some very recent research developments and, second, explore potential for new collaborations between the hosts and the visiting logician. Among these, we plan to explore the potential for collaboration under the auspices of Project KLEE on coalgebraic methods in computational synthetic biology, housed at the Universities of Minho and Aveiro in Portugal.

1 Introduction

1.1 Historical Remarks

Abstract Algebraic Logic (AAL) is the area of mathematical (or symbolic) logic that explores the interaction between logical systems and classes of algebraic systems. Its origins date back to the 1850 work "An Investigation of the Laws of Thought" [6] of the English logician George Boole. Its "modern" or "abstract" form may be said to have originated in the work of the Polish School of Logic, also known as the Lwów-Warsaw School of Logic. Pioneers included Helena Rasiowa and Roman Sikorski with the former having authored a very influential monograph [42] (see [18, 19] for more information on Rasiowa's contributions to the development of the field). A more general, one might say "truly abstract", approach to the algebraization of logical systems, which ushered in a period of intense and fruitful study that culminated in the late 1980's in the present state-of-the-art of the discipline, was initiated by the contemporary Polish logicians Prucnal and Wroński [40] and Czelakowski [13, 14], with their study of the so-called equivalential logics. This line of investigations reached its full level of maturity with the extremely influential seminal "Memoirs" monograph "Algebraizable Logics" [3] by Wim Blok and Don Pigozzi, who, in some sense, may be attributed the cognomen "Fathers of Abstract Algebraic Logic".

Abstract Algebraic Logic, or, as Josep Maria Font advocates in the introduction of his very recent book on the subject [20], simply "Algebraic Logic" (as it has evolved over time in its present form) studies, generally speaking, the interaction between logical and algebraic systems. The goal is to associate with a logical system under consideration a class of algebras whose equational deductive apparatus is related as closely as possible to the deductive apparatus of the logical system. Since algebra is a much older and very well-developed field of mathematics, the hope is that, in this way, the powerful tools of algebra can be brought to bear to draw conclusions and discover properties of the logical system, based on the established association.

A prototypical example of this process is the association to classical propositional logic of the class of Boolean algebras. Another very well-known example, originating in the philosophical work on intuitionism by the Dutch logicians Brouwer [7, 8] and Heyting [31], is the association to intuitionistic propositional logic of the class of Heyting algebras. This process was adapted by Alfred Tarski and Paul Halmos, who extended it to the realm of first-order logic, the former associating to it the class of cylindric algebras [29, 30]

and the latter the class of polyadic algebras [28].

1.2 Focus of the Field Today

At present, AAL focuses on three distinct, but closely interrelated directions.

1. The study of the abstract process by which a class of algebras is associated with a given logical system. The prototypical example is the process of association of the so-called Lindenbaum-Tarski Boolean algebras with classical propositional logic. In its modern form, the process consists of refinements and generalizations of this paradigm. This direction has been so fruitful that it has provided the field with one of its most glittering jewels, the Leibniz Hierarchy of sentential logics, a hierarchy in which logical systems are categorized according to the strength of their ties with their canonically associated classes of algebras. This hierarchy is depicted in Figure 1, borrowed from [37]. Its most important classes and their properties are encountered in detail in the monograph [21], the books [15, 20] and the article [22].

2. The study of the classes of algebras associated with specific (classes of) deductive systems. Again the extensive study of Boolean and of Heyting algebras, as well as the implicative algebras, that serve as the algebraic counterparts of Rasiowa's implicative logics, constitute prototypical examples. This direction is the one that is, naturally, the most amenable to results, methods and techniques of universal algebra [9, 34, 1].

3. The study of the correspondence between metalogical properties of classes of logical systems and algebraic properties of classes of algebras. The prototypical example in this direction, which motivated much of the original work of Blok and Pigozzi and led to their study of algebraization, is the correspondence between the deduction-detachment property in logic and the algebraic property of having equationally definable principal relative congruences [5].

Besides the rough classification of the contemporary explorations in AAL in one of these three directions, another, vertical classification, can be discerned between the study of propositional versus non-propositional logical systems.

In the non-propositional domain, the classical approach was to study first-order logic, equational logic and various combinations and expansions individually, mostly in the context of cylindric and polyadic algebras or closely associated classes of algebras, such as first-order modal algebras.

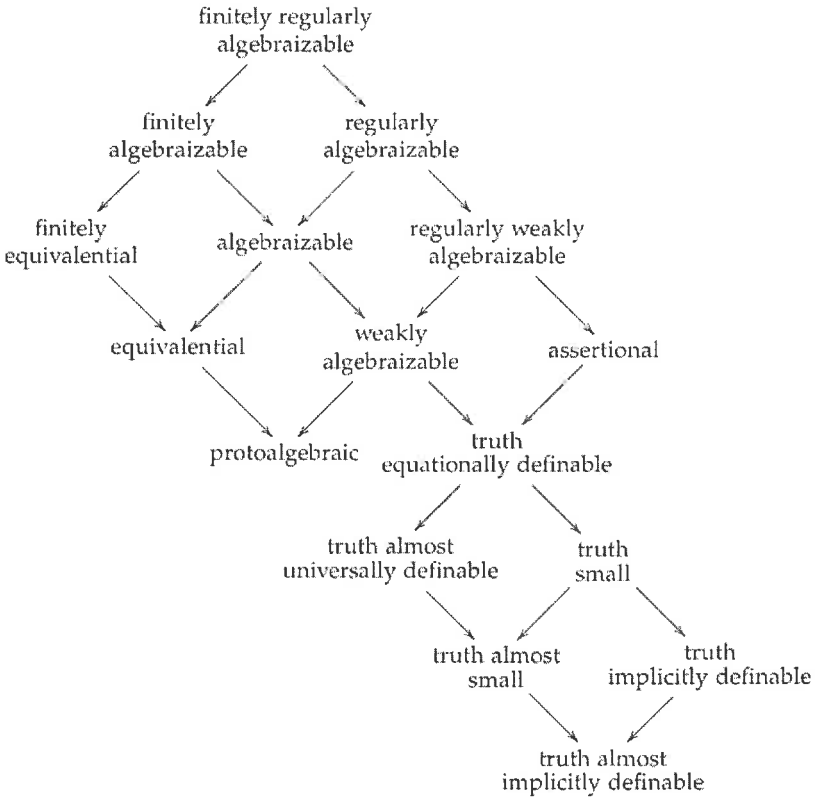

Figure 1: The Leibniz Hierarchy of Abstract Algebraic Logic

A more abstract approach was initiated by Voutsadakis, under the influence of preceding work by Diskin [16] and under the supervision of Don Pigozzi, in the doctoral dissertation [43] and subsequent work (see, e.g., [44, 45]). This direction, called Categorical Abstract Algebraic Logic (CAAL), involved the use of π-institutions, as introduced by Fiadeiro and Sernadas [17], as the underlying supporting structures of logical systems. π-institutions constitute a modification of institutions, that were introduced by Goguen and Burstall [27] in the context of the specification of data structures and programming languages in theoretical computer science. Many of the concepts, methods and results in all three directions above, that had previously been studied in the context of propositional logics, were extended and/or adapted to the case of logical systems formalized as π-institutions.

The bulk of this proposal revolves around further studying aspects of the algebraization of π-institutions, partially based on some very recent results, produced in doctoral dissertations that were completed in the last few years, in the framework of propositional logics.

2 Background on the Collaboration

Voutsadakis initiated in the mid 1990's, starting with [43], the study of the algebraization of logical systems formalized as π-institutions, a subarea of AAL known as Categorical AAL. On the other hand, Manuel António Martins, of the Department of Mathematics of the University of Aveiro, studied in his dissertation [32] and in subsequent work (e.g., [10]) the algebraization of multi-sorted hidden logics. These are logical systems intended to model computing machines, which can manipulate data of multiple sorts and, in addition, operate on both visible data (input/output) and hidden data, i.e., data that take part in the computational process but are not visible to the user, such as state variables. Voutsadakis, taking after this work of Martins and of his collaborators, contributed to these investigations in [49] and, subsequently gave a presentation of Martin's work as an invited speaker at the 7th Panhellenic Logic Symposium held at the University of Patras, Greece, in the summer of 2009.

These activities led to a first collaboration between Martins and Voutsadakis while the author was an invited consultant in 2011, under the auspices of the MONDRIAN project, at both the University of Aveiro and the University of Minho in Portugal. This cooperation led to the publication of [33] and enabled Voutsadakis to get acquainted with, and advocate for, the work of students at those two host institutions.

For this sabbatical, a proposal is made to:

- expand collaboration in order to extend some of the results already obtained in our previous collaboration;
- explore the potential for collaboration on new projects of common interest;
- update Voutsadakis on a new project, Project KLEE, hosted by the Universities of Minho and Aveiro on (co)algebraic methods in Computational Synthetic Biology and explore the possibility of starting a new collaboration in this interdisciplinary area, where expertise is pulled from logic and algebra, as well as from biological and computational sciences.

3 Proposed Outcomes

1. **Authorship of an Online Monograph in CAAL**

   Categorical Abstract Algebraic Logic, under Voutsadakis' leadership, has now matured to an autonomous subarea of AAL with its own methods and a variety of results. This past summer, Voutsadakis felt that it was time that the notions and results accumulated over the last two decades of research in this area should be pulled together and systematized in a new monograph for future consultation and use. Thus was started the online effort [52]. In this Sabbatical Proposal, some emphasis will be given in continuing authorship of this online monograph. It is, however, a rather ambitious project, which involves not only revisiting and reworking previously obtained results, but also new research on open questions and new investigations on how various results fit together in the bigger picture. We propose to advance the project during this Sabbatical, even though it will require several years until its culmination.

2. **The Categorical Leibniz Hierarchy**

   Very recently, in his doctoral dissertation [35], Moraschini extended the Leibniz hierarchy of propositional logics to the form depicted in Figure 1. Most of the classes in this hierarchy have counterparts in a similar hierarchy applicable to logics formalized as π-institutions. This latter hierarchy, termed the categorical hierarchy, has been established gradually in a series of papers published by Voutsadakis [46, 47, 48, 50, 51, 44]. However, at least two broad problems remain open and must be considered:

   - The exact relationship between the various classes of the categorical hierarchy has not been fully established. There are many inclusions which have not been shown to be proper. Moreover, it is typically the case that a single class in the propositional Leibniz hierarchy gives rise to two or more classes in the categorical hierarchy, whose interconnections need, likewise, further investigation.
   - The very recently introduced classes at the bottom of the Leibniz hierarchy [35], that lie below the class of the truth-equational logics of Raftery [41], do not have categorical analogs yet.

Another proposed goal of this Sabbatical is to investigate these problems pertaining to the algebraic hierarchy of π-institutions.

3. **Categorical Aspects of Algebraization Based on Implication**

   In two relatively recent papers [11, 12], Cintula and Noguera presented a new hierarchy of propositional logics, called the "implicational hierarchy", which expands the Leibniz hierarchy. The idea is to base the process of associating a class of algebras to a given logical system not on the relation of indiscernibility between formulas, as is done in the classical Lindenbaum-Tarski process and its various extensions and refinements leading to the Leibniz hierarchy, but rather on the relation of implication between formulas. Besides enriching the traditional hierarchy with more classes, this process also suggests new directions of research. We propose to undertake research during the Sabbatical on extending this work to the categorical hierarchy. In fact this direction of research will inform one of the chapters of the online monograph whose continued authorship was proposed above.

4. **The Equivalence Theorem in Categorical Terms**

   In [3] Blok and Pigozzi provided a characterization of algebraizability via a syntactic and a semantic isomorphism theorem. Later, Blok and Pigozzi [4], Blok and Jónsson [2] and Voutsadakis [45] gave versions of this theorem that were broader in scope by realizing that the notion of algebraizability was only a specific instance of the much more encompassing notion of (deductive) equivalence between two logical systems. These theorems were further generalized by Gil-Férez [26], Galatos and Tsinakis [25] and Galatos and Gil-Férez [24]. Based on these, one might say "third-generation", advances, Font and Moraschini [23] and Moraschini [36] investigated some novel aspects of the equivalence. Their work has resulted, on the one hand, in the characterization of the equivalence of M-sets, first studied by Blok and Jónsson [2], and, on the other, a framework for the study of the semantic isomorphism theorem by way of a newly introduced kind of structure, called "evaluation frame".

   These two novel approaches to M-sets and to the semantic isomorphism theorem have, we believe, important - and as yet unexplored - consequences for logics formalized as π-institutions.

   We propose to investigate these consequences and clarify the connections between the aforementioned results and logics formalized as π-

institutions.

5. **Seminars: Logic, Algebra, Biology and Computation**

   This last part of the proposal is more closely related to teaching and to interdisciplinary work. As already indicated previously, we propose to organize some seminars and lecture engagements in order to inform and get informed on new research developments and to explore new potential for collaborations. Some directions that we have in mind are given below, but, since we are not up to speed on those and the seminars will serve to divulge and provide information, we provide fewer details.

   i. **Computational Aspects of Abstract Algebraic Logic**

      A part of Abstract Algebraic Logic that has seen rapid development recently, due to inspirational work by Moraschini [38, 39], is the one related to computational aspects of the field. The following advances have been made:

      - In [38], Moraschini showed that, in general, there is no algorithm for classifying a logic, presented syntactically via a Hilbert calculus, in the classes of the Leibniz hierarchy. On the contrary, it is shown that such an algorithm exists in case a logic is presented semantically, via a finite set of finite logical matrices.
      - In [39], Moraschini showed that the problem of determining whether a finite reduced logical matrix of finite type determines an algebraizable, an order algebraizable, a weakly algebraizable, an equivalential or a protoalgebraic logic is complete for ExpTime. On the other hand, the same problem for the class of truth-equational logics is shown to be ExpTime-hard, but its membership into ExpTime remains unresolved.

      Given only cursory familiarity with this direction of research, we propose, during this Sabbatical to further study this line of research and present a selection of its results in a seminar.

   ii. **Algebraic Methods in Computational Synthetic Biology**

      Professor Barbosa from the University of Minho and Professor Martins from the University of Aveiro, with a team of students and collaborators are using (co)algebraic methods and techniques

to advance computational methods in synthetic biology. Voutsadakis, with their support, will attend seminar lectures and meetings to get acquainted on the details of this ongoing project. Discussions will follow to explore the possibility of pooling together relevant expertise to advance and enhance aspects of the project, which will provide partial funding for local visits.

The presentations will clearly provide valuable experience to the visiting faculty and will contribute to increasing the quality of both his understanding of deep mathematical ideas and his presentation skills. Moreover, they will help acquaint the visiting faculty with novel ideas in current trends of interdisciplinary work in areas of confluence of mathematics, logic, computational sciences and biology. Finally, the international experience in diverse environments and the "networking" with internationally recognized colleagues in the field of expertise (and related fields) will be extremely valuable.

4 Timeline

The following is a tentative timeline, since the details are to be arranged and finalized in cooperation with the host institutions upon approval of this Sabbatical Application.

- Beginning of Fall 2019, Sault Sainte Marie: Prepare lectures, refine planning of visits and initiate collaboration. Make transportation and living arrangements.
- Mid of Fall 2019: Spend a month in Portugal, advancing the proposed collaboration and giving a series of lectures/tutorials.
- End of Fall 2019 - Beginning of Spring 2020: Spend 1-2 months at the National Technical University of Athens (NTUA), present a series of tutorials and explore paths of collaboration with local mathematicians, based on these lectures.
- Mid of Spring 2020: Spend a second month in Portugal, with the goal of further advancing the status of the proposed collaboration and, hopefully, bring, at least part of it, to a closure and prepare some manuscript(s) for publication.

- End of Spring 2020: Return to Sault Sainte Marie, perhaps via a second stop at NTUA, further exploring and advancing common projects in progress.

Acknowledgements

The author wishes to express his gratitude to the three institutions that have already accepted a proposal of hosting him during part of this Sabbatical Leave. Special thanks go to Manuel António Martins of Aveiro, Luís Soares Barbosa of Minho in Braga and Konstantinos Chrysafinos of Athens for their willingness to understake preliminary arrangements and for their enthusiasm and efficiency in forwarding this proposal through appropriate channels.

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Education

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  Ph.D., Computer Science — *Jan. 2008 - May 2010*
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  Diploma, Computer Engineering and Informatics — *Sep. 1988 - May 1993*
  - Thesis Title: Valuation Theory of Fields
  - Advisor: Paul Lentoudis

Work Experience

- **Lake Superior State University, Mathematics** — Sault Sainte Marie, MI
  Tenured Assistant Professor — *Sep. 2010 - Present*
- **Iowa State University, Computer Science** — Ames, IA
  Research Assistant — *Jan. 2008 - June 2010*
- **Iowa State University, Mathematics** — Ames, IA
  Lecturer — *Jan. 2008 - June 2010*
- **Lake Superior State University, Mathematics** — Sault Sainte Marie, MI
  Assistant Professor — *Aug. 2002 - Dec. 2007*
- **Physical Sciences Laboratory, New Mexico State University** — Las Cruces, NM
  Research Scientist — *Jul. 2000 - May. 2002*
- **New Mexico State University, Mathematics** — Las Cruces, NM
  Adjunct Assistant Professor — *Jul. 2000 - May 2001*
- **Case Western Reserve University, Mathematics** — Cleveland, OH
  Visiting Assistant Professor — *Aug. 1998 - Jun. 2000*
- **Iowa State University, Mathematics** — Ames, IA
  Teaching Assistant — *Aug. 1993 - Jul. 1998*
  - **Teaching Excellence Award 1997**
  - **Aggie Ho Award for Outstanding Research in Pure Mathematics 1997**

Research (Web-Site)

Research Interests

Mathematics: Algebraic Logic, Categorical and Universal Algebra, Ordered Structures

Computer Science: Knowledge Representation and Knowledge Acquisition in AI, Modular Description Logics, Privacy-Preserving Reasoning on the Semantic Web

Grants

Project MONDRIAN Foundations for architectural design: Service certification, dynamic reconfiguration and self-adaptability, Consultant and Project Visitor, Location: University of Minho and University of Aveiro, Portugal

Center for Information Protection: CIP A grant to study secrecy-preserving reasoning in multiagent environments, Total Award Amount: $25,000, Location: Iowa State University

National Science Foundation: SGER Exploratory Investigation of Modular Ontologies (with V. Honavar, D. Caragea and G. Slutzki), Total Award Amount: $112,000, Location: Iowa State University

Publications

Dissertations:

1. *Categorical Abstract Algebraic Logic*, Doctoral Dissertation, Department of Mathematics, **Iowa State University**, Ames, IA, August 1998
2. *Federated Description Logics for the Semantic Web*, Doctoral Dissertation, Department of Computer Science, **Iowa State University**, Ames, IA, May 2010

Book:

1. *Discrete Mathematics: Problems and Solutions* (in Greek), with L. Kirousis, Ch. Bouras and P. Spirakis, **Gutenberg**, Athens 1994

Book Chapter:

1. *Package-based Description Logics*, with Jie Bao, Giora Slutzki and Vasant Honavar, in "Modular Ontologies", H. Stuckenschmidt et al. (eds.), **Lecture Notes in Computer Science**, Vol. 5445 (2009), pp. 349-371
2. *Categorical Abstract Algebraic Logic: Compatibility Operators and Correspondence Theorems*, in "Don Pigozzi on Abstract Algebraic Logic, Universal Algebra and Computer Science", J. Czelakowski (ed.), **Outstanding Contributions to Logic**, Vol. 16 (2018), pp. 421-454

Journal Articles:

1. *A Duality Theory for Bilattices*, with B. Mobasher, D. Pigozzi and G. Slutzki, **Algebra Universalis**, Vol. 43 (2000), pp. 109-125

2. *Categorical Abstract Algebraic Logic: Algebraizable Institutions*, **Applied Categorical Structures**, Vol. 10 (6) (2002), pp. 531-568
3. *Polyadic Concept Analysis*, **Order**, Vol. 19 (3) (2002), pp. 295-304
4. *Categorical Model Theory and Quasigroup Homotopies*, **Theory and Applications of Categories**, Vol. 11 (1) (2003), pp. 1-14
5. *Threshold Agent Networks: An Approach To Modelling and Simulation*, **Applied Mathematics and Computation**, Vol. 142 (2003), pp. 521-543
6. *A Categorical Construction of a Variety of Clone Algebras*, **Scientiae Mathematicae Japonicae**, Vol. 8 (2003), pp. 215-225
7. *Categorical Abstract Algebraic Logic: Metalogical Properties*, **Studia Logica**, Vol. 74 (3) (2003), pp. 369-398
8. *Categorical Abstract Algebraic Logic: The Criterion for Deductive Equivalence*, **Mathematical Logic Quarterly**, Vol. 49 (4) (2003), pp. 347-352
9. *Categorical Abstract Algebraic Logic: Equivalent Institutions*, **Studia Logica**, Vol. 74 (1/2) (2003), pp. 275-311
10. *A Categorical Approach to Threshold Agent Networks*, **Applied Categorical Structures**, Vol. 12 (2) (2004), pp. 203-223
11. *On the categorical algebras of first-order logic*, **Scientiae Mathematicae Japonicae**, Vol 10 (2004), pp. 47-54
12. *On the Limit Cycle Structure of Threshold Boolean Networks over Complete Graphs*, **International Journal of Neural Systems**, Vol. 14 (3) (2004), pp. 209-215
13. *The Categories of Finitary Binary Functions and Finite Automata Networks*, **Scientiae Mathematicae Japonicae**, Vol. 11 (2004), pp. 233-240
14. *Categorical Abstract Algebraic Logic: Categorical Algebraization of Equational Logic*, **Logic Journal of the IGPL**, Vol. 12 (4) (2004), pp. 313-333
15. *Categorical Abstract Algebraic Logic: Categorical Algebraization of First-Order Logic Without Terms*, **Archive for Mathematical Logic**, Vol. 44 (4) (2005), pp. 473-491
16. *Categorical Abstract Algebraic Logic: Protoalgebraicity and Leibniz Theory Systems*, **Scientiae Mathematicae Japonicae**, Vol. 18 (2005), pp. 167-175
17. *Remarks on Classifications and Adjunctions*, **Rendiconti del Circolo Matematico di Palermo**, Vol. 54 (2) (2005), pp. 50-70
18. *Categorical Abstract Algebraic Logic: $(\mathcal{I}, N)$-algebraic systems*, **Applied Categorical Structures**, Vol. 13 (3) (2005), pp. 265-280
19. *Categorical Abstract Algebraic Logic: Gentzen π-Institutions and the Deduction-Detachment Property*, **Mathematical Logic Quarterly**, Vol. 51 (6) (2005), pp. 570-578
20. *Corrigendum to "Categorical abstract algebraic logic: The criterion for deductive equivalence"*, **Mathematical Logic Quarterly**, Vol. 51 (6) (2005), pp. 644-644
21. *Categorical Abstract Algebraic Logic: Models of π-Institutions*, **Notre Dame Journal of Formal Logic**, Vol. 46 (4) (2005), pp. 439-460
22. *Categorical Abstract Algebraic Logic: Partially Ordered Algebraic Systems*, **Applied Categorical Structures** Vol. 14, No. 1 (2006), pp. 81-98
23. *Categorical Abstract Algebraic Logic: The Largest Theory System Included in a Theory Family*, **Mathematical Logic Quarterly**, Vol. 52, No. 3 (2006), pp. 288-294
24. *Categorical Abstract Algebraic Logic: Full Models, Frege Systems and Metalogical Properties*, **Reports on Mathematical Logic**, Vol. 41 (2006), pp. 31-62

25. *n-Closure Systems and n-Closure Operators*, **Algebra Universalis**, Vol. 55 (2006), pp. 369-386

26. *Categorical Abstract Algebraic Logic: Operators on Classes of Structure Systems*, **Scientiae Mathematicae Japonicae**, Vol. 19 (2006), pp. 1009-1023

27. *Categorical Abstract Algebraic Logic: Leibniz Equality and Homomorphism Theorems*, **Applied Categorical Structures**, Vol. 14, No. 4 (2006), pp. 357-376

28. *Categorical Abstract Algebraic Logic: More on Protoalgebraicity*, **Notre Dame Journal of Formal Logic**, Vol. 47, No. 4 (2006), pp. 487-514

29. *Categorical Abstract Algebraic Logic: Ordered Equational Logic and Algebraizable PoVarieties*, **Order**, Vol 23, No. 4 (2006), pp. 297-319

30. *Categorical Abstract Algebraic Logic: Structure Systems and Łos' Theorem*, **Far East Journal of Mathematical Sciences**, Vol. 24, No. 1 (2007), pp. 73-98

31. *Categorical Abstract Algebraic Logic: Subdirect Representation of PoFunctors*, **Communications in Algebra**, Vol. 35, No. 1 (2007), pp. 1-10

32. *Categorical Abstract Algebraic Logic: Prealgebraicity and Protoalgebraicity*, **Studia Logica**, Vol. 85, No. 2 (2007), pp. 217-251

33. *Categorical Abstract Algebraic Logic: The Diagram and Reduction Operator Lemmas*, **Mathematical Logic Quarterly**, Vol. 53, No. 2 (2007), pp. 147-161

34. *Categorical Abstract Algebraic Logic: Strong Version of a Protoalgebraic π-Institution*, **Reports on Mathematical Logic**, Vol. 42 (2007), pp. 19-46

35. *Dedekind-MacNeille Completion of n-Ordered Sets*, **Order**, Vol. 24, No. 1 (2007), pp. 15-29

36. *Categorical Abstract Algebraic Logic: Gentzen π-Institutions*, **Scientiae Mathematicae Japonicae**, e-2007, pp. 407-422

37. *Categorical Abstract Algebraic Logic: The Categorical Suszko Operator*, **Mathematical Logic Quarterly**, Vol. 53, No. 6 (2007), pp. 616-635

38. *Categorical Abstract Algebraic Logic: Equivalential π-Institutions*, **Australasian Journal of Logic**, Vol. 6 (2008), 24 pp.

39. *Categorical Abstract Algebraic Logic: Bloom's Theorem for Rule-Based π-Institutions*, **Logic Journal of the IGPL**, Vol. 16, No. 3 (2008), pp. 233-248

40. *Categorical Abstract Algebraic Logic: Local Characterization Theorems for Classes of Systems*, **Communications in Algebra**, Vol. 36, No. 8 (2008), pp. 3093-3112

41. *Categorical Abstract Algebraic Logic: Structurality, Protoalgebraicity and Correspondence*, **Mathematical Logic Quarterly**, Vol. 55, No. 1 (2009), pp. 70-86

42. *Categorical Abstract Algebraic Logic: Syntactically Algebraizable π-Institutions* **Reports on Mathematical Logic**, Vol. 44 (2009), pp. 105-151

43. *Categorical Abstract Algebraic Logic: Subdirect Representation for Classes of Structure Systems*, **Advances and Applications in Mathematical Sciences**, Vol. 1, No. 1 (2009), pp. 37-64

44. *Package-based Description Logics*, with Jie Bao, Giora Slutzki and Vasant Honavar, in Modular Ontologies, H. Stuckenschmidt et al. (eds.), **Lecture Notes in Computer Science**, Vol. 5445 (2009), pp. 349-371

45. *Universal Dialgebra: Unifying Universal Algebra and Coalgebra*, **Far East Journal of Mathematical Sciences**, Vol. 44, No. 1 (2010), pp. 1-53

46. *A Probabilistic Federated $\mathcal{ALCI}$*, **Advances in Computer Science and Engineering**, Vol. 5, No. 2 (2010), pp. 131-172

47. *Categorical Abstract Algebraic Logic: On Admissible Equivalence Systems*, **Advances and Applications in Mathematical Sciences**, Vol. 10, No. 6 (2011), pp. 583-604
48. *Secrecy Logic: $\mathcal{S}$-Secrecy Structures*, **Turkish Journal of Mathematics**, Vol. 36, No. 1 (2012), pp. 1-27
49. *Categorical Abstract Algebraic Logic: Closure Operators on Classes of Pofunctors*, **Armenian Journal of Mathematics**, Vol. 4, No. 1 (2012), pp. 1-24
50. *Secrecy Logic: Protoalgebraic $\mathcal{S}$-Secrecy Logics*, **Reports on Mathematical Logic**, Vol. 47 (2012), pp. 3-28
51. *F-$\mathcal{ALCIK}$: Fully Contextualized Federated $\mathcal{ALCI}$ with Epistemic Operators*, **Advances in Computer Science and Engineering**, Vol. 8, No. 1 (2012), pp. 1-30
52. *Categorical Abstract Algebraic Logic: Coordinatization is Algebraization*, **Reports on Mathematical Logic**, Vol. 47 (2012), pp. 125-145
53. *Categorical Abstract Algebraic Logic: Generalized Tarski Congruence Systems*, **Advances in Mathematics Research**, Vol. 17 (2012)
54. *Categorical Abstract Algebraic Logic: Meet-Combination of Logical Systems*, **Journal of Mathematics**, Vol. 2013 (2013), 8pp
55. *Categorical Abstract Algebraic Logic: Algebraic Semantics for π-Institutions*, **Mathematical Logic Quarterly**, Vol. 59, No. 3 (2013), pp. 177-200
56. *Categorical Abstract Algebraic Logic: Referential Algebraic Semantics*, **Studia Logica**, Vol. 101, No. 4 (2013), pp. 849-899
57. *Malinowski Modalization, Modalization through Fibring and the Leibniz Hierarchy* (with Manuel António Martins), **Logic Journal of the IGPL**, Vol. 21, No. 5 (2013), pp. 836-852
58. *Categorical Abstract Algebraic Logic: Behavioral π-Institutions*, **Studia Logica**, Vol. 102, No. 3 (2014), pp. 617-646
59. *Categorical Abstract Algebraic Logic: Cryptofibring of Logical Systems* **Advances and Applications in Mathematical Sciences**, Vol. 13, No. 4 (2014), pp. 155-194
60. *Categorical Abstract Algebraic Logic: Truth-Equational π-Institutions*, **Notre Dame Journal of Formal Logic**, Vol. 56, No. 2 (2015), pp. 351-378
61. *Categorical Abstract Algebraic Logic: Referential π-Institutions*, **Bulletin of the Section of Logic**, Vol. 44, Vol. 1/2 (2015), pp. 33-51
62. *Categorical Abstract Algebraic Logic: Tarski Congruence Systems, Logical Morphisms and Logical Quotients*, **Journal of Pure and Applied Mathematics: Advances and Applications**, Vol. 13, No. 1 (2015), pp. 27-73
63. *Categorical Abstract Algebraic Logic: Skywatching in Semilattice Systems*, **Logic Journal of the IGPL**, Vol. 24, No. 2 (2016), pp. 138-155
64. *Categorical Abstract Algebraic Logic: Weakly Referential π-Institutions*, **Reports on Mathematical Logic**, Vol. 51 (2016), pp. 91-103
65. *Categorical Abstract Algebraic Logic: Hidden Multi-Sorted Logics as Multi-Term π-Institutions*, **Bulletin of Symbolic Logic**, Vol. 45, No. 2 (2016), pp. 111-124
66. *Categorical Abstract Algebraic Logic: Wjcicki's Conjecture and Malinowski's Theorem*, **Reports on Mathematical Logic**, Vol. 52 (2017), pp. 69-82
67. *Categorical Abstract Algebraic Logic: Pseudo-Referential Matrix System Semantics*, **Bulletin of the Section of Logic**, Vol. 47, No. 2 (2018), pp. 69-88

Conference/Workshop Articles:

1. *On the Decidability of Role Mappings between Modular Ontologies*, with Jie Bao, Giora Slutzki and Vasant Honavar, Twenty-Third AAAI Conference on Artificial Intelligence (AAAI-08), July 13 - 17, Chicago, Illinois, USA
2. *F-$\mathcal{ALCI}$: A Fully Contextualized Federated Logic for the Semantic Web*, with Jie Bao, Giora Slutzki and Vasant Honavar, 2008 IEEE/WIC/ACM International Conference on Web Intelligence (WI'08), December 9-12, 2008, Sydney, Australia
3. *Comparing Availability in Controlled Query Evaluation Using Unordered Query Evaluation for Known Potential Secrets*, International Workshop on Logic in Databases (LID 2009), October 29, Roskilde University, Denmark

Preprints:

1. *Categorical Abstract Algebraic Logic: Compatibility Operators and the Leibniz Hierarchy*
2. *Categorical Abstract Algebraic Logic: The Subdirect Product Theorem*
3. *Categorical Abstract Algebraic Logic: Protoalgebraic Classes of Structure Systems*
4. *An Equational Theory of n-Lattices*
5. *Categorical Abstract Algebraic Logic: Operations on Classes of Models*
6. *Chu Spaces, Concept Lattices and Information Systems in n Dimensions*
7. *Categorical Abstract Algebraic Logic: Selfextensional π-Institutions with Implication*
8. *Categorical Abstract Algebraic Logic: Selfextensional π-Institutions with Conjunction*
9. *Categorical Abstract Algebraic Logic: Weakly Algebraizable π-Institutions*
10. *Categorical Abstract Algebraic Logic: Local Deduction Theorems for π-Institutions*
11. *Categorical Abstract Algebraic Logic: Fibring of π-Institutions*

Technical Reports:

1. *On Some Operations on Classes of Algebras and Coalgebras from a Bialgebraic Viewpoint*
2. *On the Categorical Möbius Calculus*
3. *Combinatorial Analysis of the State Space Structure of Finite Automata Networks*
4. *Probabilistic Threshold Agent Networks*
5. *Privacy-Preserving Reasoning for Hypergraphical Knowledge Bases*, with Jie Bao, Giora Slutzki and Vasant Honavar
6. *Secrecy Preserving Reasoning Over Entailment Systems Theory and Applications*, with Giora Slutzki and Vasant Honavar
7. *Secrecy Preserving Reasoning Using Secrecy Envelopes*, with Giora Slutzki and Vasant Honavar
8. *F-$\mathcal{ALCI}$: A Fully Contextualized, Federated Logic for the Semantic Web*, with Jie Bao, Giora Slutzki and Vasant Honavar
9. *Categorical Abstract Algebraic Logic: Equivalence of Closure Systems*
10. *Distributed Reasoning with Modular Ontologies*
11. *Package-based Description Logics: Syntax, Semantics and Complexity*
12. *F-$\mathcal{ALCI}$: A Fully Contextualized, Federated Logic for the Semantic Web*
13. *A Federated Tableau Algorithm for F-$\mathcal{ALCI}$*
14. *Reasoning with F-$\mathcal{ALCI}$ Over Lattices*

Teaching (Web-Site)

Teaching Interests

Mathematics: Category Theory, Logic, Set Theory, Abstract Algebra, Universal and Categorical Algebra, Combinatorics and Graph Theory, Topology

Computer Science: Introduction to AI, Machine Learning, Theory of Algorithms, Computational Complexity

Lecture Notes (Web-Site)

Intermediate Algebra

College Trigonometry

College Algebra

Calculus I, Calculus II, Calculus III

Calculus for Business and Life Sciences

Elementary Differential Equations

Fundamental Concepts of Mathematics

Topics in Discrete Mathematics

Discrete Structures for Computer Science

Introduction to Combinatorial Mathematics

Introduction to Graph Theory

Introduction to Linear Algebra

Abstract Algebra I

Introduction to Real Analysis

Introduction to Complex Analysis

Mathematical Logic

Introduction to Set Theory

Introduction to Languages and Computation

Introduction to Computational Complexity

Introduction to Artificial Intelligence

Service

University Service

General Education Committee, L.S.S.U., 2012-

Member of the Local Organizing Committee, 2013 Sectional Meeting of the Michigan Section of the Mathematical Association of America.

Hiring Committee, School of Mathematics and Computer science, L.S.S.U., 2003, 2004, 2012, 2013, 2016, 2017

Member of the Local Organizing Committee, 2004 Upper Peninsula Regional Meeting of the Michigan Section of the Mathematical Association of America.

Library Liaison, School of Mathematics and Computer Science, L.S.S.U.

Member of the School Committee, School of Mathematics and Computer Science, L.S.S.U.

Member of M.Sc. Committee for Eric Pacuit, Mathematics, C.W.R.U., Spring 2000.

Advising

B.Sc. Thesis Advisor for Edward Kramer, L.S.S.U., Fall 2012

Faculty Advisor of the 2011, 2012, 2015 L.S.S.U. Putnam Mathematical Competition Team.

π-Day Poster Competition Judge, L.S.S.U., March 14, 2006

Faculty Advisor of the 2002, 2003, 2004 L.S.S.U. Putnam Mathematical Competition Team.

Member of the Math Quiz 2000 competition N.M.S.U. Team, which ranked 14th worldwide.

Faculty Advisor of the 1999 C.W.R.U. Putnam Mathematical Competition Team, which ranked 21st in the nation.

Refereeing

Journals: Journal of the Korean Mathematical Society, Mathematical Logic Quarterly, Theoretical Computer Science, Journal of Zhejiang University-Science A, Discussiones Mathematicae: General Algebra and Applications, Algebra Universalis, Journal of Logic and Computation, The Journal of Symbolic Logic, Order

Conferences: CSL 2000, 8th International Computer Science Symposium (CSR 2013)

Funding Organizations: FONDECYT (National Fund for Scientific and Technological Development of Chile) National Contest for Funding 2006.

Awards

Aggie Ho Award for Outstanding Research in Pure Mathematics, I.S.U.	May 1997
I.S.U. Teaching Excellence Award	May 1997
Greek State Scholarships Foundation Award	May 1990
Technical Chamber of Greece Award	May 1990
3rd Place Award in Greek National Mathematical Contest	1988
8th Place Award in Greek National Contest in Chemistry	1988
5th Lyceum of Athens Alumni Association Award	1988
Distinction in Greek National Mathematical Contest	1987
Municipality of Athens High School Student Awards	1983-1988

Recommendations

Research: 1. Professor Emeritus Don Pigozzi, 3215 Burdeck Drive, Oakland, CA 94602-2613, Phone: (510) 482-3887, Email: dpigozzi@iastate.edu

2. Professor Emeritus Josep Maria Font, Department of Mathematics and Computer Engineering, Faculty of Mathematics and Computer Engineering, University of Barcelona, Gran Via de les Corts Catalanes 585, E-08071 Barcelona, Spain, Phone: (+34) 934-020-172, Email: jmfont@ub.edu
3. Professor Jonathan D.H. Smith, Department of Mathematics, 396 Carver Hall, Iowa State University, 411 Morrill Road, Ames, Iowa 50011-2104, Phone: (515) 294-8172, Email: jdhsmith@iastate.edu
4. Professor Clifford Bergman, Department of Mathematics, 396 Carver Hall, Iowa State University, 411 Morrill Road, Ames, Iowa 50011-2104, Phone: (515) 294-8137, Email: cbergman@iastate.edu

Teaching: 1. Professor Kimberly Muller, Dean of the College of Innovations and Solutions (Business, Engineering and Computer Science and Mathematics), 450 W. Easterday Avenue, Sault Sainte Marie, MI 49783, Phone: (906) 635-2170, E-mail: kmuller@lssu.edu

NATIONAL TECHNICAL UNIVERSITY
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Department of Mathematics
Zografou Campus, 157 80
Athens - GREECE
TEL. : 772 1774
FAX : 772 1775

Dr. George Voutsadakis
Lake Superior State University
650 W. Easterday Avenue
Sault Ste. Marie, MI 49783
U.S.A.

Dear Dr. Voutsadakis,

I am writing on behalf of the Department of Mathematics of the National Technical University of Athens to invite you to complete part of your sabbatical leave for the year 2019-2020 here at our Department. Your duties will include theoretical research in Abstract Algebraic Logic and a mini series of seminars/tutorials on the subject, or a subject of your choice, in the weekly seminars organized by our Department and / or our graduate program "Applied Mathematical Sciences".

Assoc. Prof. Dr. Konstantinos Chrysafinos (Directror of Department of Mathematics) and Assist. Prof. Dr. Petros Stefaneas will be your hosts during your visit. We acknowledge that you will receive no monetary remuneration from our University and that you will be responsible for all your financial needs, including transportation, housing and living expenses throughout your program.

Aside from the institutional affiliation with the NTUA during your stay with us, the Department will provide office space, computer access and full access to the seminars and colloquia during your visit.

We are all looking forward to your visiting us in the coming academic year.

Sincerely,

[redacted]

Konstantinos Chrysafinos

Associate Professor
Director, Department of Mathematics

[redacted]

Dr. George Voutsadakis
Lake Superior State University
650 W. Easterday Avenue
Sault Ste. Marie, MI 49783
U.S.A.

Dear Dr. Voutsadakis,

I am writing on behalf of the Department of Mathematics of the University of Aveiro to invite you to complete part of your sabbatical leave for the year 2019-2020 at our University. Your duties will include conducting independent research, working on your planned monograph and collaborating with Professor Martins on both theoretical research in Abstract Algebraic Logic and in applied research in Coalgebraic Modeling and Analysis for Computational Synthetic Biology. You may also coordinate with Professor Martins to present a mini series of seminars/tutorials on subject(s) related to the interdisciplinary project KLEE (http://klee.di.uminho.pt/) for which he is the Co-IR at the University of Aveiro.

Dr. Martins will also serve as your host during your visit. We acknowledge that you will receive no monetary remuneration from the University of Aveiro and that you will be responsible for your transportation expenses. However, Dr. Martins has secured some funding for your housing accommodation and for part of your living expenses throughout your stay with us.

Aside from the institutional affiliation with the University of Aveiro during your stay with us, the Department will provide office space, computer access and full access to the seminars and colloquia during your visit.

We are all looking forward to your visiting us in the coming academic year.

Sincerely,

Manuel Antonio Gonçalves Martins
Associate Professor
CIDMA & Department of Mathematics
University of Aveiro

Campus de Gualtar
4710-057 Braga – P

Universidade do Minho
Escola de Engenharia
Departamento de Informática

Dr. George Voutsadakis
Lake Superior State University
650 W. Easterday Avenue
Sault Ste. Marie, MI 49783
U.S.A.

Dear Dr. Voutsadakis,

I am writing on behalf of the Department of Informatics of the University of Minho to invite you to complete part of your sabbatical leave for the year 2019-2020 here at our Department. Your duties will include theoretical research in Abstract Algebraic Logic framed in the PT-FLAD Chair on Smart Cities, established in this Department under coordination of Prof. Luis Soares Barbosa, and a mini series of lectures on a subject of your choice in a seminar organized in collaboration with the Department of Mathematics of the University of Aveiro.

It will be my pleasure to be your host during your visit. We acknowledge that you will receive no monetary remuneration from our University and that you will be responsible for all your financial needs. The Chair, however, may secure funding to support your accommodation during the period of your stay.

We are looking forward to your visit in the coming academic year.

Sincerely,

(Luis Soares Barbosa, PT-FLAD Chair on Smart Cities)