

# Fredrik Dahlqvist

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## Education

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<b>Imperial College London</b> <i>PhD in Computer Science</i> Completeness-via-Canonicity in Coalgebraic Logics. Awarded 1 October 2015.	<b>London</b> 2010–2013
<b>Birkbeck, University of London</b> <i>MSc in Computer Science, Distinction</i> Part-time evening course. Dissertation on spatial logic.	<b>London</b> 2008–2009
<b>Imperial College London</b> <i>MSc in Quantum Fields and Fundamental Forces, Pass</i> Dissertation on two-dimensional superconformal field theories.	<b>London</b> 2003–2004
<b>Université Libre de Bruxelles</b> <i>Licence en Mathématique, Distinction</i> Awarded 75% for the ‘Licence’ in Mathematics (equivalent to an MSci). Dissertation on sheaf theory.	<b>Brussels</b> 2000–2003
<b>Université Libre de Bruxelles</b> <i>Licence en Philosophie, Grande Distinction</i> Awarded 80% for the ‘Licence’ in Philosophy (equivalent to an MA). Dissertation on ‘The evolution of the concept of space in contemporary mathematics’.	<b>Brussels</b> 2000–2003
<b>Danmarks Tekniske Universitet (DTU)</b> <i>Erasmus Exchange Program</i> Part of my mathematics degree.	<b>Lyngby, Denmark</b> 2002
<b>Université Catholique de Louvain</b> <i>Candidature en Philosophie</i> First two years in philosophy and first year in mathematics.	<b>Louvain-la-Neuve, Belgium</b> 1998–2000

## Employment history

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<b>Cornell University</b> <i>Postdoctoral Associate, A Framework for Programmable Network Management Jul 2017—current</i> I am currently spending some time at Cornell University working with Prof. Dexter Kozen on the development of a simple imperative language with enough features to express <i>probabilistic programs</i> written in, for example, Anglican or Probabilistic C. The language aims to include <i>conditioning</i> as a primitive operation. Parallel to the development of a <i>syntax and type system</i> , we are developing the mathematical infrastructure to provide the language with both a <i>denotational semantics</i> in terms of Markov kernels, and an <i>operational semantics</i> in terms of sampling.	<b>Ithaca, NY</b>
<b>University College London, PPLV team</b> <i>Research assistant, ERC ProFoundNet Project</i>	<b>London</b> 2016–current

I am also working with Dr. Alexandra's Silva team on the foundations of *probabilistic network programming*. Amongst our avenues of research are questions about what a good notion of probabilistic Kleene algebras should be, what their semantics would be, how denotations can be computed or approximated, and how automata-theoretic constructions translate in the probabilistic case. I will also investigate how network symmetries could be used to significantly reduce the size and complexity of probabilistic network verification problems.

**University College London, PPLV team**

**London**

*Research assistant, EPSRC Resource Reasoning Project*

*2014–2016*

I have worked with Prof. David Pym on applying the techniques developed in my Ph.D. to the substructural logic underpinning *separation logic* (Boolean Bunched Implication) and its modal extensions. Together we published a coalgebraic *completeness result for all distributive substructural logic* with a very natural relational semantics. This result is completely modular, and many modal extensions of separation logic can thus also be given a complete semantics, in particular dynamic logics with a separation conjunction.

**University of Edinburgh, LFCS**

**Edinburgh**

*Research Assistant, ERC RULE Project*

*2013–2016*

Together with Prof. Vincent Danos and my colleague Ilias Garnier (both now at ENS Paris) we have been developing a structural approach to probability theory, in an effort to solve some difficult problems related to stochastic semantics of rule based system and to provide general semantic principles for *probabilistic programming* and *machine learning*. In another strand of research we have re-interpreted Bayesian inversions, the mathematical engine room of *Bayesian learning*, as adjoint linear operators.

**HSBC Bank Plc**

**London**

*Quantitative Fixed-Income Strategist*

*2005–2010*

Located on the trading floor, my role was primarily as a researcher, publishing regular quantitative analyses and trade ideas. Specific duties included:

- Coverage of interest rate derivatives markets (futures, options on futures, swaps, cap/floors, swaptions, sovereign CDS, money market) within the Fixed Income Strategy team: formulation of trade ideas, publication of analyses as well as ad-hoc projects for clients.
- Responsible for the development and maintenance of analytical tools for the Fixed Income Strategy team in London: fair value models, pricing and analytics for bonds, STIR futures, volatility products, swaps and CDS, yield curve modelling.
- Five years of programming (C++, C# and VBA) and databases experience.
- In charge of the development of HSBC's Fixed Income Strategy internet platform in conjunction with a Java developer

## Teaching and supervision

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I have always enjoyed teaching (my mother was a teacher) and volunteered for teaching duties during my PhD. My teaching aims to be enthusiastic, structured in content and informal in style.

**University College London**

**London**

*PhD co-supervisor*

*2016–current*

I am co-supervising a PhD student together with Alexandra Silva. Following the pattern of my very positive experience with my own PhD supervisor, I meet with our student every week for several hours.

**University College London**

**London**

*Teaching Assistant*

*2016–current*

I have taught the exercise part of the second year course 'Logic and Database Theory' and will be teaching the exercise part of the third year course 'Computational Complexity'.

## Imperial College London

*Teaching Assistant*

I have taught the exercise part of the 'Logic' course and have been a mathematics tutor (vectors, calculus, etc) for first year computer science students. The latter involved weekly lectures and exercises to small groups of 6-8 students as well as the marking of weekly assignments.

London

2010–2013

## Kensington and Chelsea Tutors

*Private Tutor*

Private tutoring in Maths, Physics and French.

London

2004–2005

## Research Vision and Interests

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I learned programming and modelling as an analyst for the investment banking division of HSBC and I gradually realised that the foundational aspects of what I was doing were really interesting, but far from understood. I also realised that these foundational questions (e.g. 'how can we specify the dynamic behaviour of probabilistic systems?', 'how can we model concurrent economic agents?') were directly relevant to an extremely wide range of domains: from software engineering to economics and natural sciences. I had to learn more, and this first led me to an evening class MSc in computer science, and subsequently to leave my position at HSBC altogether and embark on a PhD at Imperial College.

In my PhD, I have been looking at the foundations of reasoning about abstract, state-based systems, formalised as coalgebras. Specifically, I have been interested in the problem of frame condition specification in coalgebraic logics which I studied through the concepts of canonicity and functor presentation, which are two very interesting areas of research in their own right.

Coalgebras are very versatile and well suited to both qualitative and quantitative reasoning, through the use of functors carrying quantitative information (as in the case of Markov chains for example). However, they do have some limitations, in particular the lack of a general framework to formalize time and dynamics and the expressiveness to talk about symmetries. On the other hand, quantitative modelling paradigms such as stochastic processes offer rich and powerful methods such as stochastic differential equations to study the time evolution and symmetries of dynamical systems. I aim to explore the interplay between formal systems specification and quantitative methods, and to understand how they can be unified or combined to better formalize and understand dynamical systems. The problems arising in the field of probabilistic programming are an ideal test bed for many of these ideas.

## Technical Expertise

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**Probability theory and stochastic processes:** My current research relies heavily on probability theory, topology and functional analysis. In particular, I am well acquainted with Lebesgue integration theory, Polish and Borel spaces, the key results of functional analysis (e.g. Radon-Nikodym and Riesz-type theorems, etc), Markov processes, martingales, Bochner's extension theorem, etc.

**Models:** By their very nature, studying coalgebras has acquainted me with a very wide class of models and related concepts: Automata, Kripke frames, Labelled Transition Systems of all kinds (e.g. with probabilities, non-determinism, etc), notions of simulation and bisimulation, etc.

**Logics:** Similarly, thanks to the unifying power of coalgebraic logic, I have worked more or less directly with classical and positive modal logic, graded modal logic, probability logic, intuitionistic logic, modal and coalgebraic  $\mu$  calculus, temporal logics, PDL, LTL, CTL, etc. I have also gained some experience recently in the fields of substructural and separation logics.

**Category theory:** Although vast swathes of Category Theory are not directly relevant to the

everyday work of a coalgebraist, most basic concepts have to be understood. Moreover, I have learned a great deal more about specific topics such as locally presentable categories, regular categories, universal algebra and coalgebra in categorical form (e.g. monads and algebras, varieties, co-varieties, Birkhoff and co-Birkhoff theorems) and the theory of presentations of functors.

**Ordered structures:** A large part of my PhD dissertation dealt with the problem of canonicity, i.e. of determining which varieties of Boolean algebras or distributive lattices with extra operations are closed under the operation of canonical extension. This has led me to learn a fair amount about ordered structures of various kind (mostly lattices and Boolean algebras) and some of the topologies which can be defined on them (e.g. the Scott topology) which turn out to be very important to study canonicity. I am also interested in the theory and uses of residuated lattices.

**Programming and Databases:** Programming Languages: Five year experience in C#, C++ and VBA, as well as some experience in Java. Markup Languages: XML (including XPath and XSLT), HTML+CSS and  $\LaTeX$ . Financial software: Bloomberg, Bloomberg Excel addin, Bloomberg API (.NET), Bloomberg PriceLink, QuantLib financial library. Databases: Oracle, Sybase ASE and Microsoft SQL Server. Extensive use of most database APIs: ODBC, ADO DB and ADO .NET (SQL statements, stored procedures).

## Grants and Awards

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**2010-2013:** Awarded a 3 year EPSRC DTA fellowship by the Computer Science Department at Imperial College. Funding was subsequently awarded a 6 month extension.

**2013:** ETAPS 2013 best paper nomination at FoSSaCS 2013, one of four nominated papers from 153 accepted submissions with an acceptance rate of 24%.

## Publications and talks

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### Conference Papers.....

- F. Dahlqvist, A. Kurz. *The positivication of coalgebraic logics*. Algebra and Coalgebra in Computer Science (CALCO) 2017.
- F. Dahlqvist, A. Kurz. *Positive Coalgebraic Logic*. Topology Algebra and Categories in Logic (TACL) 2017.
- F. Clerc, F. Dahlqvist, V. Danos and I. Garnier. *Pointless learning*. FoSSaCS 2017.
- F. Clerc, F. Dahlqvist, V. Danos and I. Garnier. *Semantics for probabilistic programming*. Workshop on probabilistic programming semantics (PPS) 2017 (part of POPL 2017).
- F. Dahlqvist, V. Danos, I. Garnier and O. Kammar. *Bayesian inversion by  $\omega$ -complete cone duality*. CONCUR 2016, LIPIcs-Leibniz International Proceedings in Informatics. Vol. 59. Schloss Dagstuhl-Leibniz-Zentrum fuer Informatik, 2016.
- F. Dahlqvist, V. Danos and I. Garnier. *Robustly parameterised higher-order probabilistic models*. CONCUR 2016, LIPIcs-Leibniz International Proceedings in Informatics. Vol. 59. Schloss Dagstuhl-Leibniz-Zentrum fuer Informatik, 2016.
- F. Dahlqvist, V. Danos and I. Garnier. *Giry and the machine*. Mathematical Foundations of Programming Semantics (MFPS) XXXII. 2016.
- F. Dahlqvist, *Coalgebraic completeness-via-canonicity: principles and applications*. International Workshop on Coalgebraic Methods in Computer Science (CMCS), pages 174-194. Springer, 2016.

- F. Dahlqvist and D. Pym. *Completeness via canonicity for distributive substructural logics: a coalgebraic perspective*. RAMiCS 2015, volume 9348 of Lecture Notes in Computer Science, pages 119-135. Springer, 2015.
- F. Dahlqvist and D. Pattinson. *Some Sahlqvist completeness results for coalgebraic logics*. In F. Pfenning, editor, Proc. FoSSaCS 2013, volume 7794 of Lecture Notes in Computer Science, pages 193-208. Springer, 2013.
- F. Dahlqvist and D. Pattinson. *On the fusion of coalgebraic logics*. In A. Corradini, B. Klin, and C. Cîrstea, editors, Proc. CALCO 2011, volume 6859 of Lecture Notes in Computer Science, pages 161-175. Springer, 2011.

#### Journal Papers.....

- F. Dahlqvist, V. Danos, and I. Garnier. *Giry and the Machine*. Electronic Notes in Theoretical Computer Science 325 (2016), pages 85-110.
- F. Dahlqvist and D. Pym. *Completeness via canonicity for substructural logics and relation algebras*. Special Issue '15th International Conference on Relational and Algebraic Methods in Computer Science' of the Journal of Logical and Algebraic Methods in Programming. Accepted for publication.

#### Thesis.....

- F. Dahlqvist. *Completeness-via-canonicity in coalgebraic modal logics*, PhD Dissertation, Imperial College London.

#### Some Talks.....

- A meta-theory of program semantics, March 2017, Computer Science Seminar of the University of Leicester
- Coalgebraic completeness-via-canonicity, at CMCS 2016, Eindhoven, Netherlands
- Completeness via canonicity for distributive substructural logics: a coalgebraic perspective, at RAMiCS 2015, Braga, Portugal
- A theory of strong completeness for relational semantics, London Logic Forum, 2015, London
- Principled modelling via coalgebras, University of Edinburgh, 2013
- Some Sahlqvist Completeness Results for Coalgebraic Modal Logic, at FoSSaCS 2013, Rome
- On the Fusion of Coalgebraic Logics, at CALCO 2011, Winchester, UK

## Miscellaneous

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#### Conference and workshop program committee member.....

- Dalí 2017 : DaLí - Dynamic Logic: new trends and applications (co-located with FROCOS TABLEAUX and ITP 2017)
- CMCS 2018: International workshop on coalgebraic methods in computer science.

#### Refereeing.....

I am involved in conference and journal paper refereeing on a very regular basis, including reviews for the journals *Mathematical Structures in Computer Science* and *Journal of Logical and Algebraic Methods in Programming*.

#### Other services.....

I am the organiser of the PPLV seminar series at UCL, and I also organise well-attended bi-weekly research brainstorming sessions for the PPLV group. I have participated in the organisation of the

CALCO 2011 conference.

## Visits

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I regularly visit Vincent Danos' team at ENS Paris and Alexander Kurz's group at Leicester University. I have attended PropProgSchool 2017, the 1st School on Foundations of Programming and Software systems: Probabilistic programming.

## Languages

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- French, *native*
- Swedish, *conversational*
- English, *fluent*
- Danish, *conversational*

## Additional Information

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- Two daughters.
- Keen piano player, qualifications include English piano grade eight exam and music theory grade five exam.
- Dual Belgian/Swedish citizenship.

## References

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- Prof. Dexter Kozen  
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