THE UNIVERSITY of EDINBURGH informatics

Vacancies

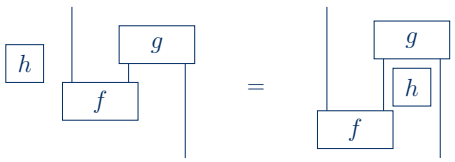
The EPSRC-funded project "Combining Viewpoints in Quantum Theory" is currently recruiting:

- 1 postdoctoral researchers: 18 months, with a possible extension to 27 months, grade 7 salary (£33,797 – £40,322). Additional benefits: travel budget, laptop, career development. The successful candidate(s) must hold or be about to receive a PhD in Computer Science, Mathematics, or Physics, and have a strong background in one of the project topics listed below. Start date: March 2020 or soon thereafter.
- 1 PhD student: 3 years paid tuition (EU/UK fees) plus stipend and travel budget. Candidates should have an interest in the project topics listed below, and ideally a matching preparatory background. Supervisor: Chris Heunen. Starting date: October 2020.

The successful candidates will join the Quantum Informatics group of the Laboratory for Foundations of Computer Science (see opposite side).

Monoidal categories

A monoidal category is a way to to speak about processes that compose both serially and in parallel. They are nice because we can compute in them graphically.



The following examples all have a fibred flavour:

- Sheaves over a topological space X
- Hilbert $C_0(X)$-modules for a topological space X
- The locale of open sets of a topological space X

Space and time

Any monoidal category has a built-in notion of 'space':

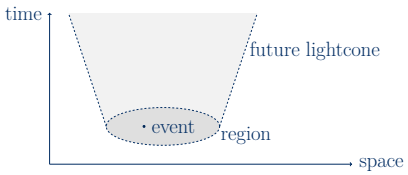
> A subunit in a monoidal category is a monomorphism $s\colon S \rightarrowtail I$ such that $S \otimes s\colon S \otimes S \to S \otimes I$ is invertible.

The subunits form a semilattice, and may be thought of as the open sets of a topological space X. There are well-behaved notions of restriction, support, and localisation. This lets us speak about 'where morphisms happen'. It does what you would expect in the examples above, where subunits are exactly open sets of X.

An additional closure operator on X turns it from a 'space' into 'spacetime'. Can we enrich the graphical calculus to take this into account?

Causality

A spacetime manifold X has a closure operator by future lightcones:



Can we axiomatise the resulting causality relation in terms of subunits (i.e. open sets), without using points? Can we model location-aware protocols like authentication, port-based teleportation, or summoning? Can this give foundations for relativistic quantum information theory?

Concurrency

In computer science, X may be:

- a shared memory that many processes act on;
- a space of permissions of many interacting users;
- a network topology that many agents communicate along;
- a set of capabilities of many interlinked program fragments.

Can we give denotational semantics for programming languages or calculi describing such situations? What do such foundations say about deadlock, livelock, or race conditions?

References

- C. Heunen, J. Vicary, "Categories for Quantum Theory: an Introduction", Oxford University Press, 2019.
- P. Enrique Moliner, C. Heunen, S. Tull, "Tensor Topology", arXiv:1810.01383, 2018.
- C. Heunen, M. L. Reyes, "Frobenius Structures over Hilbert C*-modules", Communications in Mathematical Physics, 2018.

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THE UNIVERSITY of EDINBURGH informatics

University of Edinburgh

The University of Edinburgh, founded in 1582, is the sixth oldest university in the English-speaking world and one of Scotland's ancient universities. It is consistently ranked 20th in the world and 6th in Europe. Edinburgh's alumni include 19 Nobel laureates, 3 Turing Award laureates, 1 Fields Medalist, and 1 Abel Prize winner.

School of Informatics

With over 450 staff and 850 students, the School of Informatics is the largest centre for Informatics research in the UK and one of the largest in Europe. The 2014 Research Excellence Framework ranked us 1st in research power: we produce more world-leading and internationally excellent research than any other university in the UK. Our submission of 95 staff was more than 20 larger than the nearest competitor (Oxford).

Laboratory for Foundations of Computer Science

The LFCS hosts 40 theoretical computer scientists with interests in concurrency, semantics, categories, algebra, types, logic, algorithms, complexity, databases and modelling, including:

- Chris Heunen
- Ohad Kammar
- Gordon Plotkin
- Ian Stark
- Phil Wadler

with an additional 40 postdocs and 80 PhD students. There are two weekly seminars, and a category theory seminar.

Quantum Informatics

Quantum Informatics studies the structure, the behaviour, and the interactions of quantum technology. Staff include:

- Myrto Arapinis
- Raúl García-Patrón Sánchez
- Elham Kashefi
- Petros Wallden

with 5 postdocs and 12 PhD students. There is a biweekly reading group.

Edinburgh

Edinburgh is Scotland's capital city, renowned for its heritage, culture, and festivals. Its historic centre is a World Heritage Site. Easy access to beautiful Scotland makes Edinburgh the second most popular tourist destination in the UK.

School of Mathematics

There are close links to the School of Mathematics. In particular the Hodge Institute, the research groups in algebra, geometry, and topology, has 15 faculty, including:

- Ben Davison
- David Jordan
- Tom Leinster
- Antony Maciocia

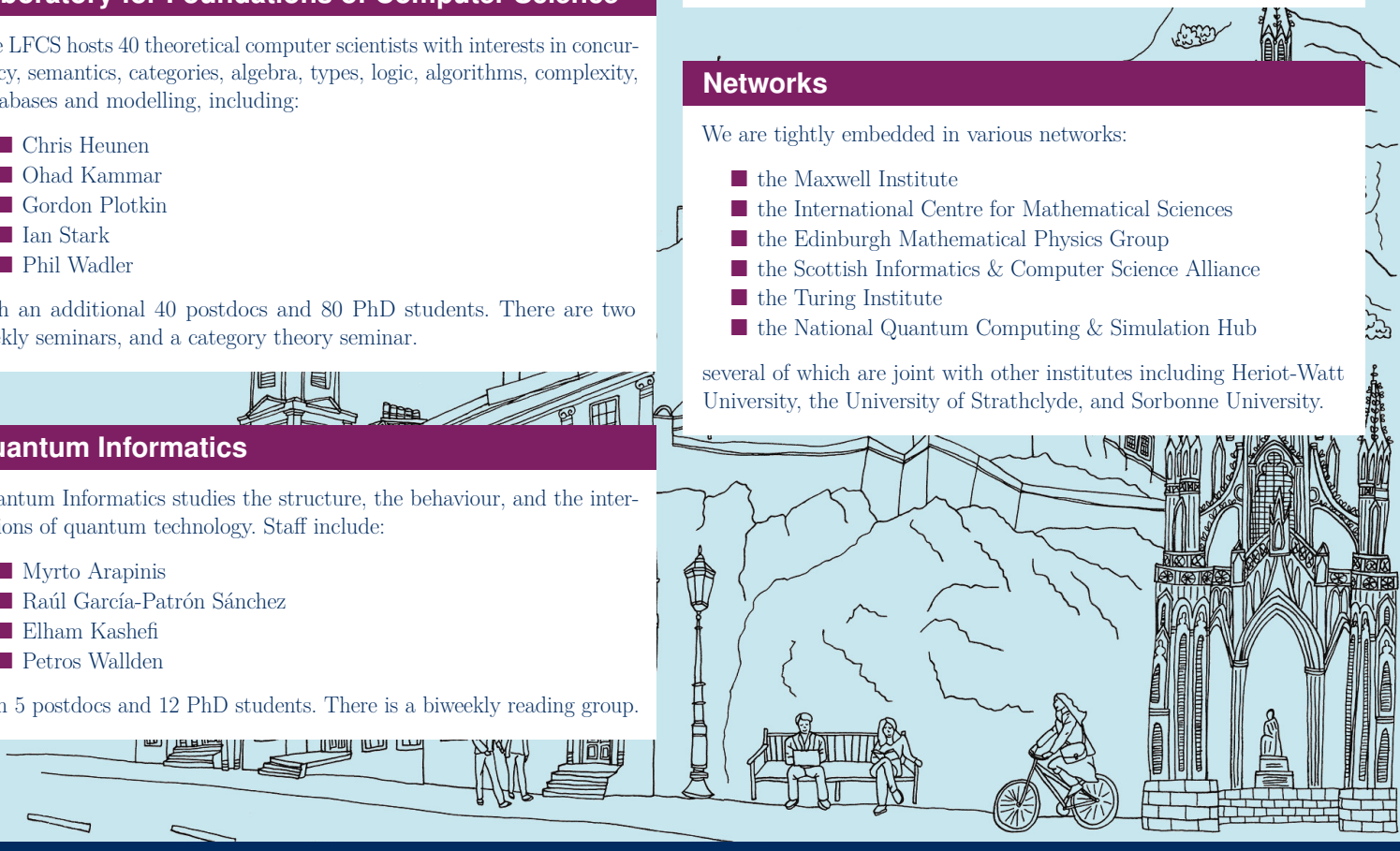
with a large number of postdocs and PhD students. There are several weekly seminars, including a higher category theory seminar.

Networks

We are tightly embedded in various networks:

- the Maxwell Institute
- the International Centre for Mathematical Sciences
- the Edinburgh Mathematical Physics Group
- the Scottish Informatics & Computer Science Alliance
- the Turing Institute
- the National Quantum Computing & Simulation Hub

several of which are joint with other institutes including Heriot-Watt University, the University of Strathclyde, and Sorbonne University.



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