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# Quantum Information Scotland Inaugural Meeting

School of Informatics University of Edinburgh

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1000	Introductory Remarks
1015	Samson Abramsky (Oxford) - Quantum Information Flow: A Computer Science Perspective
1115	Coffee (Poster Set-up)
1130	Stephen Barnett (Strathclyde) - Physical qubits and how to measure them
1230	Student Poster Presentations
1300	Lunch
1400	Lucas Dixon (Edinburgh) - Reasoning with Graphs for Quantum Computation
1430	John Jeffers (Strathclyde) - TBA
1500	Simon Gay (Glasgow) - Formal Modeling and Analysis of Quantum Protocols
1530	Coffee
1600	Erika Anderson (Heriot-Watt) - Quantum Information at Heriot-Watt
1630	Natalia Korolkova (St Andrews) - Entanglement distribution: new concepts and the continuous variable toolbox
1700	Concluding Remarks
1715	Student Poster Session Continued

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## Posters

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- Laleh Memarzadeh (Sharif University and Imperial College London) - Is it possible to define every valence bond state as a Matrix Product State?
- Michael Merkl (Heriot-Watt) - Ultra-cold and ultra-relativistic, exotic quantum states with cold atoms
- Ho-Tsang Ng (UCL) - Mesoscopic superpositions in Bose condensates
- Caleb O'Loan (St Andrews) - Estimation of non-identical unitary channels
- Gary Sinclair (St Andrews) - The cross-Kerr non-linearity in atomic Rubidium
- X. Wang (Cambridge) - Complete Analysis on Lyapunov Control

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## Abstracts

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- Samson Abramsky (Oxford) - Quantum Information Flow: A Computer Science Perspective

We shall describe how methods and concepts from Computer Science can be used to recast the formalism of Quantum Mechanics itself in an elegant and conceptual form, well suited to the needs of Quantum Information; and how this can be applied very effectively to the description and analysis of quantum information protocols.

This opens up the field of Quantum Information and Computation to the kind of high-level, compositional methods which have proved so important in classical Computer Science. Moreover, the formalism can be presented in a visually appealing and intuitive diagrammatic form, with links to ideas both in graphical representations of proofs, and in current work in knot theory and mathematical physics.

- [Stephen Barnett \(Strathclyde\) - Physical qubits and how to measure them](#)

The basic building block in quantum information science is the qubit: a two-state quantum system. What could be simpler? There are many proposals for realizing qubits and these have been employed in a variety of quantum information processing experiments. I shall review some of these including photons, nuclear and electron spins and energy levels in trapped ions or atoms. When you look closer, however, most (if not all) of them are not really two-state systems at all. Peres showed that even the electron spin and photon polarization are not really ideal qubits. I shall show why this is so using fundamental physical ideas.

The Strathclyde group has a long-standing interest in generalized measurements. If time permits, I shall conclude with a brief introduction to these ideas.

- [Lucas Dixon \(Edinburgh\) - Reasoning with Graphs for Quantum Computation \(joint work with Ross Duncan\)](#)

Graph-based formalisms of quantum computation provide an abstract and symbolic way to represent and simulate computations. However, manual manipulation of such graphs is slow and error prone. We will present a formalism, based on compact closed categories, that supports mechanised reasoning about such graphs. This gives a compositional account of graph rewriting that preserves the underlying categorical semantics. Using this representation, we describe a generic system with a fixed logical kernel that supports reasoning about models of compact closed category. A salient feature of the system is that it provides a formal and declarative account of derived results that can include 'ellipses'-style notation. We illustrate the framework by instantiating it for a graphical language of quantum computation and show how this can be used to perform symbolic computation.

- [Simon Gay \(Glasgow\) - Formal Modelling and Analysis of Quantum Protocols](#)

Quantum communication and cryptographic protocols are well on the way to becoming an important practical technology. Although a large amount of successful research has been done on proving their correctness, most of this work does not make use of familiar techniques from the formal methods area of computer science: formal logics for specification, formal modelling languages, separation of levels of abstraction, compositional analysis, and so on. We argue that these techniques will be necessary for the analysis of large-scale systems that combine quantum and classical components, and present the results of initial investigation in several areas.

- [Erika Anderson \(Heriot-Watt\) - Quantum Information at Heriot-Watt](#)

This talk will give a brief overview of theoretical and experimental activities connected to quantum information science at Heriot-Watt. The theoretical activities concern e.g. quantum measurements and the theory of open quantum systems. Experimental activities are mainly in the field of quantum cryptography, but quantum dot experiments with possible applications to quantum information science are also being developed. Links and collaborations with other Scottish universities will be outlined.

- [Natalia Korolkova \(St Andrews\) - Entanglement distribution: new concepts and the continuous variable toolbox \(joint work with, T. Tyc, L. Mista, D. Menzies, G. Sinclair\)](#)

In the view of the long-distance quantum communication applications, we discuss entanglement concentration scheme for infinite-dimensional quantum systems based on non-linear cross-Kerr coupling of the one part of two-mode squeezed vacuum and an ancillary coherent state. We then show how the whole family of such entanglement concentration protocols can be derived using the framework and concept of weak quantum measurement. Next, we modify the scheme to create highly non-classical non-Gaussian states with the negative Wigner function. Finally, we address the question of quantum information distribution in general. As a development from the earlier work of Cubitt et al for qubits [Phys. Rev. Lett. 91, 037902 (2003)], we demonstrate the possibility to distribute entanglement without sending entanglement in infinite-dimensional systems.