Discussion on Quantum Information Flow
Computer Journal Lecture by Samson Abramsky FRS

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It is a great honour to have had the opportunity to attend Samson's Computer Journal Lecture on quantum information flow; Samson is an eloquent speaker who has made many seminal contributions to theoretical computer science, and his recent work with Bob Coecke on developing a category–theoretic foundation for the mathematical formalism of quantum mechanics is an essential step towards bringing the benefits of the categorical approach (which has proved highly successful in classical computation) to the burgeoning field of quantum computation and quantum information.

As Samson himself indicated, high–level approaches help to manage and abstract away much of the complexity inherent in computations and communicating systems, allowing one to isolate and understand the true *structure* of a process; I believe that the categorical formalism which he has been describing provides a solid theoretical basis for ongoing research in quantum programming languages and formal methods for quantum computing. It might be suggested that the categorical formalism, elegant, compositional and endowed with an attractive graphical language, could be further extended so as to enable the high–level description of larger systems composed of quantum and classical components. The emphasis in current work is on the concept of *information flow*; indeed, the categorical framework has been set up so as to account for both quantum and classical flows. It would certainly be very interesting to be able to specify and reason about other, more traditional yet still significant aspects of systems such as timing and concurrency also. Surely new programming formalisms and models for quantum computation would merit from using the categorical framework as a semantic layer.

I believe that this last direction of work is likely to prove highly beneficial to designers and implementers of commercial quantum technology, such as manufacturers of quantum key distribution systems. One can conceive of a formal specification and verification framework for quantum systems and protocols, with a high–level specification language (at least partially) translatable into Abramsky's and Coecke's graphical calculus; an automated verification tool would allow a system designer to analyse the behaviours of a composite quantum/classical system, while the categorical semantics of the specification language would enable one to formally reason about the various information flows in the system and to make simplifications using axioms such as those which Samson presented in his lecture.

I believe that there is much to be gained from the application of well-established techniques and theories from computer science, such as formal specification, automated verification and programming language semantics, to the emerging challenges arising in quantum computation and quantum information. The categorical approach being developed by Samson is exemplary of this cross-pollination between computer science and quantum mechanics. Hopefully there will be many more efforts in this direction; one can expect that future implementations of quantum technology will rest not only on fascinating experimental developments, but also on strong theoretical results.

— N.P.