

# Quantum geometry aspects of quantum computing

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Research Group: [Geometry, Analysis & Gravitation](#)

## Project description:

Quantum algebras, including quantum groups[1] and quantum geometry[2] have a long association with mathematical physics, topological quantum field theories and quantum gravity. The project will leverage on this and seek to repurpose such tools to quantum computing, particularly to topological quantum computing or 'surface codes'. Due to quantum noise, topological stabilisation currently offers the best hope for quantum computers with more than a few nodes. The well-studied Kitaev model is already known to be a lattice version of quantum gravity based on quantum group doubles, but new methods are needed to work with it and to generalise it to other Hopf algebras and include boundary defects. Some initial work by the supervisor [4] will be a starting point. Further work will may also involve braided and 2-categories. [SEP]

On another front, central in quantum gravity is a link between entropy and geometric curvature. The project will aim to transfer this to novel ideas about quantum information geometry. The mathematics here is a formulation [2] of geometry where coordinates are replaced by operators or elements of a noncommutative algebra as in quantum theory, but so far this formalism has not been applied to quantum computing. For example [3] offers a formulation of 'quantum geodesics', including a new understanding of Schroedinger's equation as a quantum geodesic flow and the implications of this for quantum computing will be explored.

The PhD student will be located in the supervisor's well-established 'quantum algebras' group in SMS.

## References

- [1] S. Majid, Foundations of Quantum Group Theory, CUP (2000) 640 pp
- [2] E.J. Beggs and S. Majid, Quantum Riemannian Geometry, Springer (2020) 809pp.
- [3] E.J. Beggs and S. Majid, Quantum geodesics in quantum mechanics, arXiv:1912.13376
- [4] A. Cowtan and S. Majid, Quantum double aspects of surface code models, arXiv: 2107.04411

**Further information:**

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[Entry requirements](#)

[Fees and funding](#)