**Q5: Are we confident that quantum spin microscopy will work?**

**A5: The key pieces are in-place: QMOR, HWIL, and experiment**

## For details: www.mrfm.org

### UW Quantum System Engineering Seminar Write-up

This web page summarizes the findings of a two-year UW Quantum

- QSE_is_in_NP.pdf: *Measurement operator methods for quantum model order reduction in large-scale spin simulations*
- QSE_is_in_NP.tar.gz: tarball of the LaTeX for the above

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**Measurement operator methods for quantum model order reduction in large-scale spin simulations**

into an equivalent continuous measurement process; and finally the projection of the resulting quantum trajectory onto a product-sum manifold of Beylkin-Mohlenkamp type. The application of this technique is illustrated by numerical quantum trajectory simulations of single-spin detection by magnetic resonance force microscopy (MRFM). Excellent agreement with experimental results is obtained. It is shown that in the Markovian noise limit single-spin data statistics can be predicted in closed form to all orders, despite the nonlinearity of the underlying quantum model. A new closed-form positive $P$-representation of the thermal density matrix is derived as an auxiliary result. Large-scale quantum simulations of up to eighteen interacting spins are then presented, in the context of a spin-dust model that has no symmetries, no spatial ordering, and high temperature; the technique is found to work well even within this deliberately challenging model. Classical and quantum model order reduction (MOR) techniques are compared, and the invariance associated with Choi's Theorem is shown to be essential to quantum model order reduction. A surprising equivalence between compressed wave functions and cryptographic keys is noted, and as a proof-of-principle, the numerical spin-dust trajectories are used to implement a public key exchange protocol. A large class of quantum systems can be simulated in polynomial space and time by this method, with the main restriction that the noise level be large enough that the system being simulated is not running a quantum computation.

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# MRFM Summer School, June 21-24

## Kavli Institute at Cornell University

## Organizer: Prof. John Marohn

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