

## PROGRAM MANAGER

Prof Gerard Milburn – UQ

## QUANTUM INFORMATION RESEARCHERS

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## COLLABORATING CENTRE RESEARCHERS

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Prof Howard Wiseman

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Prof Jason Twamley, Dr Stojan Rebic

## INTERNATIONAL COLLABORATORS

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**Max Planck Institute, Germany**

Dr Magdalena Stobinska

**University of Vienna, Austria**

Dr Markus Aspelmeyer, Dr Nathan Langford,

Dr Markus Arndt, Dr Frank Verstrate

**University of Nottingham, UK**

Dr Denzil Rodrigues

**University of New Mexico, USA**

Prof Carlton Caves

**National Taiwan University**

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## OTHER COLLABORATORS

**University of Queensland, Australia**

Dr Ross McKenzie

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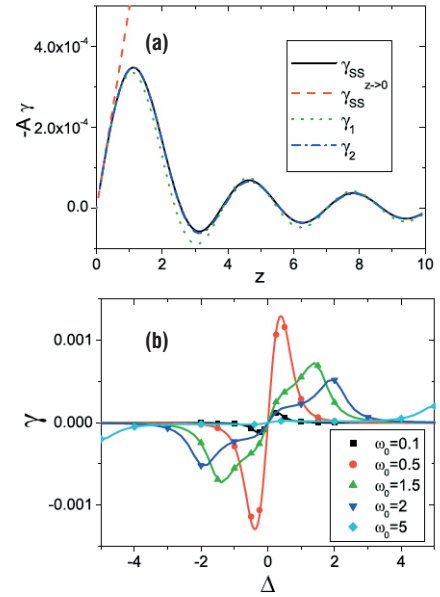
Prof David Hinde, Dr Mahananda Dasgupta

**University of Melbourne, Australia**

Dr Maximilian Schlosshauer

## PROGRAM DESCRIPTION

The research program in quantum information theory is directed towards general aspects of quantum information, such as entanglement, decoherence and error correction, with a particular emphasis on condensed matter systems and quantum optics.



**FIGURE 1**  
(color online). Plot of the superconducting single electron transistor damping. Plot (a) shows non-linear damping. Plotted are the full expression for the damping, superconducting single electron transistor, the linear damping, and approximations for the nonlinear damping. Plot (b) shows the linear damping over a range of resonator frequencies, where the points are the damping calculated numerically.

## 1. Quantum information

According to the Gottesmann-Knill theorem, non-Gaussian states are necessary components for a nontrivial quantum computation. In a collaboration with Magda Stobinska at MPI Erlangen, we showed that applying a well-known protocol for a finite ion motional-superposition-state-generation one can produce, with an arbitrary good approximation, the Kerr non-Gaussian states. The method is experimentally feasible. We also gave criteria, based on the Wigner function comparison and its measurement precision, which quantify the error resulting from the approximation. In a collaboration with Dr M. Schlosshauer at University of Melbourne I studied decoherence and dissipation of a quantum-mechanical harmonic oscillator interacting with a bath of independent two-level systems in the weak-coupling limit. This model is an important cornerstone for an understanding of decoherence and dissipation in quantum-electromechanical systems and in micron-scale ion traps. To investigate the influence of further couplings of the environment spins to a dissipative bath, we also derived the master equation for a harmonic oscillator interacting with a single spin coupled to a bosonic bath. We found that the systematic dissipation rate for the central oscillator decreases with increasing temperature and that it goes to zero at zero temperature, but that there also exists a temperature-independent momentum-diffusion (heating) rate. This was published as M. Schlosshauer, A.P. Hines, and G.J. Milburn, Phys. Rev. A **77**, 022111 (2008). In a collaboration with D. Hinde at ANU and R. McKenzie at UQ, I studied the role of decoherence

in nuclear fusion. New measurements at ANU of fusion cross-sections at energies far below the barrier showed a saturated (though very large) logarithmic slope at the lowest energies. Conventional theory, based on coupled-channels calculations, does not reproduce this data and previous above-barrier cross-sections with the same nuclear potential. We proposed a model that explicitly included a physical processes causing energy dissipation and decoherence inside the barrier that with further work might explain the data. This is the first experimentally testable model of quantum decoherence involving a nuclear potential. This was published as A. Diaz-Torres, et al., Phys. Rev. C. **78** 064604 (2008). In collaboration with D. Rodrigues at University of Nottingham, I investigated the noise properties of an harmonically driven resonator coupled to a superconducting single electron transistor (SSET). Using a Langevin equation approach, we calculated the frequency spectrum of both the SSET charge and the resonator in the limit of low Josephson energy. We found that the heights of the peaks in the frequency spectra depend sensitively on the amplitude of the resonator oscillation and hence suggest that the heights of these peaks could act as a sensitive signal for detecting the small changes in the amplitude of the drive. The previously known results for the amplitude-dependent damping and temperature provided by the SSET for the case of a low frequency resonator are generalized for all resonator frequencies. This is published as D.A. Rodrigues and G.J. Milburn, Phys. Rev. B **78**, 104302 (2008).